Final Drought Plan

April 2017
Main Report
(Addendum added June 2020 at start of plan)

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Addendum

On 4 May 2020 Defra permitted Thames Water to publish the final version of its Drought Plan (DP). This process started in 2016 and. its development timeline is shown below.

- Thames Water submitted its draft DP to Defra on 14 Oct 2016
- Thames Water received approval to publish its plan for consultation on 19 Dec 2016 and published its draft DP for consultation between 6 Jan 2017 and 17 Feb 2017
- Thames Water submitted its revised draft Drought Plan and Statement of Response on the 21 April 2017.
- Thames Water made further revisions and submitted these to Defra on 30 August 2018

Our Final Drought Plan 2017 is now available on the Thames Water website at :
https://corporate.thameswater.co.uk/about-us/our-strategies-and-plans/our-drought-plan

Following our submission to Defra a number of operational changes have occurred. These do not alter our ability to manage the service levels shown in our Drought Plan 2017, and they will be updated in our next Drought Plan. For completeness, these changes relate to the Thames Gateway Water Treatment Works and the Hoddesdon Transfer reuse scheme as set out below. The Environmental Agency is aware of the updated information.

Thames Gateway Water Treatment Plant

Our Drought Plan 2017 includes this option with a resource benefit of up to 150 Ml/d. This has recently been revised to 100 Ml/d.

Hoddesdon Transfer reuse scheme

Our Drought Plan 2017 includes this option with a resource benefit of up to 12.5 Ml/d. This has recently been revised to zero Ml/d.

These changes in supply options result in a reduction to the deployable output of these schemes, However, they are balanced by increases in available water resources to Thames Water as a result of increased effluent discharges arising from increased water use by customers in Affinity Water's supply area. There is therefore no reduction in the overall supply demand balance and hence no increase in drought risk or decrease in resilience. We are publishing our final Drought Plan 2017 without making any amendment to reflect these recent changes. The Drought Plan 2017 does not need amending for the reasons set out above. We are working on our next draft Drought Plan, which is due for submission to Defra in April 2021, as required by the Drought Plan regulations. The new plan will include the updates to the supply side options detailed above.

END

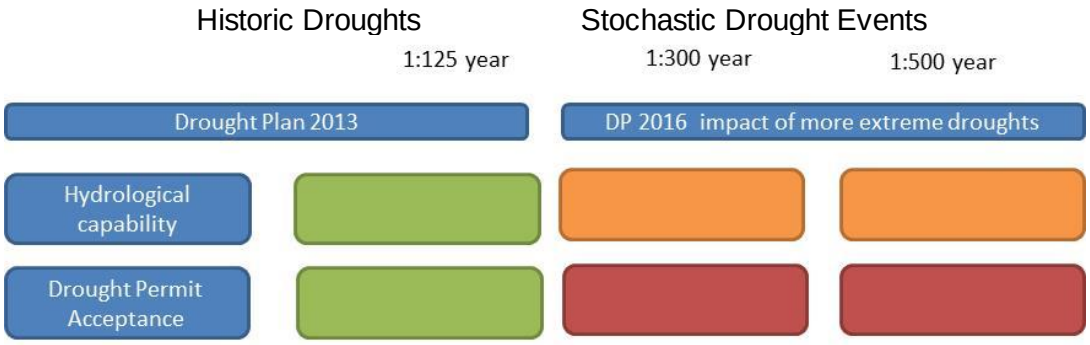
S1 Overview of Drought Plan 2017

Our Drought Plan 2017 covers the next 5 years, up to 2022 and demonstrates how Thames Water will react to a period of unusually low rainfall. The Plan meets the Drought Plan guidelines and develops the path to achieve increased protection against more severe droughts. For this planning period the Drought Plan shows that Thames Water can meet with the existing asset base:

i) Its 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.

The Plan does not take account of the forecast increase in population in the Thames catchment and associated increased demand for water, the future impacts of climate change, or potential future reductions in abstractions in order to provide greater protection for the aquatic environment. Our long-term solution to these issues will be set out in our next Water Resources Management Plan, which will be submitted to the Secretary of State for approval in 2018.

We have carried out detailed analysis of more severe droughts using a stochastic approach. Although it can be shown we can maintain supply, it also shows that our current asset base will be placed under great strain, impacting the capability of the water system and potentially having a significant detrimental effect on the environment and ecology.



It is expected that more severe water use restrictions could be required for at least nine months, requiring a review of a number, if not all, of our Drought Permits and Drought Orders for future drought plans. Furthermore the associated water use restrictions also have the potential to have a significant detrimental effect on a number of small businesses.

Imposing a Drought Order to curtail non-essential water use for six months during a severe drought is estimated to cost businesses between £750 million to £1.7 billion1. The environmental and economic impacts have not been comprehensively evaluated for the current drought plan but would be important considerations when looking at the planning of water resources over a longer timescale.

[1] NERA 2012 A non-essential use drought order for London: economic impact assessment

As stated above, the Drought Plan covers up to 2022 and therefore does not take account of the increasing population, climate change, or potential reductions in abstractions. These factors are all forecast to have a significant effect in the Thames catchment. Our Water Resources Management Plan 2014 has forecast a growth of population of between 2-2.9 million people in Thames Water's supply area, three quarters of which is expected to be in London. An increasing incidence of droughts and more extreme weather events are 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 the 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 WRMP19 which will describe our longer term supply and demand position, which is expected to cover the period 2020-2100 for some water resource zones. The assessment of current water availability in the Drought Plan also assumes that all existing resources are operating to their expected capacity.

Conclusions

Although the assessment shows that for this planning period the Drought Plan is robust it highlights that further work and assessment will be required to support future Drought Plans. This may include work to cover the potential requirement for Environmental Assessment Reports (EARs) to cover a period of greater than six months and to address consecutive drought periods, and work to understand the impact on small businesses of the imposition of TUBs and drought orders for extended periods. In addition, the Drought Plan highlights the need for the Water Resources Management Plan to provide the significant resources requirement to address the future supply and demand balance and drought risk arising from population growth, climate change and the loss of existing resources 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 allows us build an asset base to provide the required resilience for the future.

Material Changes Since the Last Drought Plan (2013)

Thames Water has made material changes to the Drought Plan through the addition of two Drought Permit options at Childrey Warren and Pann Mill and has modified the options at Ogbourne and Axford following licence reductions that have been implemented at these sites.

S2 Summary Overview

S2.1 Regulatory requirements

The purpose of a Drought Plan is to set out the timely actions a water company will take to protect water supplies and the environment. 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 this requirement. This document has been produced in line with the Drought Plan Regulations

2005 and the guidelines provided by the Environment Agency (EA) (guidance contained in 'How to write an publish a drought plan' – July 2016, referred to herein as 'Drought Plan Guidelines').

Thames Water last updated its Drought Plan in 2013 to include:

- legislative powers arising from the Flood and Water Management Act 2010 and further prescribed by the Water Use (Temporary Bans) Order 2010 (referred to herein as Temporary Use Ban or 'TUB') and the Drought Direction 2011 (referred to herein as DD11). These respectively replaced the historic hosepipe ban and non-essential use ordinary drought order restrictions;
- amendments responding to comments received from the EA on Thames Water's 2010 Drought Plan; and
- amendments to comply with the EA Drought Plan Guidelines (2011) in respect of the Strategic Environmental Assessment (SEA) and Habitats Regulation Assessment (HRA).

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 Regulations 2005 (the Regulations).

Publication and Consultation

This draft plan is for submission 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 will notify Thames Water on any decisions made in respect to national security or commercial confidentiality and direct the Company to make the appropriate amendments before it proceeds to publish its draft plan.

Thames Water will then publish the draft plan on its website and in paper form. A 12 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 Thames Water. The Company will assess the representations and produce a statement of response detailing any changes it has made to the draft Drought Plan as a result of the representations and the reasons for these changes. Conversely, where changes have not been made as a result of the representations, it will explain why not. The statement of response will be published on the company website and those who have made representations will be notified that the statement has been published.

Thames Water will prepare the final draft taking into account any directions received from the Secretary of State and the Environment Agency will check the plan to ensure it complies with directions. The final Drought Plan will be published to the same requirements as the publication of the draft Drought Plan.

Website

The Final Plan and a copy of the summary version of the Final Plan will be available on the Thames Water website.

S2.2 Water Supply in the Thames Catchment and Drought

Approximately 80% of Thames Water's 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.

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.

The four worst summer droughts affecting water supply capability on record in the Thames catchment occurred over 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 and they form the basis for planning London's water resource needs which are largely dependent upon the flow in the River Thames as it enters London before Teddington Weir.

As for most of South East England, during drought conditions water supply is largely sustained by groundwater abstraction and the groundwater that flows out of aquifers into rivers (baseflow). Due to the extent of the catchment above Teddington Weir, the London Water Resources Zone (London WRZ) is less vulnerable to shorter periods of below average rainfall than the Swindon and Oxfordshire Water Resources Zone (SWOX WRZ) in the upper Thames, which is more typical of the rest of the South East in terms of drought vulnerability. This difference between London and the rest of the South East can sometimes be important when it comes to explaining to the public why Thames Water has not introduced water use restrictions when other neighbouring companies have done so.

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.

S2.3 Water Resource Strategy and Drought Management

Supply demand planning and thus drought planning starts at the Water Resource Zone (WRZ) level. A WRZ is defined in the EA's Water Resources Planning Guideline as an area of well-integrated water supply connectivity in which there is the same risk to security of supply. For water resource planning purposes the Thames Water supply area is divided into six independent WRZs reflecting the different characteristics of the supply areas and associated risks to meeting demand.

The London WRZ is the largest of the six zones and covers the Greater London area. The next largest is the Swindon and Oxfordshire zone (SWOX). The water resources for both of these zones are largely based on abstraction of water from the River Thames, which is stored in large raw water reservoirs. The other zones within the Thames Valley are Kennet Valley (including Reading and Newbury), Henley, Slough/Wycombe/Aylesbury (S/W/A) and Guildford.

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

Both the Drought Plan and WRMP are based on the following principles:

- The need to maintain security of supply for our customers.
- The level of restrictions imposed on customers is commensurate with the Company's Levels of Service (LoS).

The planned Levels of Service for water supply restrictions adopted by the Company are set out below in Table A.

Table A 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**	**Sprinkler/unattended hosepipe ban, enhanced media campaign. This would be implemented through a Temporary Use Ban (see Level 3).**
Level 3	**1 year in 20 on average**	**Temporary Use Ban (formerly hosepipe ban), Drought Direction 2011 (formerly non-essential use bans) requiring the granting of an Ordinary Drought Order**
Level 4	**Never**	**If extreme measures (such as standpipes and rota cuts) were necessary their implementation would require the granting of an Emergency Drought Order**

A fundamental assumption in Thames Water's Drought Plan is that the risk to Levels of Service is minimal when all WRZs are in supply demand balance. The balance between supply and demand has been reviewed for all our WRZs within the Water Resources Management Plan, July 2014 to ensure the levels of service in Table A. All WRZs are in balance and are forecast to remain so within AMP6.

Thames Water recognises that the droughts that have occurred in the period of record for London 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 in the Drought Plan Guideline and consequently water companies are required to test their Drought Plans against more severe droughts. This has been undertaken for the Drought Plan 2017 and 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. This work has been completed and describes our current protection against a level 4 event as 1:125 year. The ability to cope with more severe droughts is described and also tested by assessing what measures are required and determining the ability to maintain supplies. This work has been used to confirm our current ability to provide security of supply, and will also be used to assess the need to provide added protection to more extreme droughts through the WRMP.

S2.4 Drought Management Methodology

The Temporary Use Ban (TUB) and Drought Direction 2011 (DD11) water use restrictions have respectively replaced the historic hosepipe ban and non-essential use ordinary drought order restrictions, see next sub-section. The incorporation of the enhanced restrictions stemming from the new legislation in 2011 has not produced a significant change in the way Thames Water manages drought. However, the SWOX WRZ protocol was amended in response to Defra and EA comments on the Drought Plan 2010 to include a new trigger for initiating the DD11 order and drought permit applications based on the River Thames flow at Farmoor.

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 WRZ consist of:

- Demand-side measures in which water use restrictions associated with Levels of Service play a major role and are triggered by the London WRZ protocol, which uses both the latest observed hydrological data to assess the *prevailing* water situation and *predicts* how this might develop under worse case scenarios; and
- 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 water supply capability under drought conditions (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 the 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 WRZ drought management methodology is similar to that of the London WRZ and is based on the *prevailing/predicted* assessment. The introduction of water use restrictions is determined, in the first instance, by the London WRZ protocol. However, a trigger has been added for submitting DD11 orders and drought permit applications based on the level of flow (200 Ml/d 5-day running mean) in the River Thames at Farmoor. Unlike the London WRZ, there are no supply-side strategic drought schemes available to supplement SWOX WRZs deployable output; the major supply-side augmentation comes in the form of increased abstraction from existing sources introduced at Level 3b 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. 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.

S2.5 Demand-side measures

Table B below provides the full range of demand-side measures and shows that most of them are associated with Thames Water's stated Levels of Service (Table A). These measures are a sub-set of the baseline demand management programme, which is an ongoing major activity comprising leakage reduction, metering and water efficiency.

In accordance with the Levels of Service, 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 and activities is commensurate with increasing risk to security of supply, as defined operationally by the Drought Event Level (DEL), which escalates incrementally from DEL1 through to DEL4 as the drought worsens.

Table B Demand-side measures

Measure	Description of measure	Drought Event Level (DEL)	Company Level of Service	Additional comments
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	These activities will escalate over DEL1 and DEL2 .
Sprinkler and unattended hosepipe ban	Sprinkler and unattended hosepipe ban	DEL2	Level 2	Would normally be introduced at the same time as the enhanced media/water efficiency campaign. Net effect is to reduce peak demand.
Temporary Use Ban (formerly Hosepipe ban)	11 categories of use (largely domestic) banning the use of a hosepipe.	DEL3	Level 3	If predicted, the protocol will combine this measure with sprinkler ban. Net effect is to reduce peak demand.
Drought Direction 2011 measures (formerly non-essential use Ordinary Drought Order)	Application to Defra to grant all 10 categories of non-essential use restrictions affecting commercial businesses.	DEL 3 or 4	Level 3- if enacted	
Emergency Drought Order	Application to Defra to grant an emergency drought order, including rota cuts and stand pipes.	DEL4	Level 4- if enacted	

Water use restriction legislation introduced in 2011 - Temporary Use Ban

The Temporary Use Ban replaced the previous hosepipe ban legislation from 1945 and has a much wider scope of restrictions that can be controlled by water companies. In all, eleven categories of use 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:

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;
6. drawing water, using a hosepipe, for domestic recreational use;
7. filling or maintaining a domestic pond 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.

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). The most notable and important change under the Temporary Use Ban legislation was ~~is~~ the definition of 'garden', which was greatly widened to include:

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.

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.

Temporary Use Ban – Implementation policy

The Company's 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.
- Findings from the customer research survey.
- Clarity of message - consistent with Thames Water's 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.
- Consultee representations from the December 2011 public consultation process and ongoing stakeholder dialogue.
- Experience of implementing a Temporary Use Ban in 2012.

Phasing

The Temporary Use Ban legislation includes an option for phased implementation of the possible prohibitions.

Thames Water does not propose any phasing to the imposition of the eleven categories of use as set out in the TUB. However, dependent upon the Drought Event Level assigned, not all of the categories of use will be prohibited in any one year. As part of a Drought Event Level 2, DEL2 (see Table 10) an unattended hosepipe and sprinkler ban is likely to be enforced (see Table 15), with authorisation given through the Temporary Use Ban legislation, see Section 5.4.1. This level of water use restriction would be consistent with Level 2 of Thames Water's Levels of Service, that is to say, a drought of severity with an occurrence no more frequent than one year in ten on average.

A more severe drought of frequency of occurrence at least one year in twenty on average would be designated a DEL 3 event. As part of a DEL3 (see Table 10), the introduction in a single phase of all eleven categories of use as set out in the legislation is considered to be the most appropriate way for Thames Water to implement the Temporary Use Ban measures. A single phase would help to maximise water savings as well as send out a strong simple message that the situation is worsening. In practice, because a combined Level 1 and 2 Media Campaign (see Table 15) would be introduced well in advance to prepare the way for the Temporary Use Ban, customers would not experience an abrupt start to restrictions.

The Drought Event Level is a function of the prevailing and potential water situation (Section 4.3.3.3) 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. Therefore, unless the dry period is exceptionally long, extending well into the next winter recharge period the following autumn, it is very unlikely that a DEL2 involving an unattended hosepipe and sprinkler ban would be followed by a DEL3 involving the full eleven Temporary Use Ban restrictions within the same year.

Exemptions

The following will be exempted from the Temporary Use Ban restrictions:

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 (n.b. a list of sporting events exempt under a TUB or DD11 will be published on the Thames Water website during a drought and will be 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:

vi) 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 a 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.

Exemption i) is included to help to ensure that, as stated in the Temporary Use Ban legislation, the use of a hosepipe for the purposes as stated for health and safety reasons is not restricted.

Exemption ii) will apply to Blue Badge holders engaged in the following two categories of use:

- Category of use 1): Watering a garden using a hosepipe (including an allotment), and
- Category of use 3): Watering plants on domestic or other non-commercial premises using a hosepipe.

This exemption is intended to allow people who are disabled or physically impaired to continue to use a hosepipe in their own garden who would otherwise find difficulty in carrying a watering can. Exemptions i), ii) and iv) will be allowed to run throughout the drought event.

Exemptions iii) and vi) are intended to alleviate the potential hardship a Temporary Use Ban and DD11 could have on some businesses, particularly the smaller businesses whose income is derived from a single or limited number of activities. However, this exemption will be withdrawn if and when DD11 measures are imposed. The rationale for such phasing of the commercial users exemption is to enable it to run for a reasonable length of time before banning the activity in line with the DD11 measures. If the drought has become sufficiently serious as to introduce such measures then it could be reasonably argued that the exemption applied to commercial users should be lifted. On the other hand, it is felt that the physical impairment and disability exemption should remain in place throughout the drought event because the reason for its implementation still remains.

- Exemption iv) is an exemption that arose from the Company's internal review of its implementation policy as part of the consultation/response during the drought of 2012. Given that events of national or international importance can take place throughout the year and they will be of a limited number, this exemption will run throughout a drought event.
- Exemption v) is an exemption that arose from the December 2011 consultation process and from otherwise ongoing stakeholder dialogue. The EA has accepted the inclusion of this exemption provided the opportunity was taken to gather information on its effectiveness. Consequently, Thames Water and the other companies exempting drip irrigation plan to work with Waterwise during a drought to monitor results and build the long-term evidence base of the savings delivered. As with Exemption iii) & vi), this exemption will be lifted if and when DD11 measures are introduced.

Insofar as exemptions iv) and v) were supported by customers, the proposed approach is consistent with the findings from the customer survey. These exemptions represent an approach that minimises any complication to the message to customers and which is consistent with the 2nd principle of proportionality in the Code of Practice. That is to say, it can be shown that together, all the exemptions do not constitute a significant reduction in the potential water savings, but not including the exemptions could mean loss of livelihood in the case of affected commercial customers and undue personal hardship in the case of people with health impairment or disability. 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.

Legislation revised in 2011 - Drought Direction 2011 (DD11)

DD11 (replacing the Drought Direction 1991) sets out the categories of use that can be prohibited in an ordinary drought order. These are usually referred to as the "non-essential use bans" and 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.

Statutory health or safety exemptions apply to some of the categories of water use.

This is a more extensive list than existed prior to 2011 and seeks to reduce commercial and industrial water use through the legal mechanism of 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.

DD11 - Implementation policy

In good time prior to a DD11 order application, Thames Water 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. As for Drought Plan 2010, Thames Water has selected a 10 week minimum period to allow for the submission to granting or otherwise of the drought order application.

Because of the serious conditions of drought severity under which the Thames Water would consider DD11 restrictions, all ten measures would be applied for to the Secretary of State.

Leakage and Water Efficiency

During the course of a drought leakage reduction activities and the promotion of water efficiency can to some extent be enhanced. However, enhancement of the installation of metering over and above the ongoing programme is not regarded as effective, efficient or flexible during the relatively short duration of a drought event.

S2.6 Supply-side measures

The full range of supply-side measures can be categorised into:

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

With the notable exception of drought permits/orders, supply-side measures are not part of the Levels of Service (see Table A above) but rather are measures that are introduced by the Company during the course of a drought to increase the amount of water available for supply.

Optimisation of existing sources

Thames Water's policy is to optimise the use of existing sources such that those that are most resilient to drought conditions are used preferentially. In general, this means that in London and SWOX WRZ, full use of groundwater sources would be made in order to conserve reservoir storage.

Strategic schemes

This section should be read in conjunction with the Addendum at the start of the document.

London WRZ relies on the WRZs introduction of strategic schemes (Table C below) which can provide 430 Ml/d to London's supply capability thereby helping to off-set the depletion of surface water resources during drought. With the exception of the West Berkshire Groundwater Scheme (WBGWS), these supply-side options are triggered by the naturalised flow above Teddington Weir receding down to 3000 Ml/d on average for 10 days during the course of a drought event (defined as having a Drought Event Level (DEL) equal to or greater than DEL1) and reservoir storage levels having fallen to the 800-700/600 flow requirement at Teddington Weir. The WBGWS is triggered by London reservoir storage drawing down to the Level 2 control curve on the Lower Thames Control Diagram (LTCD).

Table C Strategic schemes for London WRZ

Scheme	Benefit Ml/d
North London Artificial Recharge Scheme (NLARS)	220 to 156
Hoddesden Transfer scheme	12.5
Thames Gateway Water Treatment Works (TGWTW)	Up to 150
West Berkshire Groundwater Scheme (WBGWS)	123 to 66
Small scale groundwater schemes • ELRED, Stratford Box and Old Ford • Chingford Artificial Recharge Scheme (CHARS)	 27.8 15.1 to 10.6

Bulk supplies

Bulk supplies are transfers of either raw or treated water exported or imported between neighbouring Water Company areas.

Within the Thames Water supply area, the majority of bulk supply options are in the London WRZ. Due to the fact that most of the bulk supply agreements were drawn up at a time when London tended to have a surplus during times of raw water scarcity, there is a net export of water to surrounding companies.

Table D sets out the current bulk supply agreements for London WRZ. 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 such that 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. Thames Water will endeavour to assist other water companies in the situation where its 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 company areas may be at greater risk.

Table D London WRZ - Current Bulk Supply Agreements

Imports	Exports
None	Essex and Suffolk Water - 91 Ml/d 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 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. There is agreement to reduce export by 25% where Thames Water has implemented Temporary Use Ban restrictions and Essex and Suffolk Water has 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; agreement exists for supply to Affinity Water's South WRZ area from Kempton Park but can be reduced to 0 Ml/d during drought.
	Sutton and East Surrey Water Company (S&ES) - agreement exists to supply up to 13.6 Ml/d. S&ES 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 the Company's existing sources that is outside of the conditions stated in the relevant abstraction licence. Drought permits are grouped into Category 1 and Category 2, the former being considered less environmentally damaging than the latter and therefore more likely to be implemented before the latter. The EA is responsible for granting a drought permit and, in so doing, it must be satisfied that the benefits to supply outweigh the environmental impacts and that the Company has implemented demand-side measures such as a Temporary Use Ban.

Drought permits would generally be implemented at Level 3 of the Company's Levels of Service. As a working rule, the plan assumes a three month preparation period prior to the need for implementation of drought permits, although the less environmentally sensitive options are likely to require less lead time.

Environmental Assessment Reports (EARs) and preliminary Environmental Assessment Reports (pEARs) were reviewed and updated to accompany potential drought permit options in 2012. All EARs and pEARs have been further updated for the 2016 Drought Plan to take into account further data collected since 2012 and any revisions to the assessed impact of the Drought Permit options. The updated EARs and pEARs have been prepared in accordance with Government regulations and good practice guidance, including the EA Drought Plan Guideline updated in 2016. Thames Water has liaised closely with the EA to ensure it is satisfied with the approach and outcomes of the EARs reports.

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

Whilst drought permits are part of the supply-side measures for all WRZs, they are particularly important for maintaining security of supply during extreme drought periods in SWOX and Kennet Valley WRZs.

Recommissioning

With only a few notable exceptions, a majority of Thames Water's licensed sources are fully utilised. There are a few sources that are not in regular use generally because they are not cost-effective to operate or have water quality problems. Where there is the potential for a source to be recommissioned during a drought, these sources have been included as drought options.

In extremis options

These are options that would be considered beyond DEL3 where relevant and include: tankering of raw water supplies, reduction in bulk supplies, temporary desalination units, temporary potable reuse units and alternative sources for non-potable use.

S2.7 Communications Strategy

The plan's communications strategy recognises the importance of keeping customers and stakeholders well informed before, during and after a drought event. Therefore clarity of communication to customers on the actions proposed during a drought is of great importance. In this respect the protocols will provide a clear course of action to be communicated from the onset of a drought.

Customer research conducted in June and July 2011 sought views and attitudes on the water restriction measures within the Temporary Use Ban and Drought Direction 2011 legislation, 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 2016 and so are retained as key features informing the communications plan.

The main findings in respect of key learning points for customer communication have been incorporated into the communication plan, however, the overall conclusion is that the media campaign should start well in advance of any imposition of restrictions and it should focus on setting out clearly the measures that are likely to follow.

As a drought is unlikely to be limited to the Thames Water operating area, it is important that Thames Water works together with other water companies in the region to align communications, as was done successfully in 2012. Water UK will be an important link in this process. To aid customer communications a joint statement has been prepared for the purpose of explaining to customers the reasons for possible differences between companies in the application of water use restrictions.

To gain maximum coverage, communication throughout the drought event will be primarily based on public information through our media relations. 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. The Company's website will be used for regularly updating drought-related information and provide water efficiency advice as well as featuring special events or publicity as and when required. Social media, including Twitter and Facebook, will be used alongside media and web communications channels to reinforce drought messages via digital media. Links to other relevant sites of interest would also lead to a wider recognition of working in partnership with key stakeholders and regulatory bodies.

Thames Water will work closely with the EA in all aspects of managing its plan. During the course of a drought event the EA will fulfil technical, advisory and regulatory roles including the provision of important hydrological data, drought order/drought permit applications and the operation of the Lower Thames Operating Agreement (LTOA). The Company will also consult with the EA in regard to the operating agreements for its water resource schemes, for example for the switch on of NLARS or the TGWTW desalination scheme.

Other key stakeholders include Defra, Ofwat, DWI, Natural England and CCWater. Where necessary these organisations will be consulted and informed on the development of the drought situation and proposed measures. Thames Water will be proactive in its 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.

S2.8 Effectiveness of the Drought Plan

For the Drought Plan to be considered effective and fit for purpose, the Company considers 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;
- timely and clear communication to customers and stakeholders.

A reliable assessment to show that the measures being either considered or actually implemented are consistent with the Company's Levels of Service. The effectiveness of the drought protocols for each of the six WRZs has been tested for flexibility and robustness using a stochastic drought generation assessment. This approach is following Environment Agency guidance and generates droughts of greater severity than those in the historic record.

Thames Water has 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 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.

For the London and SWOX WRZs the drought risk is dominated by surface water vulnerability, so for these two WRZs the assessment concentrates exclusively on the two major surface water systems; the London reservoirs and the SWOX Farmoor reservoir. Because of this dominance and 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 300 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 seen in the historic record. However these scenarios highlight the reliance on drought permits and/or orders for extended periods of time. This reliance on such long durations of drought permit installation or operation would potentially have a significant adverse impact on the environment and so indicate that to meet the challenge of 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 addition, the reliance on Drought Orders to restrict non-essential commercial water use over an extended period is likely to have a significant adverse impact on small businesses and wider costs to the economy.

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 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 installation or operation would potentially have a significant adverse impact on the environment and so indicate that to meet the challenge of 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, S/W/A and Henley WRZs against more severe droughts as required by the guidance. However, because rainfall-runoff models were not available for the two key main surface water resources in these WRZs (the River Kennet at Theale and the River Wey at Tilford), a fully stochastically based analysis, as carried out for the London reservoirs, could not be carried out. However, by using Extreme Value Analysis (EVA), based on the rainfall and Potential Evapotranspiration (PET) outputs from the stochastic weather generator, it was possible to analyse the severity of the simple generated events which were included in the 2013 Drought Plan. The results of the EVA analysis for the Kennet Valley, Guildford, S/W/A and Henley WRZs indicate that the drought scenarios that have been tested as part of the 2013 Drought Plan are extremely severe. The surface water and groundwater sources therefore appear to be very resilient to drought risk under the current climate within these WRZs with the Drought Permits in operation.

S2.9 Conclusions

This draft Drought Plan has been prepared to ensure Thames Water is able to manage water resources effectively and provide a secure water supply to customers in drought periods. It complies with requirements under s39B of the Water Industry Act 1991 (WIA), as introduced by the Water Act 2003 and has been produced in line with the Drought Plan Regulations 2005 and the EA's Drought Plan Guidelines (How to write an publish a drought plan' – July 2016).

This draft Drought Plan retains the methodologies and protocols given in the Drought Plan 2013.

In developing its approach for the legislative powers introduced in 2011 Thames Water has endeavoured to adhere to a balanced approach based on a sensible application of UKWIR Code of Practice guidelines, in particular, the 2nd principle of proportionality. Important factors also taken into account were the findings from the customer research survey, clarity of message and consistency with neighbouring water companies.

Incorporating the new powers into the Plan has 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 Thames Water's 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 (WRSE).
- Consultee representations from the December 2011 public consultation process and ongoing stakeholder dialogue.

Thames Water proposes to introduce all eleven categories of use of the Temporary Use Ban legislation in a single phase as part of Level 3 of the Company's Levels of Service. However, within this set of restrictions, exemptions will be allowed for:

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 (n.b. a list of sporting events exempt under a TUB or DD11 will be published on the Thames Water website during a drought and will be 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.

vi) 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.

Exemptions i), ii) and iv) will be allowed to run through the drought event.

However, exemptions iii), v) and vi) will be removed if and when DD11 measures are introduced.

The new exemptions were supported by customers and their inclusion in the implementation policy represents an approach that minimises any complication to the message to customers and which is consistent with the 2nd principle of proportionality in the Code of Practice. 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.

DD11 restrictions broadly 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 uses in a single phase.

Thames Water has undertaken a Strategic Environmental Assessment (SEA) for its draft Drought Plan but does not consider that it is a statutory requirement that an SEA is completed. However the SEA has been undertaken in order to provide a formal review of the environmental impact of the options for drought management included within its 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. Thames Water has also undertaken a Habitats Regulations Assessment (HRA) of its draft 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 has been ~~was~~ incorporated into the Drought Plan Appendix C tables and used, together with operational considerations, to prioritise the options for implementation in a drought.

The methodologies and associated protocols for each WRZ are fundamentally the same as for Drought Plan 2013. The methodology for the SWOX protocol includes a trigger for initiating the DD11 order and drought permit applications based on the River Thames flow at Farmoor.

The Drought Plan Guidelines requires companies to test their Drought Plans against a range of droughts of greater severity than in the historic record although the severity is not specified. A comprehensive study has been undertaken describing our current level 4 protection as equivalent to a 1:125 year drought. Further extreme droughts have been described, focusing detail on the London and SWOX WRZs. It was demonstrated that all 6 WRZs are shown to demonstrate robustness against more extreme droughts, although at levels that are considered

unsuitable for future Drought Plans and Water Resources Management Plans, given the forecast future impacts of population growth and climate change. The impact on the environment was much greater. The WRMP19 will include measures to address this.

The methodologies and associated protocols have been shown to be fit for purpose under the extreme and severe droughts generated using stochastic modelling, equivalent to 1:300 and 1:500 drought scenarios and the extended 1976 scenario. All six Water Resource Zones were shown to demonstrate their adherence to the effectiveness criteria and in all cases, the protocols triggered the appropriate demand and supply measures sufficiently early to maximise their benefit and provide adequate lead in times for subsequent more stringent measures, thereby averting Level 4 emergency measures.

The London WRZ proved to be robust even without the need to employ drought permits for the existing record, but for the stochastically generated more severe droughts, drought permits are required to avoid level 4. However it is anticipated from initial assessments that this would lead to potentially unacceptable damage to the environment and impacts on small businesses. The London protocol initiates a company-wide set of demand management measures at an early stage in the 1976 test scenario. 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 Drought Direction 2011 order and drought permits enabling sufficient lead in time for determining these orders.

For the London and SWOX WRZs the drought risk is dominated by surface water vulnerability. Unlike the other WRZs, no analysis of groundwater drought vulnerability was carried out. 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. This reliance on such long durations of drought permit implementation would potentially have a significant adverse impact on the environment and so indicate that to meet the challenge of very severe droughts in the future greater resource development is required in order to protect the environment from 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 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 potentially 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, S/W/A and Henley WRZs against more severe droughts as required by the guidance. The results of Extreme Value Analysis for these WRZs indicate that the drought scenarios that have been tested are extremely severe. The surface water and groundwater sources therefore appear to be very resilient to drought risk under the current climate within these WRZs with the implementation of the drought permits.

Section 1. Regulatory Requirements

1.1. Introduction

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 'How to write an publish a drought plan' – July 2015, referred to herein as 'Drought Plan Guidelines').

Thames Water last updated its Drought Plan in 2013 to include:

- new legislative powers arising from the Flood and Water Management Act 2010 and further prescribed by the Water Use (Temporary Bans) Order 2010 (referred to herein as Temporary Use Ban or 'TUB') and the Drought Direction 2011 (referred to herein as DD11). These respectively replaced the historic hosepipe ban and non-essential use ordinary drought order restrictions. A particular concern raised by Defra in its initial guidance on implementing the new powers was the risk of confusion for customers in neighbouring areas where different approaches are taken by water companies to drought management. The Minister asked if consideration could be given to how such confusion might be avoided.
- amendments responding to comments received from the EA on Thames Water's 2010 Drought Plan; and
- amendments to comply with the EA Drought Plan Guidelines (2011) 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 in 2013 and these are retained for the draft Drought Plan 2016.

1.1.1. Commercial Confidentiality

In Thames Water's opinion there are no commercial confidentiality issues associated with the Drought Plan.

There are 3 licensed water suppliers that supply water or treat waste to premises in the Thames Water supply area via the Thames Water supply system, these are:

Inset Provider	Inset Site	Water/Waste
Scottish and Southern Energy Water Limited	Hale Village	Water & Waste

Scottish and Southern Energy Water Limited	Bromley Common, Kent	Water & Waste
Scottish and Southern Energy Water Limited	Park Views, Epsom	Waste only
Scottish and Southern Energy Water Limited	Kingsmere, Bicester	Water only
Scottish and Southern Energy Water Limited	Great Western Park, Didcot	Water & Waste
Scottish and Southern Energy Water Limited	New South Quarter, Croydon	Water & Waste
Scottish and Southern Energy Water Limited	Barking Riverside	Waste only
Scottish and Southern Energy Water Limited	Kennet Island Phase 5,6,7&8	Water & Waste
Scottish and Southern Energy Water Limited	Marine Wharf	Water & Waste
Scottish and Southern Energy Water Limited	Riverlight	Water & Waste
Scottish and Southern Energy Water Limited	Heart of Greenwich	Water & Waste
Scottish and Southern Energy Water Limited	Embassy Gardens	Water & Waste
Independent Water Networks Limited	The Bridge, Darford	Water & Waste
Independent Water Networks Limited	Berryfields (Phase1 and 2), Aylesbury	Water & Waste
Independent Water Networks Limited	Kings Cross, London	Water & Waste
Independent Water Networks Limited	Greenwich Millenium Village	Water & Waste
Independent Water Networks Limited	Forgewood (Formerly NES Crawley)	Waste only

Albion Water	Rissington Camp Phase 1 and 2	Water

1.1.2. National Security

With respect to National Security, Thames Water has followed the guidance outlined in Defra SEMD Advice Note AN/11 Ed5: The Control of Sensitive Water Company Security Information. The Advice Note states that certain information "must not" be published and covers information that would be of interest to terrorists or those with malicious intent because it provides useful targeting information. As such, information referenced in this advice note cannot be placed in the public domain. Appendix M has been redacted, this appendix relates to the preliminary Environmental Assessment Reports (pEARs) and detailed 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.

1.2. Public Consultation

1.2.1. 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 Regulations 2005 (the Regulations).

Thames Water has 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 (Affinity Water, Sutton and East Surrey Water, Essex and Suffolk Water, Southern Water and South East Water) and the Consumer Council for Water. Thames Water has taken into account responses received as a result of this pre-consultation in the preparation of the Draft Plan.

1.2.2. Publication process

By 1st October 2016, this draft plan will be 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 will notify Thames Water on any decisions made in respect to national security or commercial confidentiality and direct the Company to make the appropriate amendments before it proceeds to publish its draft plan.

Thames Water will then publish the draft plan on its website and in paper form. A 12 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 Thames Water. The Company will assess the representations and produce a statement of response detailing any changes it has made to the draft Drought Plan as a result of the representations and the reasons for these changes. Conversely, where changes have not been made as a result of the

representations, it will explain why not. The statement of response will be published on the company website and those who have made representations will be notified that the statement has been published.

Thames Water will prepare the final draft taking into account any directions received from the Secretary of State and the Environment Agency will check the plan to ensure it complies with directions. The final Drought Plan will be published to the same requirements as the publication of the draft Drought Plan.

Website

The Final Plan and a copy of the summary version of the Final Plan will be available on the Thames Water website.

1.3. Defra Directions 2007

In July 2007 Defra wrote to all water undertakers setting out final Directions for drought planning. These Directions required the following:

1. The inclusion of environmental reports for each drought order and permit sites to ensure applications are processed as quickly as possible.

2. Under section 37B(9) of the Water Industry Act provide the Secretary of State with any information considered to be commercially confidential and the names and addresses of the person(s) involved so that they can be contacted to provide a reasonable opportunity to object.

3. Under section 37B(10), it is for the Secretary of State to identify any information contained in the final Drought Plan that should be excluded from the final published plan on the grounds that its publication would be considered contrary to the interests of national security.

4. Although not subject to Direction it is recommended that the final plan should include:

    a. Telling people about the impact of drought on water supply so that they understand the need for measures necessary to minimise the risk to security of supply.

    b. Testing the plans against a range of droughts to demonstrate their robustness.

These Directions from Defra have been retained in the current draft plan and the plan also retains a number of changes arising from the requirements of the Flood and Water Management Act 2010 (FWMA 2010), these are described in the following section.

1.4. Additions and amendments to Drought Plan 2010 retained for Drought Plan 2016

1.4.1. New Legislation on water use restrictions

1.4.1.1. Consultation process

Thames Water's Drought Plan 2013 incorporated reviews and updates to comply with Defra's request to ensure the Plan takes account of the new powers arising from the Flood and Water Management Act 2010 (FWMA 2010) and further prescribed by the Water Use (Temporary Bans) Order 2010 (referred to herein as the Temporary Use Ban). Additionally, Drought Direction 2011 (DD11), which updated the legislation on the Ordinary Drought Order to ban non-essential use, was also considered in parallel with the Temporary Use Ban powers to produce Thames Water's implementation policy of the new legislation, see Section 5 and Appendix L.

In drawing up the implementation policy, the associated consultation process ~~has~~ involved:

- Defra/EA guidance.
- UKWIR Code of Practice (Reference: WR33-Code of Practice and Guidance on Water Use Restrictions 2011) generally and in particular adherence to the 2nd principle of proportionality.
- Findings from customer research survey.
- Clarity of message - consistent with Thames Water's 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 L4.
- Consultee representations from the December 2011 public consultation process and ongoing stakeholder dialogue.
- Experience of implementing the Temporary Use Ban in 2012.

1.4.1.2. Implementation policy

In regard to the Temporary Use Ban powers, Thames Water's Plan proposes to introduce all eleven categories of use (see Section 5) in a single phase that will replace the previous hosepipe ban restrictions as part of Level 3 of Thames Water's Levels of Service (see Section 3). However, within this set of restrictions, the following exemptions will be made for:

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. (n.b. a list of sporting events exempt under a TUB or DD11 will be published on the Thames Water website during a drought and will be 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.

vi) 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.

Exemptions i), ii) and iv) will be allowed to run through the drought event.

Exemptions iii), v) and vi) will be removed if and when DD11 measures are introduced.

The new exemptions were supported by customers (Appendix L3) and their inclusion in the implementation policy represents an approach that minimises any complication to the message to customers and is consistent with the 2nd principle of proportionality in the Code of Practice. It is considered that the exemptions would also be acceptable to the rest of the companies in the South East, and is broadly consistent with the companies imposing similar exemptions.

DD11 restrictions will replace the previous ordinary drought order for banning non-essential use as part of Level 3 of Thames Water's Levels of Service. It is proposed to apply to Defra for granting the introduction of all ten categories of uses in a single phase.

An account of the consultation process leading up to the implementation policy and the rationale behind the policy is given in Appendix L.

In addition to the exemptions set out above Thames Water would also consider the following exemptions dependent on the severity of the drought:

Additional TUB exemptions on a) water efficient drip irrigation; b) watering of newly laid turf and planted trees for a period of 28 days after planting; c) the use of a hosepipe to water areas of grass for use for sport or recreation where this is in connection with national or international sports events.

The material changes to the draft Drought Plan came from an internal review which was held alongside Thames Water's consideration of the Stakeholder and Environment Agency responses.

1.4.1.3. Water Companies in the South East

Defra's concern on the risk of confusion to customers in neighbouring areas, see Section 1.1, was, at least, partly addressed in 2012, by the agreement made with other water companies in the South East to publish a joint statement explaining to customers the reasons why company plans may differ in respect of implementing water use restrictions, Section 7.4.3. This joint statement has been retained as an example of what is likely to be used in future droughts that affect the wider South East.

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

In preparing the draft Plan there has been systematic liaison with the EA. The principle change to the Drought Plan has been the introduction of testing of the plan against more severe drought. Thames Water has undertaken this through the use of stochastic assessment of drought likelihood and this is covered in more detail in section 8. The liaison with the EA has included explaining in detail the approach adopted to the testing of more extreme droughts.

Thames Water has also added two new drought permit options to the Drought Plan, these are at Childrey Warren and Pann Mill both of which have been subject to sustainability reductions but are sites where support provides useful resilience in the event of a severe drought.

The Environmental Assessment Reports for each of the drought permit/ order options have been completed and the need for any changes discussed with the Environment Agency. Changes have been made to Appendix C which sets out the basis for the use of drought permit order options and their priority order.

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

Thames Water has undertaken a Strategic Environmental Assessment (SEA) for its draft Drought Plan, but does not consider that it is a statutory requirement that a SEA is completed. However the SEA has been undertaken in order to provide a formal review of the environmental impact of the options for drought management included within its 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[2]. An SEA Scoping Report was issued to the statutory consultees (Environment Agency (EA), Natural England (NE) and English Heritage (EH)) in July 2016. This provided an opportunity for the statutory consultees to provide views on the proposed scope and level of detail of the SEA Environmental Report. The Environmental Report will be published with the draft DP in 2016/17.

The 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. Thames Water also undertook a HRA of its 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 DP, 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) and preliminary Environmental Assessment Reports (pEARs) produced to accompany potential drought permit options were reviewed and

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

updated during 2016. Thames Water has worked closely with the EA to ensure they are satisfied with the approach and outcomes of the EARs/pEARS reports.

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

1.5. Review process

In line with regulatory requirements, the 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 Thames Water's drought management activities as well as any significant changes in its 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 the Drought Plan will be identified. The results of each annual review will be provided to the EA. If issues identified are deemed to constitute a material change, the Drought Plan will be revised in accordance with the procedure laid out in the Water Industry Act; the statutory consultation will be completed within 6 weeks and the revised Drought Plan will be submitted to the Secretary of State within 6 months of submission to the EA.

1.6. Material Changes Since the Last Drought Plan (2013)

Thames Water has made material changes to the Drought Plan through the addition of two Drought Permit options at Childrey Warren and Pann Mill and has modified the options at Ogbourne and Axford following licence reductions that have been implemented at these sites. We have also carried out detailed analysis of more severe droughts using a stochastic approach, details of this can be found in Section 8.

Section 2. Water Supply in the Thames Catchment and Drought

2.1. Water supply and the importance of groundwater

Approximately 80% of Thames Water's water supply is derived from surface water abstraction (largely from the upper and lower 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.

The major aquifer systems that contribute to the baseflow in the River Thames are:

- Great and Inferior Oolites of the Cotswolds.
- Chalk of the Marlborough Downs.
- Chalk of the West Berkshire Downs.
- Chalk of the Chilterns.
- Lower Greensand of the Guildford area.
- Chalk of the Hampshire Downs.
- Chalk of the North Downs.
- Thames River Terrace Gravel Deposits.

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). 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. From 1900 onwards four drought periods standout as being the worst in terms of their impact on London's water resources, which is assessed by the mean flow over Teddington Weir over the critical period of the drought (see Section 4). In chronological order, these are:

- 1920/1921 – rainfall second only to 1975/6 in terms of 12 month deficiency over the critical period; particularly severe groundwater drought; severe runoff deficiencies.
- 1933/1934 – a protracted 2 year drought.
- 1943/1944 – notably low 12-18 month rainfall moderated by very wet January 1943.
- 1975/1976 – extremely severe in rainfall, runoff and groundwater terms, but bracketed by wet conditions and some residual benefit from heavy groundwater replenishment in winter 1974/75.

All four droughts were characterised by a prolonged period of around 12 to 18 months of below average rainfall and they form the basis for deriving London's deployable output, see Section 3.

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.

Thames Water recognises 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 has been undertaken for the Drought Plan 2017 and 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. Hydrometric monitoring

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. For Thames Water's water supply area the essential data requirements are as follows:

- Daily measurements of London and Farmoor total reservoir storage.
- Riverflow 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, such that the extent of the potential drought can be assessed and decisions made on the required event status.

2.5. Water Situation Report (WSR)

Thames Water's monitoring of the water situation includes the production of a Water Situation Report. This report is produced on a monthly basis during periods of normal resource availability and weekly during drought periods. The report provides information and statistics covering the key water resources variables for management during drought:

- 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.

An increased frequency of data tracking and analysis will also be implemented for sources whose abstraction licences have conditions that reduce abstraction under conditions of low river flows. Particular key examples in the Thames Valley are Farmoor, constrained by flows in the River Thames and Pangbourne groundwater source, constrained by flows in the River Pang.

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

2.6. Groundwater monitoring

One of the lead indicators of the onset of drought conditions is the hydrological status of the catchment, with particular focus on groundwater levels. As described above in sub-section 2.2, 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.

Thames Water has a number of groundwater level observation boreholes (OBHs) equipped with data loggers in its water supply area. Under normal (i.e. non-drought) operating conditions, Thames Water collects groundwater level data from the data loggers approximately every 3 months as part of a rolling programme of monitoring.

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 OBHs. Thames Water 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 by Thames Water will increase.

2.7. Summary

During periods of drought Thames Water's 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.

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 geological nature of the upper Thames. 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 why Thames Water has not introduced water use restrictions but other neighbouring companies have done so.

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.

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.

Section 3. Water Resource Strategy and Drought Management

3.1. Consistency between the Water Resources Management Plan (WRMP) and the Drought Plan

A WRMP is a supply-demand plan that sets out what a water company needs to do to maintain its planned Levels of Service over a 25 year timescale. Within a WRMP, supply capability is evaluated under drought conditions; correspondingly, demand is assumed to be that which would be experienced for a dry year. Consequently, a water company's performance during drought, that is to say, its conformance to its stated Levels of Service, is a direct reflection of the combined effectiveness of its WRMP and Drought Plan.

Thames Water's water resource strategy and plans for the AMP6 period (2015-2020) are contained within its Final Water Resources Management Plan (WRMP14) published in July 2014. The WRMP14 includes the planned measures to be implemented during the AMP6 period but also includes a water resource strategy for the full 25 years planning period. The plan is based on a twin-track approach of demand management measures together with timely development of new sources of supply in order to ensure a positive supply/demand balance. The WRMP is available on our website. Thames Water's draft water resource strategy and plans for the AMP7 period (2020-2025) will be submitted to Defra in December 2017. The WRMP will set out measures to provide security of supply for 25 years or longer as requested in the current WRMP guidelines; the length of the planning horizon is dependent on the complexity of the supply demand characterisation in each WRZ.

With the aim of maintaining security of supply which ultimately means minimising the need for emergency drought measures, a Drought Plan sets out how a Water Company will manage supply and demand during the course of a drought. Consequently, this duality between Drought Plan and WRMP implies that wherever practicably possible the two sets of plans should be based on the same operational and planning assumptions. This means that, as for the WRMP, the fundamental basis for the Drought Plan is Thames Water's security of supply and its planned Levels of Service for water supply.

3.2. Levels of service

Both the Drought Plan and WRMP are based on the following principles:

- The need to maintain security of supply for our customers.
- The level of restrictions imposed on customers is commensurate with Thames Water's Levels of Service (LoS).

The planned Levels of Service for water supply restrictions adopted by Thames Water are set out below in Table 2; note that: under Level 4, 'never' means that, providing future droughts are no more severe than the most severe in the historic record over which London's supply capability has been simulated, extreme restrictions will not be required and Thames Water would never plan to include this measure as part of its operating strategy. Thames Water has tested its 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.

Table 1 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	Sprinkler ban, enhanced media campaign
Level 3	1 year in 20 on average	Temporary Use Ban (formerly Hosepipe ban), Drought Direction 2011 (formerly non-essential use bans) requiring the granting of an Ordinary Drought Order
Level 4	Never	If extreme measures were necessary (see Sections 5.7 and 6.8) their implementation would require the granting of an Emergency Drought Order

3.3. Thames Water's Water Resource Zones

Supply demand planning and thus drought planning starts at the water resources zone (WRZ) level. A WRZ is defined in the EA's Water Resource Planning Guideline as an area of well-integrated water supply connectivity in which there is the same risk to security of supply. For water resource planning purposes the Thames Water water supply area is divided into six independent WRZs, see Appendix A. This disaggregation into six discrete zones reflects the different characteristics of the supply areas and associated risks of meeting demand within the Thames Water area.

The London WRZ is the largest of the six zones and covers the Greater London area. The next largest is the Swindon and Oxfordshire zone (SWOX). The water resources for both of these zones are in large part based on abstraction of water from the River Thames, which is stored in large raw water reservoirs. The other zones within the Thames Valley are Kennet Valley (including Reading and Newbury), Henley, Slough/Wycombe/Aylesbury (S/W/A) and Guildford.

3.4. Supply demand balance

For the purposes of supply-demand planning, water companies must plan for a dry year demand. This is the demand that would be expected during dry, hot conditions. In order to plan for this dry year demand it is necessary to understand the raw water availability during normal conditions and how this may be reduced during a range of different drought conditions. The amount of water resources available to maintain water supply during drought periods, with a given frequency of demand restrictions or supply interruptions, is termed water available for use which is defined as:

Water available for use = Deployable Output (DO) minus outages plus/minus bulk supply imports/exports into WRZ

Deployable Output is defined as 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

Outages are temporary reductions in DO, which can be caused by factors such as mechanical failure or pollution events. During drought it is clearly important that outages are minimal.

The frequency of water use restrictions defines the Levels of Service customers receive. The lower the level of service, the more frequent is the imposition of restrictions to reduce demand. Conversely, the higher the level, the less frequently they are required.

Within a given WRZ, the difference between water available for use and the dry year demand plus an allowance for planning uncertainties (Target Headroom) is referred to as the supply demand balance. Should the dry year demand plus Target Headroom exceed water available for use then there is a shortfall or deficit in the supply demand balance. The greater the deficit, the greater the risk that demand restrictions would need to be introduced more frequently than Thames Water's stated Levels of Service and ultimately the greater the risk to security of supply.

A fundamental assumption in Thames Water's WRMP is that the risk to maintaining Levels of Service is minimised when each WRZ is in supply demand balance.

The balance between supply and demand was reviewed for all our WRZs for the WRMP14 and is reported each year to the Environment Agency as part of the Annual Review process. The

London WRZ is now in balance and is forecast to remain so for the remainder of AMP6 although this is subject to significant risk because of the ongoing impacts of population growth and climate change. There is an increase in the surplus compared to the WRMP14 over the AMP6 period. This is due to an increase in the WAFU component and a smaller increase in the level of Target Headroom compared to the WRMP14. For the SWOX WRZ the balance using 2015/16 as the base year, shows that SWOX remains in surplus for the AMP6 period under both Annual Average and Critical Period conditions. There is a reduction in the surplus compared to the WRMP14 over the AMP6 period, except in the final year under the Annual Average scenario. This is due to a reduction in the WAFU component and an increase in the level of Target Headroom compared to the WRMP14. The maintenance of the supply demand balance is dependent upon the timely implementation of demand management measures and water resource development schemes during the planning period.

3.5. The importance of the London WRZ and the Lower Thames Operating Agreement

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

Some 80% of London's water supply is governed by abstraction from the River Thames and River Lee and the level of storage in London's reservoirs, the remainder being largely groundwater abstraction from the London Basin.

Fundamental to the operation of London's water supply is the control of abstraction upstream of Teddington Weir, 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 was originally formulated in 1986 by Thames Water Authority to manage the four-fold process of;

- 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;
- historic mechanism for managing Levels of Service by triggering water use restrictions through control curves (Levels 1-4); now superseded by the Revised Protocol introduced in Drought Plan 2010, which invariably triggers demand-side measures much earlier in a drought than the historic protocol, see Appendix E1 and Appendix F, Section 12.

The Lower Thames Control Diagram (LTCD), is the operating tool within the LTOA, which provides the day-to-day rules for managing this four-fold process. 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 noted above in bullet four and corresponding to Thames Water's Levels of Service, Table 2.

ypothetical reservoir storage curve

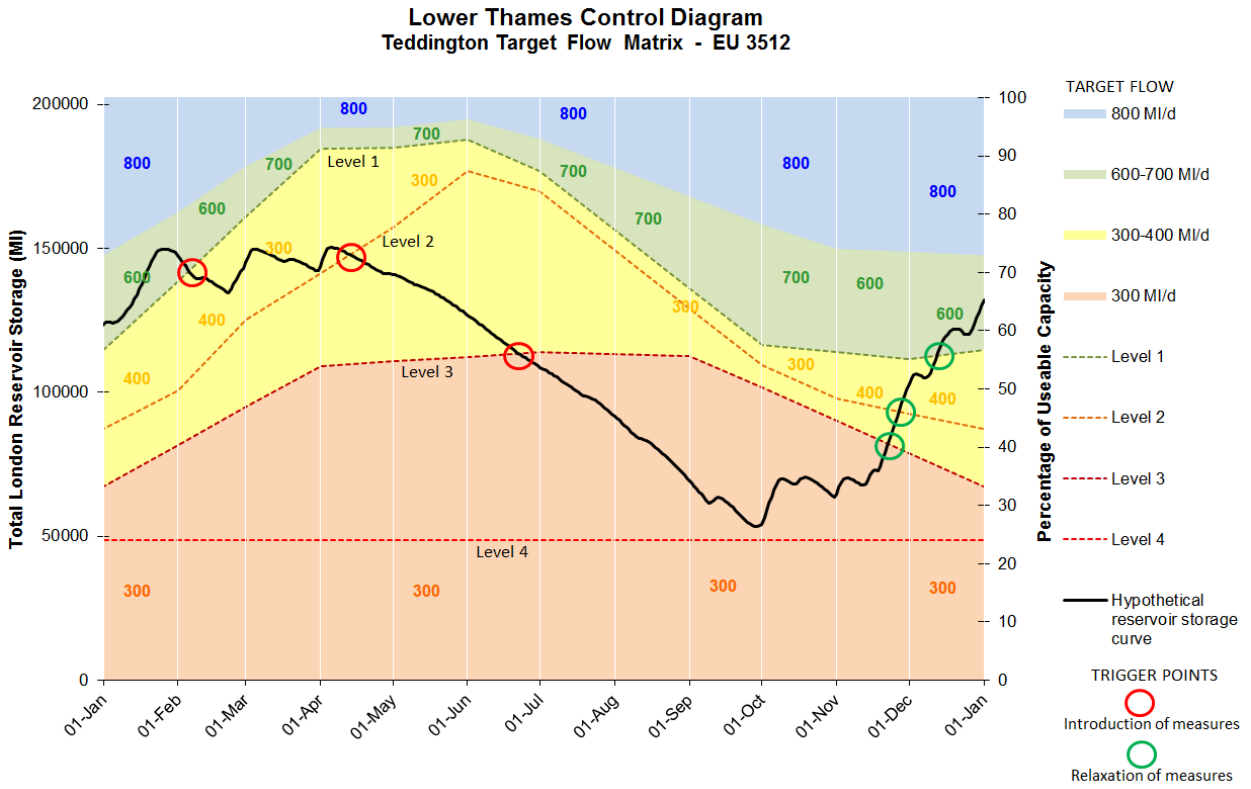


Figure 1b Revised Lower Thames Control Diagram (LTCD)

The LTCD is operated by plotting the total volume of water in storage in the Thames Water London reservoirs for every day of the year. The amount that can be abstracted within the licensed quantity is determined by the total flow at Teddington Weir minus the prevailing environmental flow constraint as given by where reservoir storage lies within the four minimum environmental flow zones (given by the blue, green, yellow and pink zones in Figure 1).

There is a direct correlation between the control curves on the LTCD and planned Levels of Service (Table 2) 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 Thames Water's 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.

- *Frequency of occurrence,* (Table 2, column 2) is a way of describing in probabilistic terms the severity of the water use restriction measure in question; the more severe droughts and associated measures occur less frequently. Related to this, is the term '*on average*' which is related to the historic period (1920 to present) over which London's supply capability is simulated in order to derive the deployable output, see Section 3.4. That is to say, over a statistically meaningful period of time, the drawing down of reservoir storage to meet any given control curve should not occur any more frequently than that stated for the frequency of occurrence in column 2 of Table 2.

Revision of the LTCD 2016

Since the last Drought Plan was issued an updated LTCD has been agreed with the Environment Agency, figure 1b. The LTCD had previously been updated in 1997, following operational experience of managing droughts which occurred in the mid-1990s. The latest review of the operating agreement for abstractions from the Lower Thames is timely in light of the recent legislative changes, the potential impacts of climate change, as well as improved hydrological and environmental information. The review of the LTCD also provided an opportunity to optimise water resources and deployable output (DO) in TW's supply area, and to reduce the environmental impact of the abstractions.

The review of the LTCD considered the environmental impacts of the abstractions to ensure environmental considerations were suitably accounted for in the optimisation process.

TW defined the environmental objectives as:

- No deterioration in the impact already associated with the Lower Thames abstraction licence (M2) and Lower Thames Operating Agreement (LTOA), and
- Opportunities for betterment i.e. reduction of impact.

TW proposed an approach to integrate environmental considerations into the wider optimisation process through consideration of the shape of the existing LTCD curves and amendment of the monthly Teddington Target Flow (TTF) values. The introduction of monthly TTF values are intended to reflect the flow thresholds and expected timings of environmental impacts and are based on key environmental factors identified in the LTOA environmental study [3]undertaken as part of the review. TW worked closely with EA colleagues to determine the environmental objectives for the LTCD and to develop the methodological approach. The environmental objectives were combined with the objective of maximising the deployable output for London using the LTCD to give a new set of optimised curves.

The revised LTCD makes an insignificant difference to Thames Water's operation during a drought and the key demand side and supply side measures are still required to be implemented at the earliest beneficial time in line with the Drought Management Methodology.

3.6. Abstraction Incentive Mechanism (AIM)

The Abstraction Incentive Mechanism (AIM) is a system introduced by Ofwat in 2016 and designed to incentivise water companies to use flexibility available within water resource zones, to reduce abstraction at sites perceived to be environmentally sensitive during periods of low flows. The system is designed to be implemented in the interim period, before abstraction reform is introduced after 2020.

Thames Water has selected a number of abstraction sources for implementation of AIM spread across our WRZs. The sources selected are New Gauge and North Orpington (London WRZ), Axford (SWOX WRZ), Pangbourne (Kennet Valley WRZ) and Pann Mill (S/W/A WRZ), see details in table 2. The AIM works by the abstraction being reduced through substitution to an alternative source when flows at a specified gauging point fall below a pre-defined trigger. These triggers have been set and agreed with the Environment Agency and are generally at low flows. The number of sources where AIM can be applied is restricted because in most cases for our sources it is not possible to reduce abstraction through use of an alternative and so there is very little flexibility to make abstraction reductions as part of normal operational practice. 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 2 AIM Sources

		Trigger (river flow)(Ml/d)	(a
A	**AIM sites**		
1	RIVER LEE AT NEW GAUGE PUMPING STATION POINT B	60	
2	PANGBOURNE	1.02	
3	AXFORD PUMPING STATION	166	
4	PANN MILL PUMPING STATION	5.6	
5	NORTH ORPINGTON PS	11.4	

3.7. Summary

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 Thames Water's Drought Plan is that the risk to Levels of Service is minimal when all WRZs are in supply demand balance. The balance between supply and demand has been reviewed for all our WRZs for WRMP14. London WRZ is in balance and is forecast to remain so within AMP6. The SWOX WRZ remains in surplus for the AMP6 period under both Annual Average and Critical Period conditions.

Because of its importance as the nation's capital and size of population, drought management of the London WRZ plays the central and pivotal role in the 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 LTOA which 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 initiating water use restrictions. This was done through the LTCD designed to trigger the drought measures corresponding to Thames Water's four service levels when reservoir storage drew down to intersect sequentially the Level 1 to 4

control curves. Under the current protocol the LTCD provides the definitive guidance for the latest time at which measures would be implemented. The LTCD has recently been updated to ensure it is fit for purpose in view of the legislative changes in the Flood and Water Management Act 2010 and the potential impacts of climate change. It also reflects the benefits of new hydrological information and ensures the optimum benefit to the environment and for water resources deployable output.

Section 4. Drought Management Methodology

4.1. Overview

Following the drought in 2006, Thames Water reviewed its drought management protocols and associated methodologies in line with revisions to legislation and drought guidance. This section describes the protocols for each of the six WRZs.

The incorporation of the enhanced restrictions stemming from the new legislation in 2011 has not produced a significant change in the way Thames Water manages drought. However, the SWOX WRZ protocol was amended in response to Defra and EA comments on Drought Plan 2010 to include a new trigger for initiating in a timely manner the DD11 order and drought permit applications based on the River Thames flow at Farmoor.

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 3; 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.

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 Level 3b (see Section 4.4.1.2) through the drought permit mechanism.

As discussed above in Section 3, 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.

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. But 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.

Summary

Table 3 provides a summary of the protocols for each WRZ and for introducing the Levels of Service measures.

Table 3 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	Guided by London protocol/ WRZ-specific

WRZ	Water Resource System	Protocol for introducing Level of Service measures
	river/groundwater	triggers based on 'threshold' river flow
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. Overview

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.
- Riverflows - primarily from the Lower Thames at Teddington Weir.

- The latest reservoir storage trends plotted on the LTCD

Step 1b - Predictions

For each of these hydrologic 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 and 3 months for SWOX. A shorter length of time for the prediction is used in SWOX because the Farmoor system is smaller and more responsive than the London system. 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 for which a reasonable length of observed record exists. The sites for which modelled predictions can be made by the EA are:

- Stonor Park (West Chilterns)
- Rockley (Marlborough Downs)
- Gibbet Cottages(Berkshire Downs)
- Ashley Green (Chilterns)
- Lily Bottom (East Chilterns)
- Therfield Rectory (East Chilterns)
- Tile Barn Farm (North Downs)
- Well House Inn (North Downs)

NB. The EA has replaced Oak Ash with Gibbet Cottages in the Berkshire Downs but both observation boreholes are located very close to each other and therefore the Gibbet Cottages record can be considered as an extension of Oak Ash.

Reservoir storage

The WARMS model is used to simulate 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 and can also operate in a time series mode using hydrometric records from 1920 to date and it is this mode that is used to calculate the deployable output for London. 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 hosepipe and sprinkler bans. The modelling reflects the timing of when these restrictions would be in place and the resulting reduction in demand.

Riverflow

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.

CEH Model

Thames Water commissioned Wallingford Hydrosolutions at the Centre for Ecology and Hydrology (CEH) to develop a model, based on analysis of regional groundwater levels, for providing a prediction of potential drought levels as reflected in the baseflow at Teddington and Farmoor. This tool may be used to supplement the analysis used in the protocol. The modelling system provides a linkage between groundwater levels and river flow. Through estimation of the recession based on previous years it provides a prediction of the potential baseflow in the River Thames at Farmoor and at Teddington for the summer period using recession predictions made in the early part of the year up to the end of the recharge season.

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 an excellent 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 2 demonstrates the technique for 2012, 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 first. The historic record in this case 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. 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.

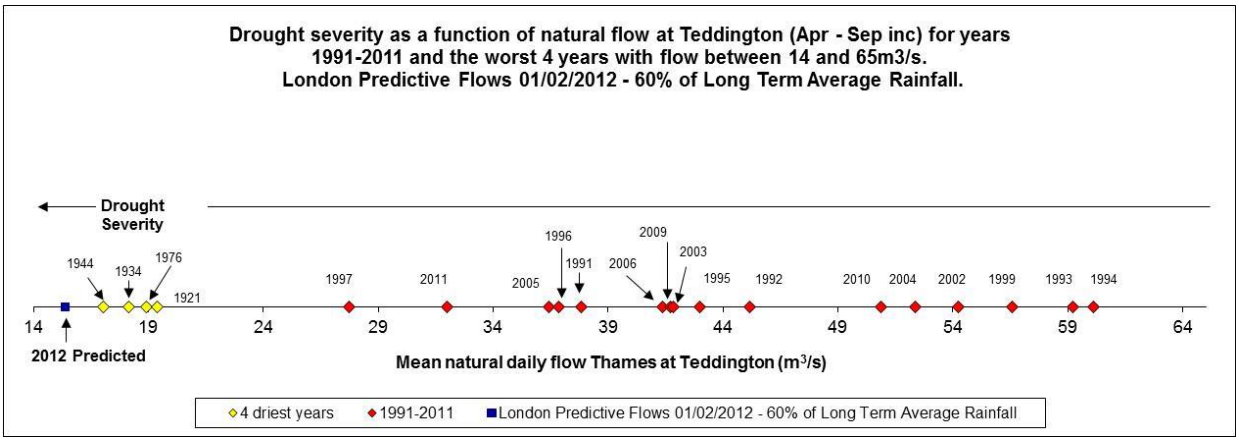


Figure 2 Drought Severity as a Function of Natural Flows at Teddington (April - September) showing the Driest Years Since 1991 and 2011 Prediction and the worst 4 years on record

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 (R_G), riverflows (R_R) and reservoir storage (R_S); where R_G and R_R are evaluated in accordance with the EA's percentile banding, Table 4; R_S is calibrated from the Level 1 to Level 4 control curves in the LTCD, Table 5.

Table 4 Groundwater and Riverflow 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 5 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
R_S 3	Level 4
R_S 4	

This methodology is demonstrated in Figure 3, Figure 4, and Figure 5 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 4 above and Figure 3 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.

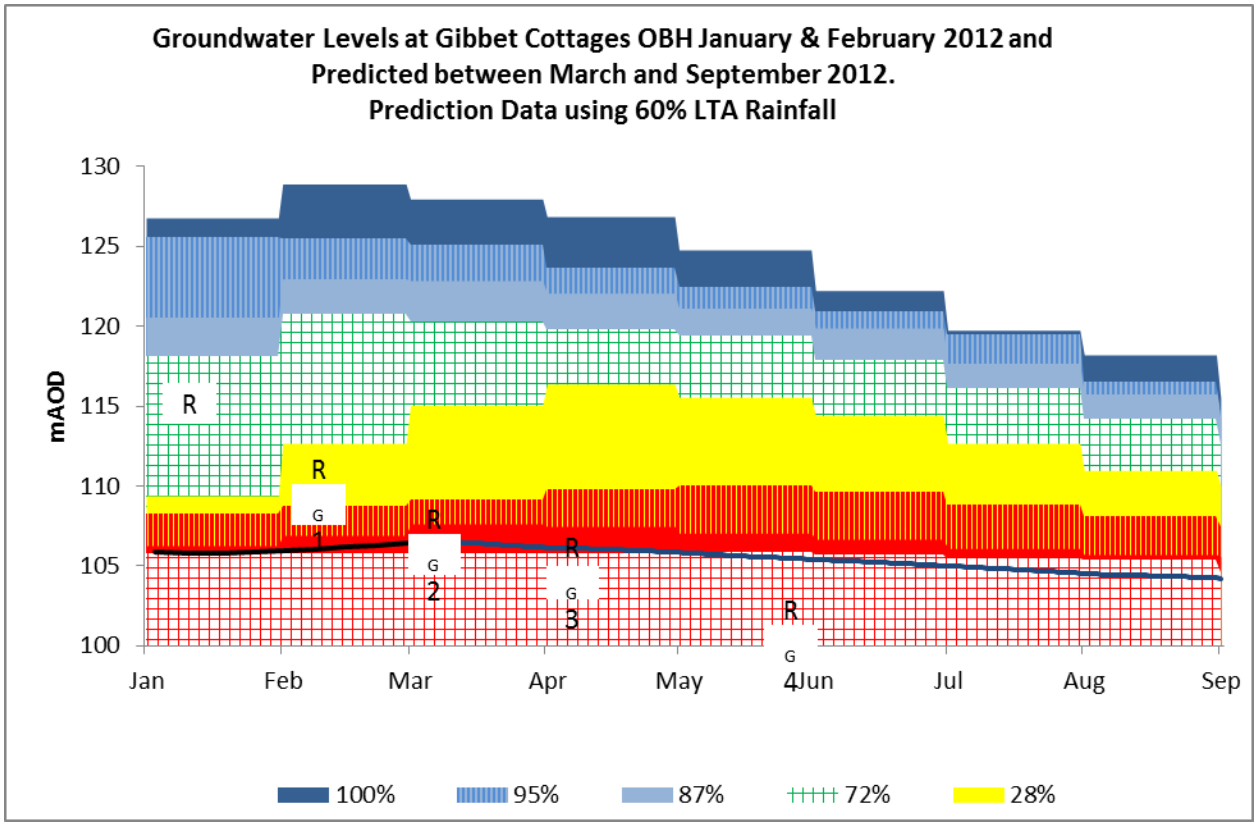


Figure 3 2012 groundwater levels (Gibbet Cottages OBH) - prevailing for January 2012 to end of March 2012, predicted thereafter to September 2012

River flow - R_R

With reference to Table 4 above and Figure 4 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.

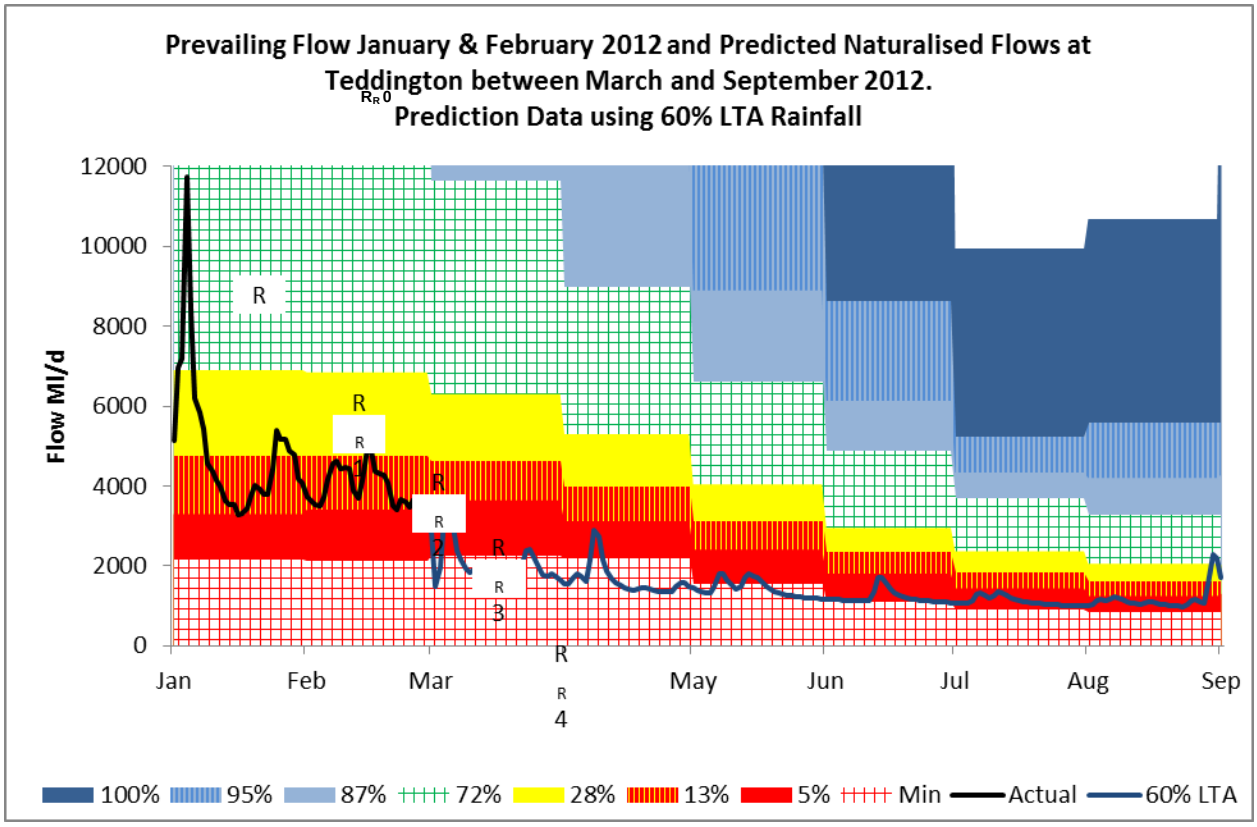


Figure 4 2012 Teddington flows - prevailing from January to end of March, predicted thereafter from March to end of September

Reservoir storage -R_S

With reference to Table 5 and Figure 5, the prevailing trend from the start through to the end of February is within the blue 800 Ml/d flow band (R_S0). With a 60% predicted long term average rainfall the storage falls into R_S3 in June 2012 then into R_S4 in July 2012.

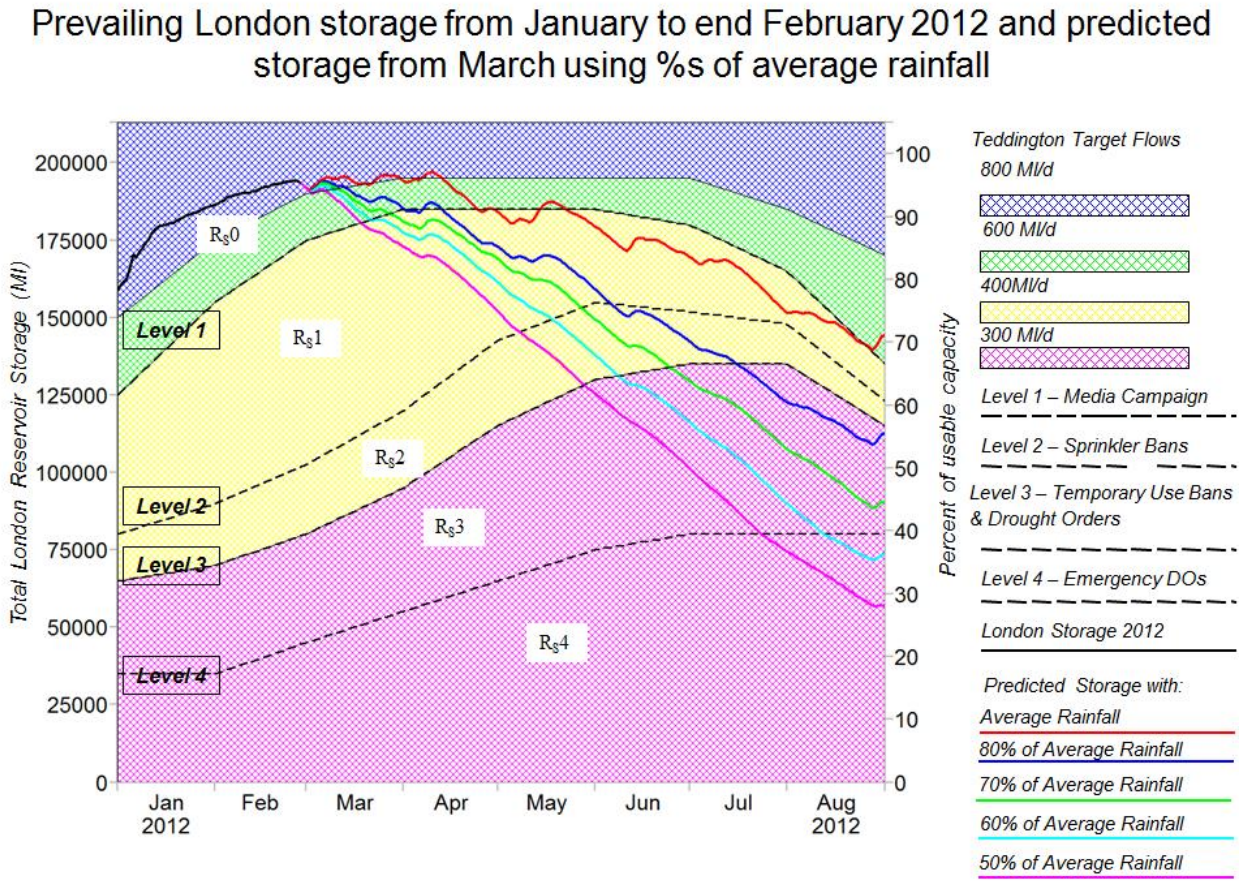


Figure 5 2012 Reservoir storage levels- prevailing to end of February, predicted thereafter (using 2012 LTOA which has now been revised)

4.3.3. Summary

The results of the prevailing and predicted analyses for all three hydrologic variables are summarised below in Table 6.

Table 6 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), riverflow (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 W_G, W_R and W_S are monthly weighting factors; their formulation is described in detail in Appendix F, Step 2b. The appropriate weighting factors are given in Table 7 below and are shown for all months in Table F6 and F7 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 7 Weighting factors for March and August 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 6 and the weighting values given in Table 6, R_C values can be calculated for predicted and prevailing conditions in August and February respectively, Table 8. The value is rounded to the nearest whole number to give the combined risk value.

Table8 Calculation of the combined risk values (Rc) for 'prevailing' March 2012 and 'predicted' August 2012

	R_G * W	R_R * W	R_S * W	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 9 below provides the correlation between the ORI and the prevailing and predicted Rc values.

Table 9 Overall Risk Indicator derived from prevailing and predicted Rc 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 9 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, 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 10 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 10 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/unattended hosepipe& sprinkler ban.	Level 2
ORI 0/3	DEL 3	Director	Enhanced media /water efficiency campaign/sprinkler & Temporary Use Ban/ DD11 ordinary drought order (ODO) and drought permit.	Level 3
ORI 1/1	DEL 1	Senior Manager	Media/water efficiency campaign.	Level 1
ORI 1/2	DEL 2	Senior Manager	Enhanced media campaign/ unattended hosepipe & sprinkler ban.	Level 2
ORI 1/3	DEL 3	Director	Enhanced media /water efficiency campaign/sprinkler & Temporary Use Ban/ DD11 ordinary drought order (ODO) and drought permit.	Level 3
ORI 2/2	DEL2	Senior Manager	Enhanced media campaign/ sprinkler ban.	Level 2
ORI 2/3	**DEL3**	**Director**	**Enhanced media/water efficiency campaign/ /Temporary Use Ban; application for DD11 order/ drought permits.**	**Level 3**

Overall Risk Indicator Level	TW Drought Event Management Level	Event Controller	Potential Drought Measures	Implied Level of Service
ORI 2/4	DEL3 or DEL 4	Director/ CEO	Enhanced media/water efficiency campaign//Temporary Use Ban; application for DD11 order/ drought permits. Preparation for EDO application.	Level 3
ORI 3/3	DEL 3	Director	Enhanced media/water efficiency campaign/ Temporary Use Ban. Introduce DD11/ drought permits.	Level 3
ORI 3/4	DEL 4	CEO	Enhanced media/water efficiency campaign/ Temporary Use Ban Introduce DD11 order/ 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 DD11 order/ 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, the Thames Water drought management structure is shown below in Figure 5b.

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 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 management role is critical in terms of providing a focus for all stakeholder engagement. The stakeholder manager 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.

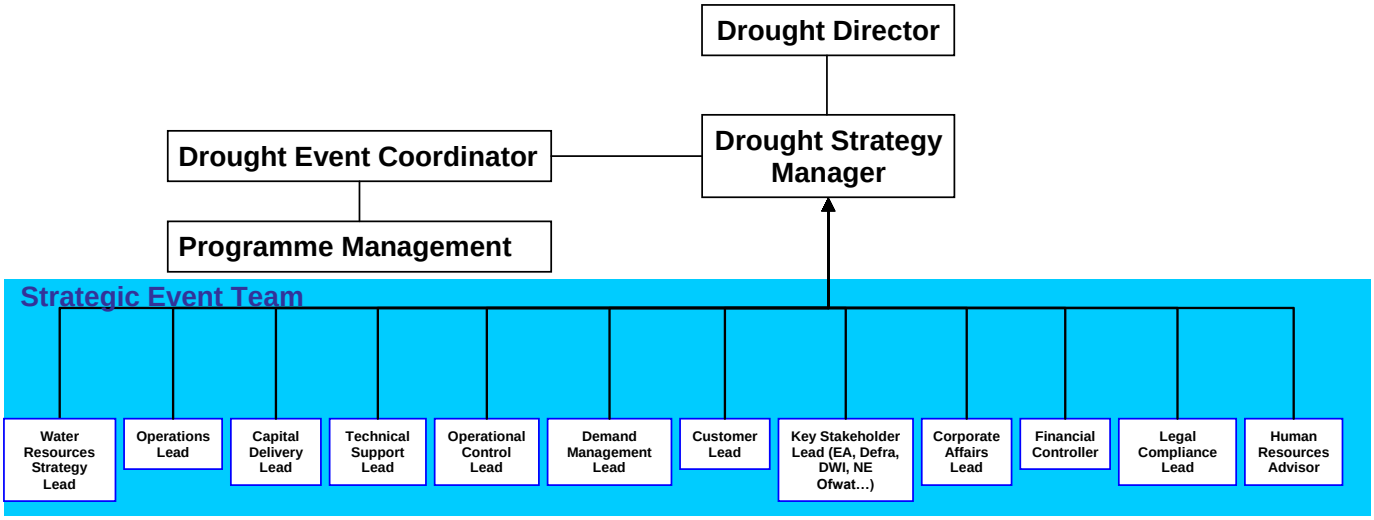


Figure 5b Drought Event Management Structure

4.3.4. Sequencing and timing of measures

4.3.4.1. Sequencing

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 time-line 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 Thames Water's Levels of Service, as follows:

- Media campaign must precede a sprinkler or Temporary Use Ban.
- Sprinkler/Temporary Use Ban must precede a DD11 order.
- Sprinkler/Temporary Use Ban must precede a drought permit.
- DD11 order must precede an emergency drought order (EDO).

4.3.4.2. Elapsed time to implement drought measures

In order to accommodate the required time line there may need to be an overlap in the process due to the time taken to determine DD11 order. 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

- Sprinkler ban: 3 weeks; likely to be combined with Temporary Use Ban in severe drought of Level 3 potential.

Level 3 measures

- Temporary Use Ban: 3 weeks formal notification (run concurrently with sprinkler ban under legislation for Temporary Use Ban)
- DD11 order 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 11, it can be seen that the elapsed time by which a DD11 order 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 11 Drought Measures Indicative Timescale for London

Measure	Time to Implement (Weeks)			
Media campaign	2			
Sprinkler /Temporary Use Ban		3		
DD11 drought order /drought permit			10	
Emergency drought order (EDO)				10
Elapsed time (WEEKS)	2	5	15	25

The elapsed times shown in Table 11 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

4.4.1.1. Revision of 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. Following the publication of the Drought Plan 2010, the methodology for the zone was reviewed and amended in recognition of the concern expressed by the EA and Defra on the potentially relatively rapid decline in Farmoor reservoir storage compared to London reservoir storage under comparable low flow conditions.

New 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 DD11 order and drought permit applications is set at 200 Ml/d (5-day running mean) under DEL3 or DEL4 drought event scenarios;
- Trigger for predicting the implementation of DD11 order and drought permit options is set at 100 Ml/d (5-day running mean) under DEL3 or DEL4. This is an alternative to using the prediction of reservoir storage reaching Level 3b on the Farmoor Control Diagram (FCD), which is subject to modelling uncertainty. 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 Level 3b, whichever is the earliest. If DD11 measures are not already in place company-wide through the London protocol, the above criteria will also be used as the basis for implementing the DD11 order.

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 the Level 3b curve on the Farmoor Control Diagram, see next section. 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. This is why 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 part F10). 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 Level 3 on the LTCD.

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 DD11 and drought permits are submitted for SWOX triggered by the 200 Ml/d flow threshold.

SWOX assessment methodology

As in the Drought Plan 2013 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 DD11 order 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 DD11 order and drought permit applications.

4.4.1.2. Farmoor Control Diagram (FCD)

As discussed above, a feature of the SWOX WRZ methodology is the control diagram for Farmoor reservoir, the zone's raw water storage bunded reservoir. It is referred to as the Farmoor Control Diagram (FCD). The FCD in SWOX is used in a similar way to the LTCD for the London WRZ. The FCD is an initial preliminary set of control curves developed in 2001/02. Although put to good use in the moderate drought of 2003, the FCD is relatively untested and based on limited data compared to the LTCD, and so remains provisional at this stage.

Although the layout of the FCD was designed along the same principles as the LTCD, there is one important difference in respect of the Level 3 curve. Because of the relatively smaller volume of Farmoor reservoir compared to the London reservoirs and the more rapid recession of the upper Thames compared to the lower Thames, Farmoor reservoir levels can decline more rapidly than the lower Thames reservoirs, see Section 2.3. Consequently, in order to effect a sufficient buffer between Temporary Use Ban measures and DD11 measures, Level 3 has been subdivided into two control curves: an 'early' Level 3a Temporary Use Ban (formerly hosepipe ban) control curve and a 'later' Level 3b DD11 order (formerly non essential use ban) control curve and drought permits, as shown in Figure 7 below. It should be noted the predictions included in Figure 6, below, do not include the benefit of Drought Permit implementation which would significantly reduce the rate of storage decline in Farmoor reservoir. Further work is proposed to develop a more robust set of drought curves for Farmoor reservoir based on more recently available data provided through the work on a stochastic approach to drought assessment as described in Section 8.

The steps for the prevailing/predicted risk methodology for SWOX are essentially the same as for London, the only difference being the split at Level 3 into 3a and 3b as discussed above.

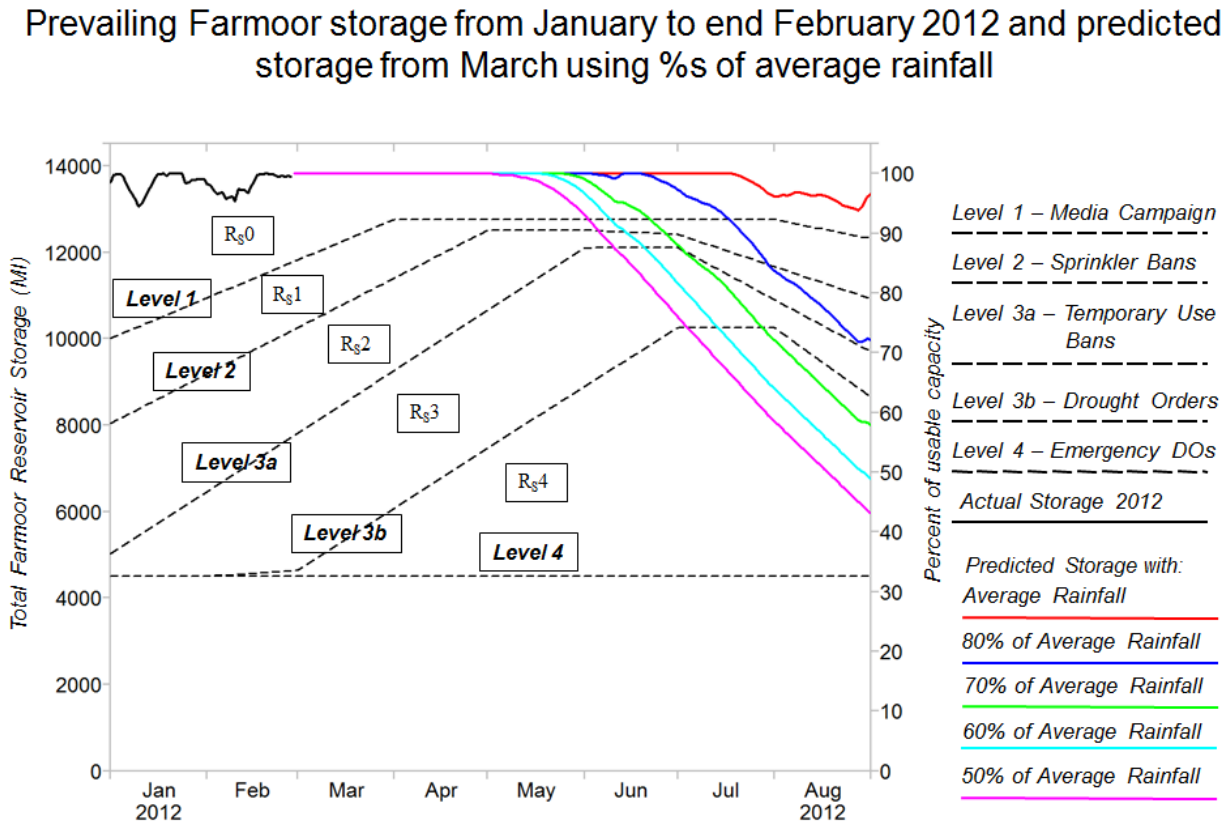


Figure 6 Farmoor Control Curve (FCD) for Prevailing and Predicted Storage in 2012

Appendix F provides a detailed description of the SWOX methodology together with examples of its application as applied to the droughts of 2005/2006, 1976, 1997 and 2012.

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 DD11 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 Temporary Use Ban restrictions would already be in force.

Implementation of DD11 or drought permits would be risk-based, triggered either by consideration of the prevailing reservoir storage approaching Level 3b 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 DD11 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 level 4 curve 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 12 below for a drought of potential severity of at least 1:20 in which the need for drought permits and DD11 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 12 Drought Measures Indicative Timescale for SWOX

Measure	Triggers	Minimum time to implement (Weeks)			
Media campaign	DEL1 or higher	2			
Sprinkler/Temporary Use Ban	DEL2 or higher		3		
DD11/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.

However, in view of the requirement to determine measures that might be required specifically in a severe drought, 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 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 new flow control structure has been installed located on the Holy Brook just downstream of its bifurcation from the River Kennet.

Thames Water has 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 55 Ml/d average and 65 Ml/d peak assuming 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 7 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.

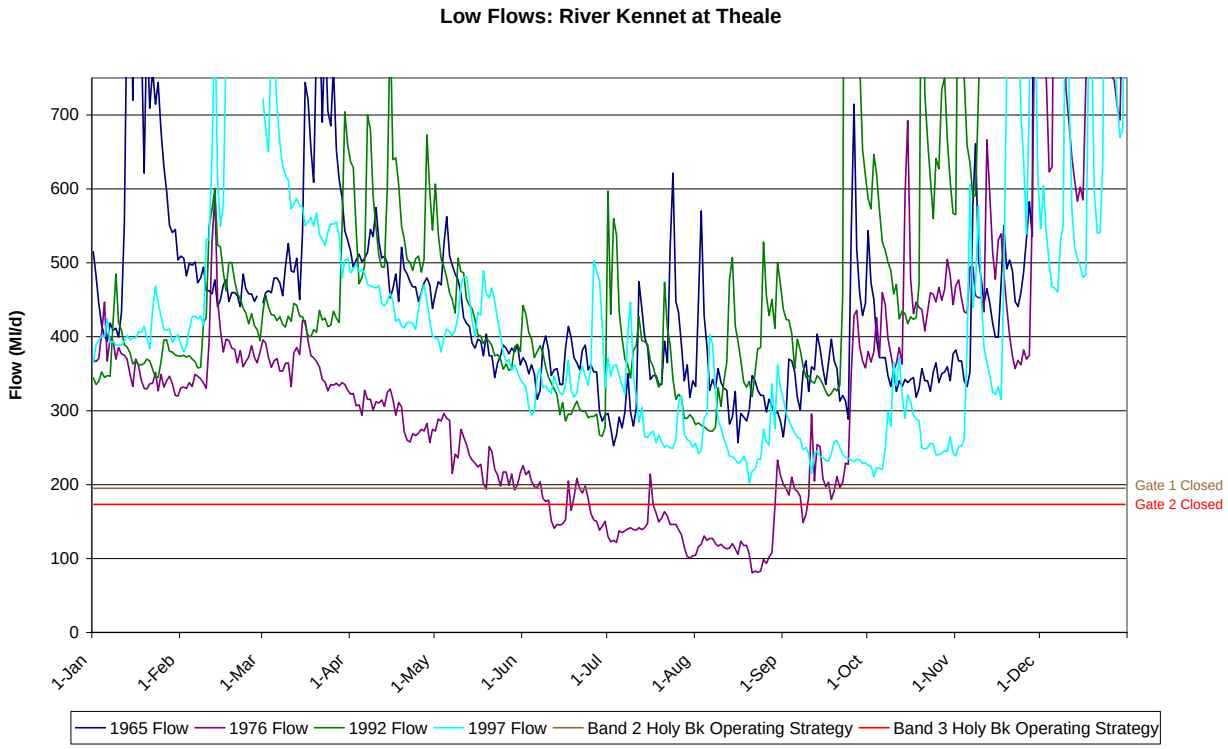


Figure 7 Historic Low Flows for the River Kennet at Theale

Figure 8 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 WTW. 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 WTW, 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.

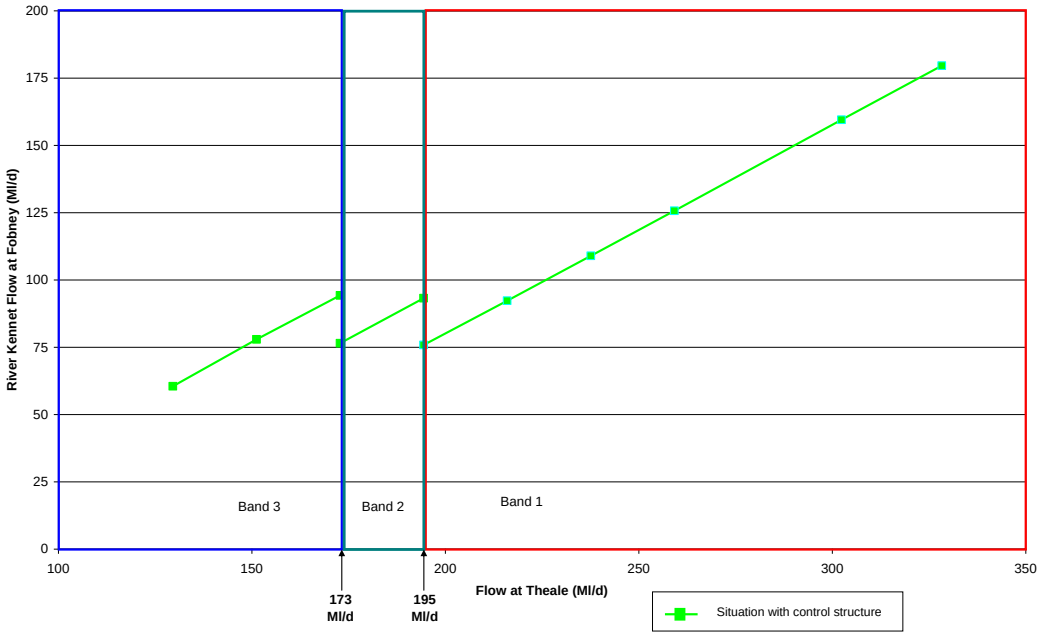


Figure 8 Impact of the flow control structure on the flow in the River Kennet at Fobney

West Berkshire Groundwater Scheme

Figure 9 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.

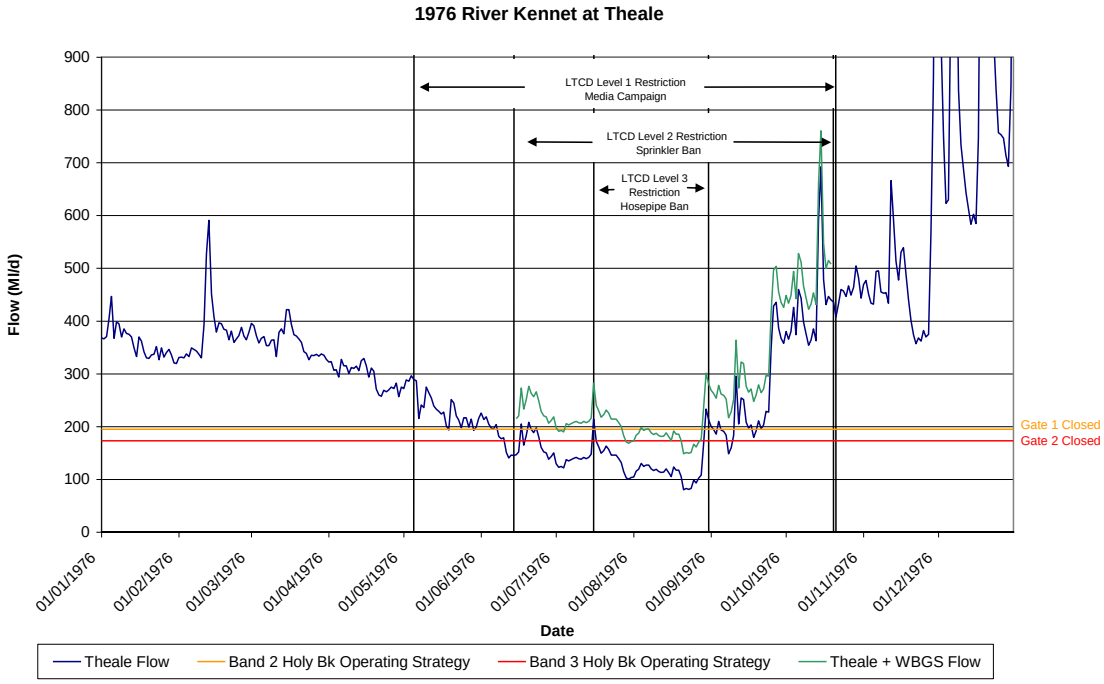


Figure 9 Benefit of West Berkshire Groundwater Scheme augmentation of River Kennet

The adopted trigger levels for guiding decision-making on the introduction of restrictions are set out in Table 13. Normally water use restrictions from the initial media campaign through to Temporary Ban and DD11 measures would be triggered from the London WRZ protocol, see Section 4.3 above.

Table 13 Proposed 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: • DD11 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 DD11 application will be underway.
Implementation of Drought Permits		DD11 measures will be implemented alongside the introduction of Drought Permit options.

Thames Water has assessed the potential impact of a severe drought on the flow in the River Kennet and the Kennet and Avon canal on the water abstraction arrangements at Fobney WTW which is fed by abstraction from the Kennet and Avon canal. 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. Thames Water's 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. Thames Water has tested the impact of a more severe drought on the Kennet Valley WRZ drought measures and this is described in section 8.

Thames Water has 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. This is formalised by Thames Water and the Environment Agency in an Operating Agreement. In a very severe drought Thames Water 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 (Figure 1). The Environment Agency cannot close the fish pass. 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. Thames Water has discussed this with the Environment Agency and has agreed that such an option should be included in the drought plan and that it 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 10.

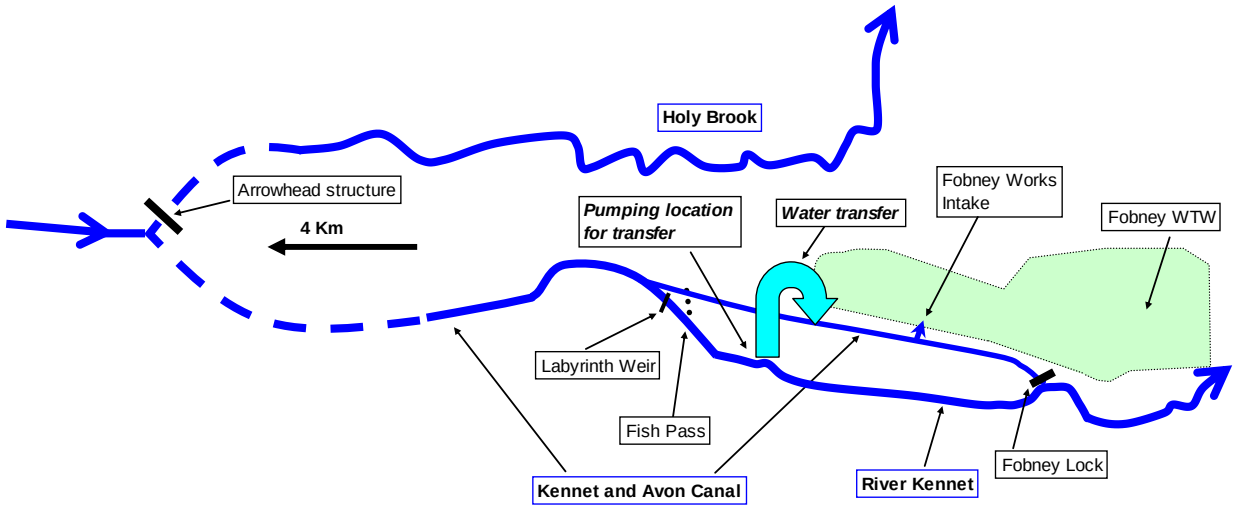


Figure 10 Configuration of pumping arrangements at Fobney intake. Water is pumped from below the Labyrinth Weir into the navigation reach above the Fobney intake channel

Kennet Valley WRZ Resilience

As noted above all the key groundwater sources in the Kennet Valley WRZ are resilient to drought, the weakest link in the zone is Fobney AWTW, by virtue of the flows in the Kennet Canal that serve the works. Three questions arise in considering Kennet Valley resilience, as follows:

Q1. Will WBGWS be in operation helping to augment natural base flows by the time they have receded down to the critical level of 150 Ml/d at Theale?

Q2. What additional support from drought permits will there be during the critical period?

Q3. Can the Kennet Valley WRZ and Fobney AWTW in particular be supported by drought permits alone if the WBGWS is not in operation?

These questions are dealt with below and the resilience of the system to a more severe drought is described in section 8. The answers are given on the basis that the fish pass at Labyrinth weir will be closed during the extreme low flow critical period for Fobney WTW.

Q1. 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 6.2.1.5). 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 11 below.

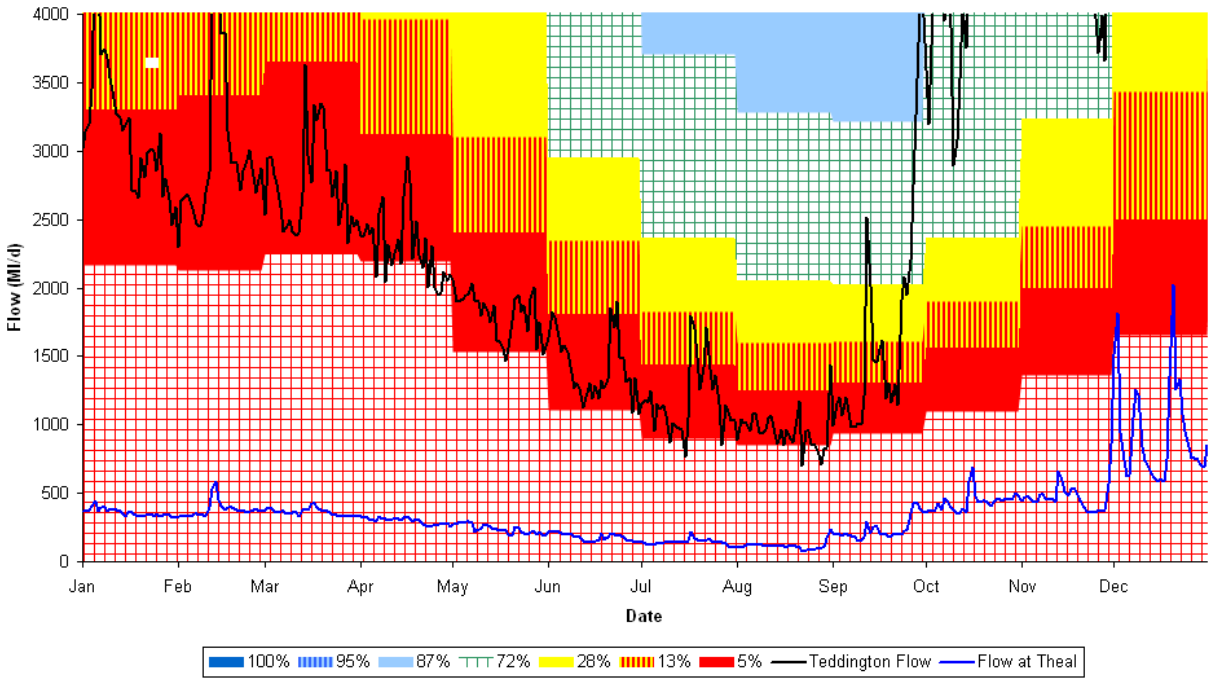


Figure 11 Comparison of River Thames flow at Teddington Weir and River Kennet flow at Theale GS during 1976.

Q2 Drought permit support

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

- Category 1 - Pangbourne Groundwater source
- Category 2 - Fobney Emergency Boreholes
- Category 2 - 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 a reliable 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 65 Ml/d at Fobney WTW, it is unlikely that any further support would be needed from reducing residual flow down the Holy Brook, let alone from the two groundwater options.

Q3 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 here 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 historic low flows, see Figure 12, 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 14.

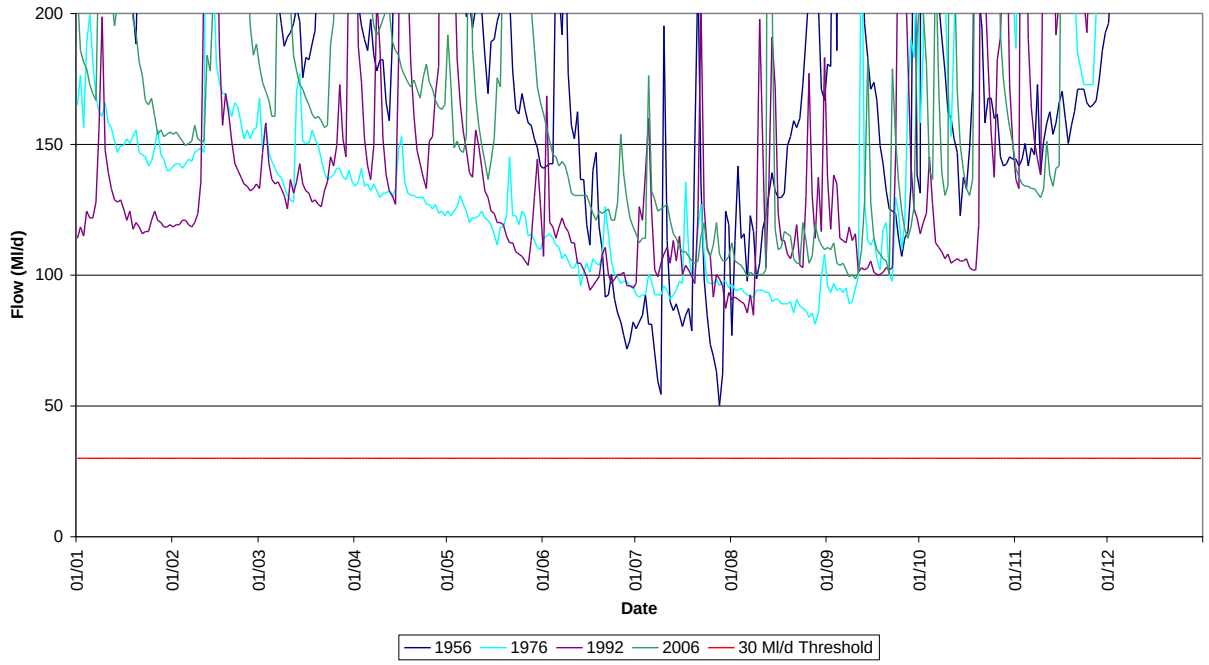


Figure 12 Historic low flow on the River Wey

Table 14 Indicative Flow Triggers for Guildford WRZ

Measure	Flow rate
Sprinkler ban	**90 Ml/d (on average for 5 days)**
Temporary Use Ban	**85 Ml/d (on average for 5 days)**
DD11 order	**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 drought order or drought permit applications.

In practice, a minimum period of 10 weeks has been allocated for the lead time for 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, as required by the Drought Plan Guideline 2016 and is described in more detail in section 8.

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

Both Slough/Wycombe/Aylesbury (S/W/A) 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 S/W/A and Henley WRZs is outlined in Appendix G.

The specific situation in the S/W/A 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 deployable output.

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 S/W/A 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 S/W/A 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 Temporary Use Ban 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 S/W/A or Henley zones, rather actions have been driven initially by supply demand conditions in London. This partly reflects the relative robustness of the S/W/A and Henley groundwater sources, but as a result, 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 13 illustrates the drought management control curves and tracking approach for the S/W/A 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 13 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 Norm) 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.

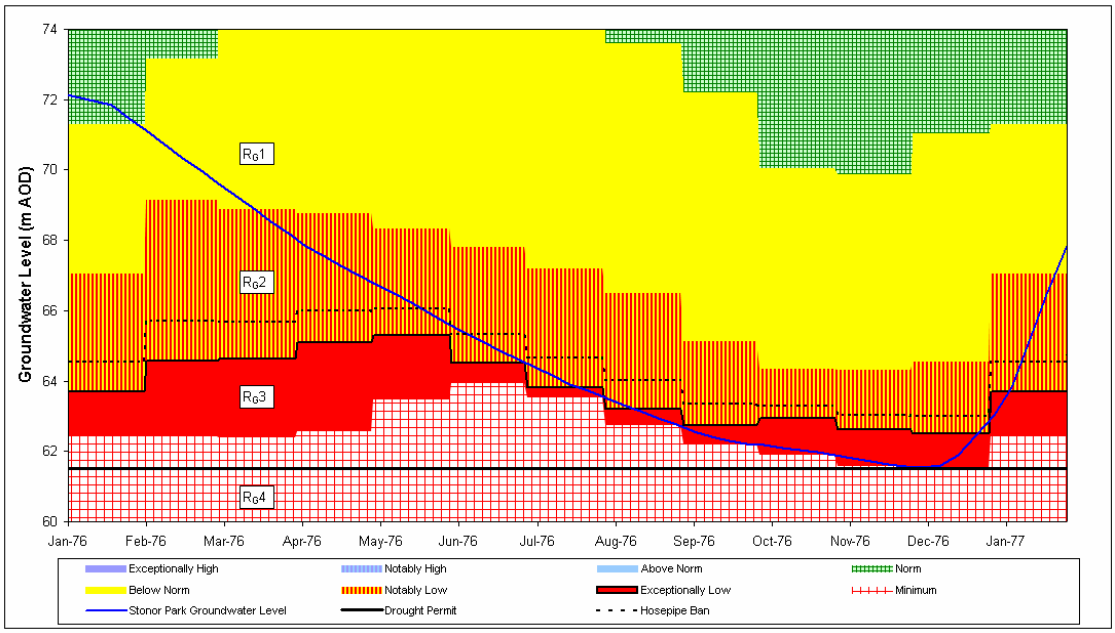


Figure 13 Groundwater Control Curves for Stonor Park OBH for 1976

- **Temporary Use Ban Implementation** – The groundwater level at which a Temporary Use Ban might be implemented has been set as a seasonally variable level, at 75% below the RG2 interface. A Temporary Use Ban 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 combined sprinkler/Temporary Use Ban was not already in place.

- This control level has been set by attempting to "calibrate" the timing of historic 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 S/W/A 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 combined sprinkler/TUB could likely be deferred to spring time to maximize savings.
- **Drought Permit Application** – As groundwater levels decline below the R_G3 (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 R_G3 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 R_G3 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, R_G4 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 Temporary Use Ban 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 S/W/A 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 by making use of the Catchmod model described in Section 4.3.2.

As for some other WRZs, e.g. Kennet Valley, the drought protocol for S/W/A and Henley is provisional and has not yet been used in practice leading up to or during a drought. 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 S/W/A 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 Thames Water 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 4.3.2.1, Step 1a). Before declaring an end to a drought event and the consequent lifting of all drought management measures, Thames Water 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. Thames Water's 'Event Management Arrangements' include allowance for a 'Review' after each significant event. This review establishes 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 is 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 are 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:

a) 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
   - DD11 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

b) On basis of results from a), carry out the following actions:
   - Prepare draft and final Lessons Learnt Report.
   - Review and, if necessary, update existing Drought Plan.

Thames Water undertook a review of the 2012 drought and included the lessons learnt in its revised plan produced in 2013. This resulted in the requirement for an updated drought protocol as outlined earlier in this section. Learning points from the 2012 drought are set out in section 7.9.

4.10. Summary

The SWOX protocol was amended following the publication of the Drought Plan 2010 to include a new trigger for initiating drought order (DD11) and drought permit applications based on the River Thames flow at Farmoor.

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 riverflow. 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 DD11 orders 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 3b 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. 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

5.1. Overview

This section outlines the full range of demand-side options available to Thames Water during the course of a drought, the aim being to mitigate the need for emergency restrictions under Level 4 of Thames Water's level of service.

Most of the demand-side measures are associated with Thames Water's stated Levels of Service, see Sub-section 3.2, and involve the sequential escalation of water use 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, metering and 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.

As noted above in Section 1, this Plan incorporates the legislation on water use restrictions introduced in 2011. Essentially, Thames Water's implementation policy is such that the Temporary Use Ban restrictions replaced the former 'hosepipe ban' restrictions and DD11 restrictions replaced the non-essential use ordinary drought order restrictions. The sprinkler ban (Level 2 of Thames Water's Levels of Service) remains the same as prior to the introduction of the new legislation, except that the power to impose it is now enabled through the Temporary Use Ban legislation, see Section 5.5 below.

In accordance with its stated Levels of Service (Table 3), 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 15 along with the respective drought event risk level (DEL), see Section 4, Table 9.

Table 15 Demand-side measures

Measure	Description of measure	Drought Event Risk Level	Level of service	Additional comments
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	
Sprinkler and unattended hosepipe ban	Sprinkler and unattended hosepipe ban	DEL2	Level 2	Would normally be introduced at same time as the enhanced media/water efficiency campaign. Net effect is to reduce peak demand.
Temporary Use Ban (formerly Hosepipe ban)	11 categories of use (largely domestic), banning the use of a hosepipe.	DEL3	Level 3	If predicted then the protocol will combine this measure with sprinkler ban. The net effect is to reduce peak demand.
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	

5.2. Savings from demand-side restrictions

Thames Water has estimated the potential water savings from demand side restrictions based on experience gained from savings realised in previous droughts, these are underpinned by the same methodology as employed for the Drought Plan 2010. The impact of an Ordinary Drought Order[4] was combined with the observed impact of the 2006 hosepipe ban[5] to produce the net impact of restrictions from levels 1 to 3 given the prevailing conditions in 2008. The 2008 estimates were revised[6] to produce figures fit for 2012 and now adopted for 2016 taking into consideration the following factors:

1. The changes due to reduced levels of Distribution Input.

2. The changes due to revisions to legislation, broken down into-

    a. The impact of powers that have been wholly or partially transferred from the pre-existing Ordinary Drought Order non-essential use ban legislation into the new Temporary Use Ban legislation.

    b. The enhanced scope of the Temporary Use Ban powers with respect of the former hosepipe ban legislation.

3. Thames Water policy on exemptions.

4. A revision to the estimated impacts of enhanced pressure management and accelerated leakage reduction in the context of Thames Water's improvements to leakage management between 2006 and the present day.

Table 16 shows for the London WRZ the latest month-by-month demand-side savings for the Service Level up to and including Level 4 (see Table 14, Column 4).

Table 16 Estimates for the impacts of month by month demand reduction for London WRZ expressed as % of the Distribution Input

Restriction level	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Level 1	1.1	1.2	1.2	1.3	1.5	2.2	2.2	2.1	1.3	1.2	1.2	1.2
Level 2	2.2	2.2	2.3	3.2	3.8	7.5	7.9	7.1	3.2	2.6	2.4	2.3
Level 3a: TUB	0.7	0.7	0.7	1.1	1.4	2.8	3.0	2.7	1.1	0.9	0.8	0.8
Level 3b: DD11	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Cumulative savings, Levels 1-3	5.4	5.5	5.5	7.0	8.0	13.9	14.5	13.2	7.0	6.1	5.8	5.6
Level 4	18	18	18	18	18	18	18	18	18	18	18	18
Total cumulative savings Levels 1-4	**23.4**	**23.5**	**23.5**	**25.0**	**26.0**	**31.9**	**32.5**	**31.2**	**25.0**	**24.1**	**23.8**	**23.6**

[4] Thames Water/R&Dreport/RST010-NEU/Version 2.0, L. Kiernan, 12-06-2006
[5] Thames Water/R&Dreport/RST010-LTOA/Version 1.2, L. Kiernan, 12-05-2008
[6] Thames Water/R&Dreport/RST010-LTOADrought2012/Version 0.8, L. Kiernan, 27-03-2012

Table 17 shows the equivalent savings for the Thames Valley WRZs. Largely due to the proportionally higher concentration of gardens, slightly higher savings are gained for the Thames Valley WRZs and the Farmoor system

Table 17 Estimates for the impacts of demand reduction for Thames Valley* expressed as % of the Distribution Input

Level of restriction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Level 1	1.3	1.4	1.4	1.8	1.9	3.6	3.8	3.7	1.6	1.4	1.4	1.4
Level 2	2.4	2.5	2.6	3.9	4.3	10.1	10.5	10.2	3.5	2.8	2.6	2.5
Level 3a: TUB	0.8	0.8	0.8	1.3	1.4	3.4	3.6	3.4	1.1	0.9	0.8	0.8
Level 3b: DD11	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Cumulative savings, Levels 1-3	5.8	5.9	6.0	8.2	8.9	18.3	19.1	18.6	7.4	6.3	6.1	5.9
Level 4	18	18	18	18	18	18	18	18	18	18	18	18
Total cumulative savings Levels 1-4	**23.8**	**23.9**	**24.0**	**26.2**	**26.9**	**36.3**	**37.1**	**36.6**	**25.4**	**24.3**	**24.1**	**23.9**

*Thames Valley WRZs are: SWOX, Kennet Valley, Henley, SWA and Guildford

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 greatest.

Level of service London WRZ- Peak month saving as a percentage of total demand (Equivalent figures given in the draft Drought Plan shown alongside)

- 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 (Equivalent figures given in DP10 shown alongside)*

- 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 3a&b: Additional 4.8% (cumulative 19.1%) maximum reduction in Unrestricted Demand.
- Level 4: Additional 18% (cumulative 37.1%) maximum reduction in Unrestricted Demand;

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%. The net change is similar in London and the Thames Valley. This reflects the fact that the opportunity for leakage and pressure management is greatest in London, where they constitute a greater proportion of total Distribution Input.

As an overall conclusion this means that the estimate of savings are that the measures introduced with the new legislation in 2011 for the London WRZ, increased total cumulative savings up to and including Level 3 from 11.1% to 14.5% and for Thames Valley[7] from 13.6% to 19.1%.

5.3. Water Efficiency

5.3.1. Baseline Water Efficiency Activity

Thames Water has promoted the wise use of water for over a decade. 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, built on lessons and experience as demonstrated by achievement of regulatory targets in 2010/11.

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 2015-2020.

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 2014.

[7] Thames Valley here refers to the 5 WRZs outside London which include SWOX, Kennet Valley, Henley, Slough Wycombe and Aylesbury and Guildford WRZs

5.3.2. 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 ~~of~~ 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 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.

5.4. Leakage reduction

5.4.1. Non-drought activities

Recent Leakage Performance

Leakage reduction remains a very important part of our plans to manage the balance between supply and demand and consequently we have challenging targets to deliver significant leakage reductions throughout the AMP6 period. These reductions are in London, but at the same time we have targets to maintain leakage levels in other WRZs whilst our supply network and the number of properties increase. During 2015/16 we have once again met our leakage target, ensuring that we have achieved our leakage target for a tenth successive year, and bringing total leakage reductions since 2003/04 to over 300 Ml/d, a reduction of over 30%.

Much of the activities we are undertaking to manage leakage build on the success of previous years:

- Repairing leaks reported to us by our customers;
- Proactively detecting and repairing leaks on our network, hidden underground;
- Undertaking free repairs of leaks for our customers' on their underground pipework;
- Installing more meters to allow us to better target customer side leakage activity;
- Optimising pressures throughout our water network, ensuring fluctuations and excessive pressures are minimised, providing more constant pressures to our customers whilst reducing bursts;
- Replacing ageing mains, targeting those that leak and burst the most, not only helping to reduce leakage but also to reduce future disruption and inconvenience to our customers;
- Introducing improvements in how we account for water use, both by our customers and by ourselves in our day to day management of the network;
- Using advanced monitoring on our trunk mains to spot small leaks before they burst and cause large scale disruption;
- Using advanced analytics to undertake flow balances across our network from abstraction to the customers tap, and all the meters in between, identifying and resolving imbalances through improving metering, network understanding, and ultimately targeted leakage reduction;
- Through the coldest parts of the winter, injecting our network with warmer water from our desalination plant and underground reservoirs.

Given the ongoing pressures on the supply demand balance within our supply area from high levels of population growth and impacts of climate change, we have an ongoing programme of leakage reduction. This is detailed in our Water Resource Management Plan 2014 and sees us reducing our leakage levels at company level to 606 Ml/d by 2019/20 with further leakage reductions beyond this.

5.4.2. Activities during drought

During drought all the activities that are part of our long-term leakage reduction programme will continue as before. However, 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. In particular, experience has shown that customers expect and appreciate the speedy reduction of visible leaks during drought events when they are being asked to use water wisely.

5.5. Temporary Use Ban restrictions, including sprinkler and unattended hosepipe ban

5.5.1. Legislation introduced in 2011

As part of Thames Water's Levels of Service, see Table 2, a sprinkler and unattended hosepipe ban can be imposed at Level 2 (drought severity at least one year in ten) and the ~~wider~~ Temporary Use Ban (TUB) powers can be applied at Level 3 (drought severity at least one year in twenty). Both sets of restrictions are aimed at reducing peak demand, which in turn, will gradually reduce the total amount of water used.

The TUB has a much wider scope of restrictions that can be controlled by water companies than the previous hosepipe ban legislation. In all, eleven categories of use 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:

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
6. drawing water, using a hosepipe, for domestic recreational use;
7. filling or maintaining a domestic pond 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.

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).

The most notable and important change under the TUB legislation was the definition of 'garden', which was greatly widened to include:

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.

5.5.2. Implementation Policy

5.5.2.1. 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, Thames Water selected a 3 week period for imposing the former sprinkler/hosepipe bans. Within the formal notice Thames Water will explain how representations about proposed prohibitions may be made and it 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 the Thames Water web site and 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 Thames Water's response will be published on its 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

Thames Water

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**

5.5.2.2. Phasing and Exemptions

Thames Water's 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 Thames Water's 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 L4.
- Consultee representations from the December 2011 consultation process and ongoing stakeholder dialogue.
- Experience of implementing a TUB in 2012

Phasing

The Temporary Use Ban legislation includes an option for phased implementation of the possible prohibitions.

Thames Water does not propose any phasing to the imposition of the eleven categories of use as set out in the TUB. However, dependent upon the Drought Event Level assigned, not all of the categories of use will be prohibited in any one year.

As part of a Drought Event Level 2, DEL2 (see Table 10) an unattended hosepipe and sprinkler ban is likely to be enforced (see Table 15), with authorisation given through the Temporary Use Ban legislation, see Section 5.4.1. This level of water use restriction would be consistent with Level 2 of Thames Water's Levels of Service, that is to say, a drought of severity with an occurrence no more frequent than one year in ten on average.

A more severe drought of frequency of occurrence at least one year in twenty on average would be designated a DEL 3 event. As part of a DEL3 (see Table 10), the introduction in a single phase of all eleven categories of use as set out in the ~~new~~ legislation is considered to be the most appropriate way for Thames Water to implement the Temporary Use Ban measures. A single phase would help to maximise water savings as well as send out a strong simple message that the situation is worsening. In practice, because a combined Level 1 and 2 Media Campaign (see Table 15) would be introduced well in advance to prepare the way for the Temporary Use Ban, customers would not experience an abrupt start to restrictions.

The Drought Event Level is a function of the prevailing and potential water situation (Section 4.3.3.3) 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. Therefore, unless the dry period is exceptionally long, extending well into the next winter recharge period the following autumn, it is very unlikely that a DEL2 involving an unattended hosepipe and sprinkler ban would be followed by a DEL3 involving the full eleven Temporary Use Ban restrictions within the same year.

Exemptions

The following will be exempted from the TUB restrictions:

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 surface used for sport or recreation, where this is required in connection with a national or international sports event (n.b. a list of sporting events exempt under a TUB or DD11 will be published on the Thames Water website during a drought and will be 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.

vi) 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 a 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.

Exemption i) is included to help to ensure that, as stated in the TUB legislation, the use of a hosepipe for the purposes as stated for health and safety reasons is not restricted.

Exemption ii) will apply to Blue Badge holders engaged in the following two categories of use:

Category of use 1): Watering a garden using a hosepipe (including an allotment), and

Category of use 3): Watering plants on domestic or other non-commercial premises using a hosepipe.

This exemption is intended to allow people who are disabled or physically impaired to continue to use a hosepipe in their own garden who would otherwise find great difficulty in carrying a watering can. Exemptions i), ii) and iv) will be allowed to run throughout the drought event.

Exemptions iii) and vi) are intended to alleviate the potential hardship a TUB could have on some businesses, particularly the smaller businesses whose income is derived from a single or limited number of activities. However, this exemption will be withdrawn if and when DD11 measures are imposed. The rationale for such phasing of the commercial users exemption is to enable it to run for a reasonable length of time before banning the activity in line with the DD11 measures. If the drought has become sufficiently serious as to introduce such measures then it could be reasonably argued that the exemption applied to commercial users should be lifted. On the other hand, it is felt that the physical impairment and disability exemption should remain in place throughout the drought event because the reason for its implementation still remains.

- Exemption iv), is as described in Appendix L 5. This is an exemption that arose from Thames Water's internal review of its implementation policy during the consultation/response during the drought of 2012. Given that events of national or international importance can take place throughout the year and they will be of a limited number, this exemption will run throughout a drought event.

- Exemption v) is as described in Appendix L 5. This is a new exemption that arose from the December 2011 consultation process and from otherwise ongoing stakeholder dialogue. The EA has accepted the inclusion of this exemption provided the opportunity was taken to gather information on its effectiveness. Consequently, Thames Water and the other companies exempting drip irrigation plan to work with Waterwise during a drought to monitor results and build the long-term evidence base of the savings delivered. As with Exemptions iii) & vi), this exemption will be lifted if and when DD11 measures are introduced.

Insofar as exemptions iv) and v) were supported by customers (Appendix L3), the proposed approach is consistent with the findings from the customer survey. These exemptions represent an approach that minimises any complication to the message to customers and which is consistent with the 2nd principle of proportionality in the Code of Practice. That is to say, it can be shown that together, all the exemptions do not constitute a significant reduction in the potential water savings but not including the exemptions could mean loss of livelihood in the case of affected commercial customers and undue personal hardship in the case of people with health impairment or disability. 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.

5.6. Drought Direction 2011

5.6.1.1. Legislation revised in 2011

The Drought Direction 2011 (replacing the Drought Direction 1991) sets out the categories of use that can be prohibited in an ordinary drought order. These are usually referred to as the "non-essential use bans" and 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.

Statutory health and safety exemptions apply to some of the categories of water use, see Appendix L1 and L2.

Following changes to the law to increase the categories of use that can be restricted under a Temporary Use Ban, a new Drought Direction was made in 2011. This outlined the additional restrictions, namely 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.

5.6.1.2. Implementation policy

Thames Water would not be introducing such extreme measures as given in the Drought Direction 2011 legislation if the water situation was not becoming demonstrably very serious. Thames Water considers that a straightforward total ban without exemptions not only sends a clear message underlining the severity but also maximises water savings and is easier to communicate and administer. In the unlikely event of the need to apply for an Emergency Drought Order, such an approach would stand Thames Water in good stead for a successful application.

In good time, prior to a DD11 order application, Thames Water 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.

Thames Water considers a 10 week minimum period is required 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', which presents Thames Water's case for seeking authorisation to implement DD11 restrictions. This report would need to explain in detail why and how the exceptional shortage of rainfall is likely to lead to a serious deficiency in water supply and that, in the meantime, Thames Water is carrying out all the necessary measures to avoid the need for Emergency Drought Orders.

It should be noted that for Thames Water to consider implementing a DD11 order, consistent with Level 3 of its Levels of Service, the potential drought severity must be at least one year in twenty. In terms of the protocol, this would mean that the Drought Event Level would need to be DEL 3 before an application for an order is made. However, for its implementation Thames Water 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 Thames Water would consider DD11 restrictions, all ten measures would be applied for simultaneously.

5.7. Emergency Restrictions - Level 4 of Levels of Service

5.7.1. Emergency Drought Order

Thames Water's Levels of Service stipulate that Level 4 emergency restrictions should never be applied. 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 2016) 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 Thames Water's 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 fire fighting could be maintained. A full consultation process would be undertaken with the fire services prior to implementation of EDOs.

5.7.2. Further Measures to Avert Level 4

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

- Reductions in water pressure
- Restricting supplies to large commercial users
- Further reduction of bulk supplies to other companies where possible

However there are also a number of supply-side options that may be considered during a drought, these are outlined in the following section on supply-side measures.

5.7.2.1. Pressure Reduction

Pressure restrictions are preferable to more extreme measures that might be implemented under Level 4 in that they carry a lower risk to public health and vulnerable customers and are therefore a better option if major restrictions to supply are required.

Pressure reduction would involve reducing pressure in the mains network below normal target Levels of Service. The pressure that would be aimed for would be the lowest measurable pressure in the system that maintains positive gauge pressure to all points in the network affected. In some pressure zones, pressure restrictions are not technically feasible. In others, the topography is such that pressures will vary greatly between higher areas (lower pressures) and lower areas (higher pressures). Therefore, in order to ensure that pressures remain

positive throughout the network during pressure restrictions, a recommended target gauge pressure of five meters is required at the high/critical point in the network.

5.7.2.2. Further Leakage Control

The potential for further leakage control would be explored, however, as described in Section 5.4 above, Thames Water is devoting significant resources to the reduction of leakage in the long term and so the scope for increased leakage activity in a drought is limited. However the potential to transfer resources to 'find and fix' activities would be implemented where possible, particularly to address the speed of repair for visible leaks.

5.7.2.3. Restricting Supplies to Large Commercial Users

The following is given as an example of the potential savings from curtailment of supplies to large commercial customers.

- A large food processing concern in London uses 4 megalitres per day
- The average domestic usage is 430 litres per property per day
- Therefore the volume used by the food processor equals the supply to more than 9,000 domestic properties

Rationing water supplies to these customers would have an immediate and significant effect on water savings. A precedent for this option exists in the Department of Trade and Industry approved arrangements for rationing gas and power. These emergency measures require minimal operational resource and present little or no risk to the operation of the network and will provide improved security of supply to other water users. However, it must be borne in mind that, whereas alternative sources for gas and power supplies can be obtained in an emergency, the substitution of water supplies is more problematic – especially for fire suppression, etc. The curtailment of water supplies may therefore result in the closure of commercial premises with significant consequential impacts on the customer, its employees and other stakeholders.

Further options for large scale savings from commercial usage of water may be achieved through agreements with commercial customers, for example power generators may be able to restrict consumption overall or at specific periods – say at night when power demand is low.

The methodology and policies needed to implement restrictions of supply to large commercial customers have yet to be detailed, and must be preceded by discussion with key account customers and stakeholders to allow them to consider their options. However, information to support the development of the methodology would be prepared in advance and would include identifying:

- Commercial key account users in the areas selected for restrictions
- Consumption rates and periods of draw-off to establish the least inconvenient periods for restricting supplies
- Those commercial users with independent storage capabilities
- Control valves for flow reductions/restrictions

Thames Water produced a register of potential options for restricting supplies to commercial customers following the drought of 2006 and updated it during the drought of 2012. This register would be used in the event of a severe drought to identify options that would be implemented if necessary. This activity would need to be undertaken through liaison with the new retail

operators following opening of the market to new retail companies for supply to commercial customers.

5.8. Summary of demand-side measures and activities

Table 18 shows the range of demand-side measures that fall within the four DEL levels. As explained in Section 5.4.2.2 under 'Phasing', because of the nature of drought events in the Thames catchment, it is unlikely that DEL2 measures would be followed by DEL3 measures in the same drought event, therefore a DEL2 drought event (exemplified by the 2005 drought) would consist of integrated DEL 1 and DEL 2 measures and activities and on the demand-side these would include:

- Under DEL1- Level 1 of Levels of Service restrictions-Media campaign/ water efficiency/ leakage reduction;
- Under DEL 2- Level 2 of Levels of Service restrictions - Enhanced media campaign; unattended hosepipe and sprinkler ban.

A DEL 3 drought, being potentially more serious than a DEL 2 drought, would include (in addition to the DEL 1 and DEL 2 measures) DEL3 demand-side measures and activities, namely: a full TUB (all eleven categories of use) at an early stage. This measure would effectively replace the unattended hosepipe and sprinkler ban. Under a DEL 3 event DD11 restrictions would follow later in the drought event, if worst-case scenario conditions continue to prevail.

Table 18 Demand-side measures and activities

Restriction/Activity		Drought Event Level (DEL)				
		DEL 1	DEL 2	DEL 3		DEL 4
		Media Water efficiency (L1)	Partial TUB (L2)	Full TUB (L3)	DD11 (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/DD11 Exemption	TUB/DD11 Exemption	
	Watering an area of grass or artificial outdoor surfaces used for sport or			TUB/DD11 Exemption	TUB/DD11 Exemption	

Restriction/Activity		Drought Event Level (DEL)				
		DEL 1	DEL 2	DEL 3		DEL 4
		Media Water efficiency (L1)	Partial TUB (L2)	Full TUB (L3)	DD11 (L3)	EDO (L4)
	recreation, where this is required in connection with a specific national or international sporting event					
	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			TUB Exemption		

Restriction/Activity		Drought Event Level (DEL)				
		DEL 1	DEL 2	DEL 3		DEL 4
		Media Water efficiency (L1)	Partial TUB (L2)	Full TUB (L3)	DD11 (L3)	EDO (L4)
	is done as a service to customers in the course of a business					
	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. Thames Water 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 DD11, 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 WRZ. With the notable exception of drought permits/orders, (see Appendices B and C) supply-side measures are not part of Thames Water's stated Levels of Service but rather are measures that are introduced by Thames Water 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 given in Appendix B. Table 16 shows the benefit in Ml/d of the strategic supply-side schemes and groundwater drought/peak load schemes available for London.

Thames Water's 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

Thames Water's 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.

As stated in Section 3.4 above, 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 2016 are 81.7 Ml/d and 31.97 Ml/d respectively, these are based on analysis of recent historic 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.

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 Thames Water's 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 categorised into Category 1 and Category 2 and then prioritised within the categories 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. The Category one options are those that are likely to be implemented ahead of the Category two 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 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 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 ~~a~~ 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 the 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. Full Environmental Assessment Reports (EARs) have been prepared for the options which are most likely to be implemented should a Level 3 risk arise based on magnitude of environmental impact, water resources benefit and ease of implementation. For the remainder of the drought permit options, preliminary Environmental Assessment Reports (pEARs) have been prepared. A programme of baseline monitoring has been undertaken to inform the completion of the environmental assessment reports.

Drought permits are categorised into Category 1 and Category 2 the former being generally less environmentally damaging than the latter and therefore more likely to be implemented. 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 given in Appendix C would form the basis of the order in which options are used in a drought.

Due to the prevailing drought conditions which had affected a number of TWUL's water resource zones (WRZs), TWUL was planning for the possibility of applying for a number of drought permits / orders to be implemented in 2012. TWUL was progressing with preparing comprehensive EARs for these drought options which, for each drought option, were based on TWUL applying for a single drought permit / order for a six month period (time-limited).

Due to the improved water resources situation following rainfall in April 2012, there was no longer a requirement for applying for these drought permits / orders for implementation in 2012. However, TWUL has made a strategic decision to progress with the completion of 12 EARs on the basis that experiences of the drought suggested that these drought permit / order options are the ones most likely to be used in the future and for which "application-ready" reports will be required. These are referred to as " EARs".

For the remaining drought permit / order options, whilst these options are less likely to be implemented, TWUL has prepared EARs which are intended to comply with the DPG, but which are less comprehensive than the EARs. These are referred to as " pEARs.

Therefore, Category 1 and 2 options, as described in the Drought Plan, do not necessarily correspond with EARs and pEARs as described above.

All EARs and pEARs were reviewed and updated to accompany potential drought permit options during 2012. All EARs and pEARs have been further updated for the 2016 Drought Plan to take into account further data collected since 2012 and any revisions to the assessed impact of the DP options. The updated EARs and pEARs have been prepared in accordance with Government regulations and good practice guidance, including the EA Drought Plan Guideline updated in 2016. Thames Water has liaised closely with the EA to ensure it is satisfied with the approach and outcomes of the EARs reports.

In preparation for and during a drought Thames Water 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.

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 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 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.

Thames Water 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 the finding of alternative sources of raw water.

Assessment of any potential derogation resulting from Thames Water's 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 Thames Water has undertaken an assessment of the likelihood of this occurring and has 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. Thames Water has discussed this 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. Thames Water and RWE Generation UK 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 Thames Water will pursue the option of insurance against the potential for compensation in liaison with RWE Generation UK.

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.

Thames Water 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 19 Abstractors potentially requiring compensation/mitigation (update this table).

Drought permit or order option	Abstractor/ Licence Holder	Risk to licence
Lower Thames	Private abstraction – Shepperton Marina Private abstraction – Kingston upon Thames	Low 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 Hammpton (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. Thames Water's 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 manged 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 Thames Water's licensed sources are fully utilised. There are a few 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.

Thames Water has 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

These are options to be considered beyond Level 3 and 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.

With the exception of the last mentioned category - in extremis options - each of these supply-side options are discussed below in turn for each WRZ; in extremis options are discussed in the final sub-section.

6.2. London WRZ

This section should be read in conjunction with the Addendum at the start of the document.

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 is one disused sources that could be recommissioned. Thames Water's Merton source is currently out of service and the deployable output is declared as zero. Significant investment is required to return the source to operation and so it is intended that this will be included as a requirement for our AMP7 (2020-2025) Business Plan and will be included as an option in our WRMP19. Our Drought Plan will be revised as necessary following the redevelopment of this option in AMP7.

6.2.1. 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 430 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 20, which gives the schemes' contribution to London WRZ's supply capability.

Table 20 Benefit provided by Strategic Schemes

Scheme	Benefit Ml/d
North London Artificial Recharge Scheme (NLARS)	220 to 156
Hoddesden Transfer scheme	12.5
Thames Gateway Water Treatment Works (TGWTW)	Up to 150 (see section 6.2.1.3)
West Berkshire Groundwater Scheme (WBGWS)	123 to 66
Small scale groundwater schemes • ELRED, Stratford Box and Old Ford • Chingford Artificial Recharge Scheme (CHARS)	 27.8 15.1 to 10.6

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

6.2.1.1. Triggers

With the exception of NLARS and the WBGWS, the trigger for switching on all the strategic schemes (see Table 21 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 21 Triggers for Strategic Schemes

Scheme	Trigger
NLARS	**NLARS Operating Agreement: Teddington target flow reduces down to 600/400Mld curve (Level 1 curve on LTCD)**

Scheme	Trigger
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.
Hoddesdon	Internal operating rule: as per TGWTW
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 flow 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.

6.2.1.2. 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.

NLARS is operated in accordance with the North London Artificial Recharge Scheme Operating Agreement between Thames Water and the EA, dated 25th March 2014.

6.2.1.3. Thames Gateway Water Treatment Works (TGWTW)

This section should be read in conjunction with the Addendum at the start of the document.

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 150 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.

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 and subsequently operating the site in 2012, 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.

Thames Water can confirm that Thames Gateway has the capability to achieve 150Ml/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 in 2011, 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. In particular, 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 will require further investment in WRMP19.

6.2.1.4. Hoddesdon Transfer Scheme

The Hoddesdon Transfer Scheme involves transferring flow from Deephams STW catchment to Rye Meads STW catchment via an 18.9km, 600mm diameter pipeline and a new sewage pumping station. The transfer increases the volume of water in the River Lee diversion channel and allows increased abstraction during periods of drought. It has an estimated net benefit to the London water resource system of 12.5 Ml/d.

The implementation time for this supply-side measure is at least 28 days and is dependent on Rye Meads operation being sufficiently stable to take the additional flows.

6.2.1.5. 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. 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. Thames Water 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 measures of Thames Water's Levels of Service (enhanced media campaign and sprinkler ban). Under the new protocol, in a severe drought, a TUB would be in place in a severe drought well before this trigger was reached, effectively exceeding the Level 2 demand management measures.

A benefit of some 123 Ml/d reducing to 66 Ml/d in a prolonged drought is provided by the scheme.

The implementation time for full operation is between 2 - 21 days.

6.2.1.6. 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 of 15.3 Ml/d and this contributes to the provision of 28 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.

6.2.2. Bulk supplies

Within the Thames Water supply area, London has the majority of its bulk supply options. However, because most of the bulk supply agreements were drawn up at a time when London tended to have a surplus during times of raw water scarcity, there is a net export of water to surrounding companies. During the London WRZ's period of supply-demand deficit prior to 2010, Thames Water has explored with its neighbouring water companies on several occasions the possibility of terminating, or at least reducing, its exports.

Table 22 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 such that 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. Thames Water will however endeavour to assist other water companies in the situation where its 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 2 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 the TUB and Essex and Suffolk Water have not.

Imports	Exports
	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; agreement exists for supply to Affinity Water's South WRZ of up to 10 Ml/d from Kempton Park but can be reduced to 0 Ml/d during drought.
	Sutton and East Surrey Water - agreement exists to supply up to 13.6 Ml/d. S&ES 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. 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 23. 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 Temporary Use Bans 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 23 Bulk Transfer to Essex and Suffolk Water

	Average daily Ml/d	Maximum daily Ml/d
Provision during non-drought periods Provision during drought	90.92 71	118.2
Provision during drought periods (25% reduction) if TUB is imposed in Thame's Waters supply area but not Essex and Suffolk's	53	88.65

The process for implementation of this provision involves dialogue between the 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, Thames Water will inform Essex and Suffolk Water and 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. Thames Water 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 have not imposed a TUB but Thames Water have, then Essex and Suffolk Water will keep Thames Water informed on the likely date of their 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 Thames Water is 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 DD11 order. If this situation occurred 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.

Sutton and East Surrey Water

The bulk supply agreement between Thames Water and Sutton and East Surrey Water provides for a supply of up to 13.6 Ml/d via Thames Water's pumping station at Merton. Thames Water has agreed to maintain the supply during drought, if required by Sutton and East Surrey Water, as long as there is no risk to supply to Thames Water customers. The provision of the bulk supply would be likely to be unavailable if Thames Water had implemented a DD11 order measure. Sutton and East Surrey Water has not required the full 13.6 Ml/d in recent years.

Affinity Water

- Kempton Park to Affinity Water.
- This bulk supply agreement is for the provision of 10 Ml/d to Affinity Water, with the provision of a greater volume in emergencies, if available. Thames Water would suspend this provision during drought if the continued bulk supply resulted in risk to supplying Thames Water customers.
- Fortis Green
- This bulk supply is for a maximum of 27 Ml/d although Affinity Water has a maximum requirement of only 12.2 Ml/d. This supply would be maintained during a drought unless continued supply was prevented by unusual drought.
- 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.

New bulk supply opportunities

Affinity Water, in its Water Resources Management Plan 2014, identified the potential for new bulk supplies to become available over a ten year period with provision for extension depending upon its future supply demand balance from its supply area. This has been agreed and the bulk supply is set to increase over the planning period; in 2015 to 11.8 Ml/d (implemented), in 2018 to 12.6 Ml/d, in 2034 to 16.1 Ml/d. Thames Water continues to be in discussions with Affinity Water on this potential option.

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

6.2.3. 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 well field.
- South London groundwater
- Relaxation of annual limit at Waddon

SWOX WRZ

6.2.4. Optimisation of existing sources

Over the last four years supply capability has been made more robust by improving the connectivity from Thames Water's 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.

6.2.5. Strategic resources

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

6.2.6. 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 Thames Water customers.

6.2.7. Drought permits

Drought permit options form an important part of SWOX WRZ's plan. All the possible options and their order of priority within Category 1 and Category 2 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 the disused Meysey Hampton summer boreholes. This would be followed by the options at Latton and then Baunton, the latter being in Category 2.

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 have 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. An additional option would be to abstract from the Sor Brook when the flow constraint is in place. Thames Water will discuss the requirement for a Drought Permit with the Canal and River Trust and 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.

Following this option, the potential for drought permits at Axford and Ogbourne are included but these would be of lower priority than the options above because of the potential impact on the River Kennet.

6.2.8. Recommissioning

The re-commissioning of Compton pumping station has been included as a drought permit option although it is considered that this would be likely only under extreme circumstances as the re-commissioning would require substantial capital works in order for the source to be used. The source would also require nitrate treatment.

The option for a drought permit at Blewbury 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 can only be pursued if the current high nitrate levels are addressed. Thames Water no longer holds 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. The need for a drought permit for Blewbury is only necessary following the transfer of the licence to Gatehampton. Any use of the Blewbury source under a drought permit in the future would require the temporary installation of nitrate treatment equipment. A further option will be available following the closure of Childrey Warren in 2020 as the source will be retained for use in severe drought conditions.

6.3. Kennet Valley WRZ

6.3.1. Existing sources

During low flow conditions Pangbourne groundwater source is subject to a reduction in abstraction. This places more importance on the Fobney WTW.

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 at Pangbourne 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 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 WTW 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.

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

All sources can operate normally in this zone.

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 Ladymeade via Park Barn	2.2Ml/d	2.2Ml/d

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.

6.5. Slough/Wycombe/Aylesbury WRZ

6.5.1. Existing sources

There are no vulnerable sources in this zone and all sources can operate normally under drought conditions experienced historically.

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 Slough/Wycombe/Aylesbury zone is a drought permit option to allow abstraction at New Ground pumping station. A further option has become available following the reduction in licence at Pann Mill involving a return to the previous deployable output volume.

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.

6.7. In extremis options

In extremis options would generally be considered in situations more severe than Level 3 of Thames Water's Levels of Service hierarchy. The categories are outlined below.

6.7.1. 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.

6.7.2. Tankering

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.

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.

Thames Water recognises that certain external measures would need to be put in place before the option can be considered to be available but these can be remedied fairly quickly.

6.7.3. 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.

6.7.4. 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.

Potential options also include reuse of Deephams effluent which was considered/tested in the 1976 drought.

6.7.5. Back, pumping over Lower Thames Weirs

As mentioned in Section 7.1.6 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.

6.8. Permits and approvals required for drought options implementation.

Thames Water has reviewed requirements for permits and approvals arising from drought option implementation. These are shown in Table 25 below.

Table 25 Permits and approvals likely to be required prior to implementing drought options.

Option	Action	Consents that may be required

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. Thames Water recognises 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
Compton	Minor construction works including temporary water treatment facility	• 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

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

Section 7. Communications Strategy

7.1. Introduction

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.

7.2. Objectives

An important factor in developing the revised 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 the Thames Water drought 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.

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 pro-actively. 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.
- 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).

- Full information about Thames Water's 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.

7.4. Stakeholders

It is important to clearly identify stakeholders and their individual communication needs.

7.4.1. Environment Agency (EA)

Throughout the drought event Thames Water will work closely with the EA. During the course of a drought event the EA will fulfil technical, advisory and regulatory roles. As discussed in Section 2, Thames Water depends 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), Thames Water will discuss with the EA the possibility of drought order/drought permit applications, see Appendix C. Central to its 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, see sub-section 3.6. Also Thames Water is required to consult with the EA with regard to the operating agreements for its water resource schemes, for example to switch on NLARS or the TGWTW desalination scheme. A detailed description of the interactions with the EA is given in Appendix K.

7.4.2. Other key stakeholders for the water industry

These include Defra, Ofwat, DWI, Natural England, CCWater and Port of London Authority (PLA). Where necessary these organisations will be consulted and informed on the development of the drought situation and proposed measures. To this end, Thames Water will arrange a liaison protocol with each of these organisations.

Thames Water recognises 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.

7.4.3. Water companies and Water UK

Water companies, regulators and customers alike all agree that water use restrictions should be implemented in a clear and consistent manner across the South East. For example, in his letter of 14 January 2011 to Thames Water, Richard Benyon, the Minister for Natural Environment and Fisheries at the time, expressed a particular concern that had been raised on the risk of confusion for customers in neighbouring areas where different approaches are taken and stated that it would be helpful if consideration could be given on how to avoid such confusion. Thames Water subsequently took the lead in coordinating communications across the affected companies.

The need for water companies to review their Drought Plans to incorporate the Temporary Use Ban powers provided an opportunity to work towards a consistent approach.

In 2011 Thames Water agreed, with unanimous support from most of the other companies in the South East to work towards a consistent approach, although it was acknowledged that due to inherent differences in water resource systems and variations in rainfall patterns, it was unlikely that the implementation of restrictions could always be simultaneously applied across the South East. However, the reasons for any differences should be understood and clearly explained to customers. It was agreed that a joint statement, see Box 1 below, explaining the position should be included in each updated company Drought Plan for the purpose of aiding customer communication.

In 2011 companies discussed progress towards their implementation policy for incorporating the new legislation. Generally companies would introduce the TUB measures in one phase, although some companies that were solely reliant on groundwater sources had decided on a more gradual introduction involving two or three phases. With regard to exemptions, a minimalist approach had been adopted by all companies. The two main exemptions on using a hosepipe were for undue commercial impact largely on businesses whose income depended largely on the banned activity and the elderly or disabled whose impairment was such that they were physically unable to cope with watering their garden, plants or allotment with a watering can. In implementing the banned activities under DD 11, all companies would apply to the Secretary of State for the full powers. It was felt in this case that if such powers were needed the drought would have to be posing a serious risk to supplies and so maximum water use savings should be aimed for.

Water UK will play an important role in ensuring clear and consistent communication between the water companies and their customers. During the drought of 2011/2012 a Water Resources in the South East (WRSE) communications group was set up which greatly helped with communicating a clear and consistent message to customers. It is expected that this would be instigated in any future drought.

Box 1 South East companies - Joint Statement

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 prior to treatment 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.

Unlike unseasonably dry soil that constitutes an agricultural drought and which can arise from only a few weeks of dry and sunny weather over the growing season, it takes at least several months of below average rainfall to initiate a water resources drought. Particularly important is winter rainfall as it is this that replenishes most water resources. The low groundwater levels and river flows that result from this type of dry period reduce water availability from rivers and boreholes, and reservoir levels fall. This 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 for later in a drought and reduce the environmental impacts of abstraction during this critical period.

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 among some customers when one company introduces restrictions but its neighbouring company does not. Clearly from a customer point of view, if restrictions need to be imposed then a simple and consistent approach should be adopted for introducing water use restrictions across the South East. Where your water company has to appeal for restraint or impose restrictions, it will always give as much information to you as possible. 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 may cause differing levels of drought severity across the region. In other words, the need to impose restrictions for one company may not equally apply to another company in the South East.

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 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 preferentially in its more vulnerable WRZs while it may not need to extend the ban to the remaining zones in its area of supply. 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 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 interpreting the new powers as consistently as possible. However, due to the local differences highlighted above, not all plans will be the same as each other.

7.4.4. Support services

Thames Water will be proactive in its 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.

7.4.1. 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 will be multiple retail providers to non-household customers throughout England including in Thames Region. Thames Water remains the wholesale provider for water supply in the Thames supply area and has 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.

Implementation of Temporary Use Bans

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

Implementation of Drought Orders

TWUL Wholesale will inform retailers operating within 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

Thames Water 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. 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 will 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.

Social media, including Twitter and Facebook, will be used alongside media and web communications channels to reinforce drought messages to customers familiar with digital media.

Thames Water also aims to integrate drought messages where possible with other communications material, for example on water efficiency.

These communication methods will, as in 2012, need to be supplemented by proactive advertising, moving from radio to printed communications 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.

7.6. 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 while 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:

- The crossing of enhanced media campaign triggers on the relevant control diagrams.
- The announcement and implementation of sprinkler and / or TUB, including their formal notification and allowance for and consideration of representations.
- The application for and implementation of DD11 Ordinary Drought Order
- 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.

7.7. Consultation, feedback and effectiveness of communications

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

The Drought Plan will be available on the Thames Water website, at the headquarters in Reading and the Customer Centre in Swindon.

Effectiveness of communications will be monitored throughout the drought event. Thames Water 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 with regards to the drought.

Other opportunities to provide feedback on a daily basis will include the Thames Water website and our Customer Centre.

Periodic surveys using a range of research techniques will be conducted throughout the course of a drought event. The aim will be to gauge the effectiveness of communications and 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.

7.8. Learning points from 2012 drought

Thames Water's customers responded well to communications in the 2012 drought.

Learning points included:

- It is important to demonstrate and communicate Thames Water's 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 the customer 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.

7.9. Learning points from customer survey research 2011

Customer research conducted in June and July 2011 (see Appendix L3), sought views and attitudes on the water restriction measures within the TUB and DD11 legislation, 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 2016 and so are retained as key features informing the communications plan.

The main findings in respect of key learning points for customer communication were as follows:

- The media campaign is essentially the first phase of any drought management plan and the messages given out here are likely to stick throughout the drought event.
- The most important questions to which customers are seeking answers are the basic ones around the 'what', 'why' and 'when' elements of the drought and its management, namely:
- What is a drought and why are we having one now?
- What may happen if no action is taken?
- What do you want customers to do, why and when?
- In the meantime, what are you the water company doing about it?
- Differentiation across the supply area (London versus Thames Valley) both in regard to overall message and garden/allotment ownership or non-ownership is unnecessary.

With specific regard to the TUB, the key findings can be summarised as follows:

- Overall, garden or allotment ownership appeared to have little impact on views.
- No significant difference in attitude between London and Thames Valley customers.
- Almost half of respondents would not be affected by any of the measures.
- The top three activities affecting the most respondents were:
    - Watering a garden or allotment using a hosepipe
    - Watering plants on domestic properties using a hosepipe
    - Cleaning a private vehicle using a hosepipe
- 75% of respondents agree with restrictions on five or more proposed TUB measures, 21% agreed with all.
- Younger respondents (16 to 34) were more negative about the ban and had lower levels of agreement with all of the individual measures.

The overall conclusion is that the media campaign should start well in advance of any imposition of restrictions and it should focus on setting out clearly the measures that are likely to follow.

7.10. Communications Plan

An outline of Thames Water's 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 Thames Water is 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, installing a free cistern device in older-style toilets cuts the amount used per flush. Also, water gardens by hand using a watering can rather than by unattended hosepipe.
- The drought has been caused by a lack of rainfall, which has depleted local water resources.
- Thames Water realises there is a particular onus on it to reduce wastage – for example, by fixing leaks – in order to encourage customers to help conserve supplies.

7.10.3. Target Audiences

- Staff
- Domestic customers, with particular emphasis on the younger age groups, see S7.9.
- School pupils
- Local authorities
- Groups particularly affected by restrictions, e.g. allotment owners, turf growers.
- Business customers

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 Defra guidelines ask companies to test the 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 existing and revised protocols against the full range of criteria specified within the Defra Directions and EA guidelines.

In addition the requirements of the Water Company Drought Plan Guideline 2015 state that: *'Your plan should include how you'll deal with a range of droughts including both long duration and very low rainfall relative to expected conditions in your water resource zones (WRZs). You should at least plan to be able to provide supplies through a repeat of historic droughts in your company records. However, we strongly encourage you to plan for drought events that are of longer duration and lower rainfall than those in the historic record, or if not you should explain why. You should understand what drought events your supply system is vulnerable to and what the probability of such an event occurring is.'*

In light of this requirement Thames Water has tested its 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 Thames Valley WRZs.

The approach for the London system has been to use 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.

The stochastic weather and flow generator that has been developed to enable the stochastic approach to drought assessment for WRMP19 is based on the rainfall and potential evapotranspiration (PET) properties that were demonstrated within the 20th Century, 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 contained in WARMS2) 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. 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) which is at the same spatial scale as is used within the WARMS2 model. This data can therefore be 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 the revised plan to be considered effective, or fit for purpose, Thames Water considers 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. Worked Examples - 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 the 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 is being undertaken for Thames Water as part of its WRMP19 modelling investigations. Unlike the 2013 Drought Plan 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. It should be noted that this does not currently include expected forecast increases in population or the effects of climate change on water availability that may have an effect over the duration of the Drought Plan (2017 to 2022).

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

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

Impact of stochastically generated droughts

Analysis of the impact of stochastically generated droughts has also been included, following guidance from the Environment Agency. The analysis is based on the large data set generated from the stochastic analysis. From this large data set, a 'library' of droughts of known relative severity was selected to represent a wide range of return periods. A total 40 droughts were selected for this library as this covered a wide range of potential return periods, from less than 1 in 10 years through to around 1 in 1000 years, at yield increments of 15Ml/d. This 'library' therefore represented sufficient numbers of droughts to adequately describe the return period – yield relationship curve for the Thames-London system. All droughts in the 'library' were run through Thames Water's WARMS2 water resources model to allow the identification of drought sequences of known severities that could be used to test the Drought Plan interventions.

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 193/34). 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 300 years, and 'extreme' droughts with a return period of approximately 1 in 500 years. The 1 in 300 return period droughts incorporated two separate events, which allowed for some additional examination of the interaction between the pattern and duration of droughts and the benefits that could be gained as a result of drought permits during those droughts.

All three droughts 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 2016 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 2016 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 these three droughts on the aggregated London reservoir storage under the Lower Thames Operating Agreement, with and without Drought Permits, is shown in Figure 14, Figure 15 and Figure 16.

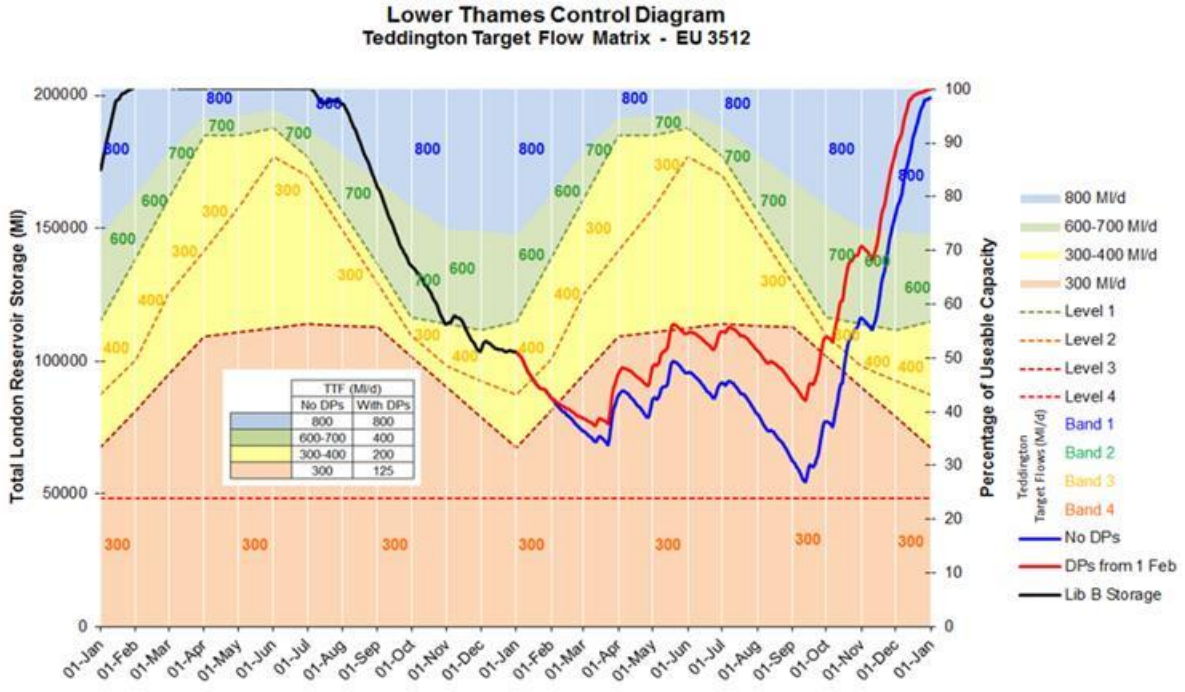


Figure 14 Impact of the Generated 'Severe' Drought Event 1 (modelled 1 in 300 Return Period) on Aggregated London Reservoir Storage – example 1

Implementation of measures during a more severe drought

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 12). In the example shown in Figure 14 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 this case the drought progression indicated by the reservoir control curves show that this would mean that a media campaign would begin in October. In this severe drought example a TUB would be implemented from November over the winter months, which would have a relatively smaller impact on demand when compared to implementation of a TUB in the summer, but would still be important given falling reservoir storage and low groundwater levels and the importance of ensuring all measures are implemented at the right time to ensure subsequent measures can be implemented. A DD11 non-essential use ban and Drought Permits would be implemented 10 weeks later at the end of January/start of February in line with crossing level 3 on the control diagram.

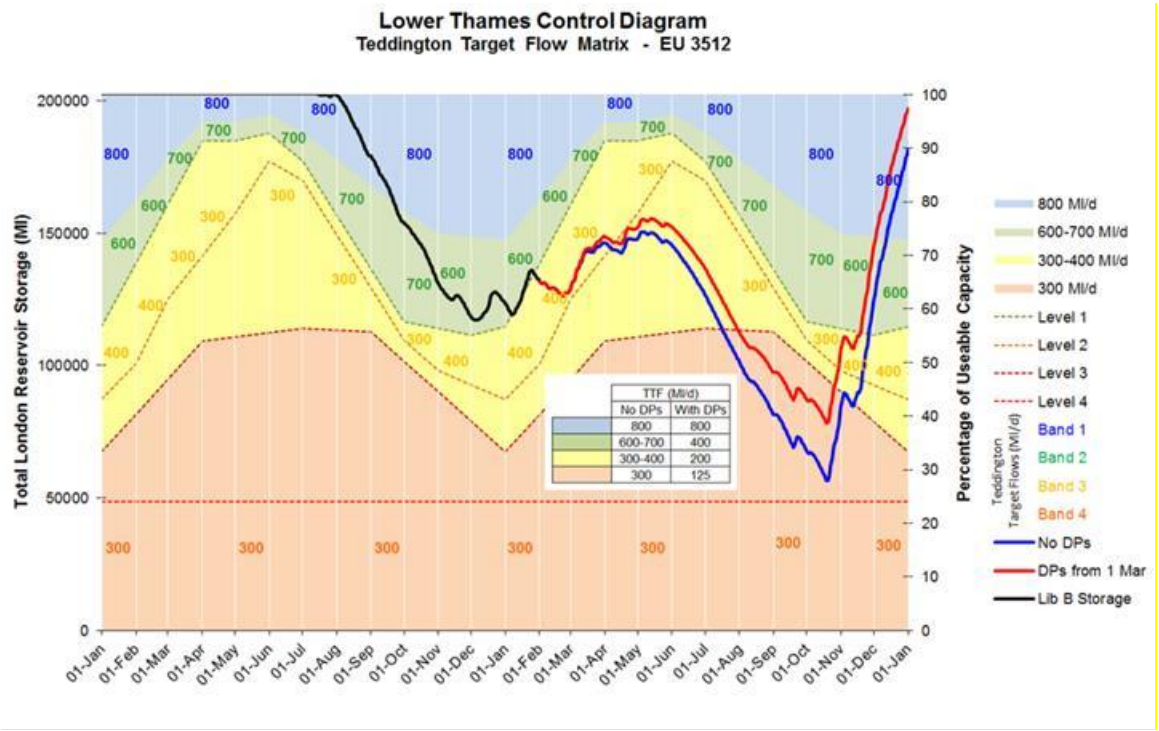


Figure 15 Impact of the Generated 'Severe' Drought Event 2 (modelled 1 in 300 Return Period) on Aggregated London Reservoir Storage – example 2

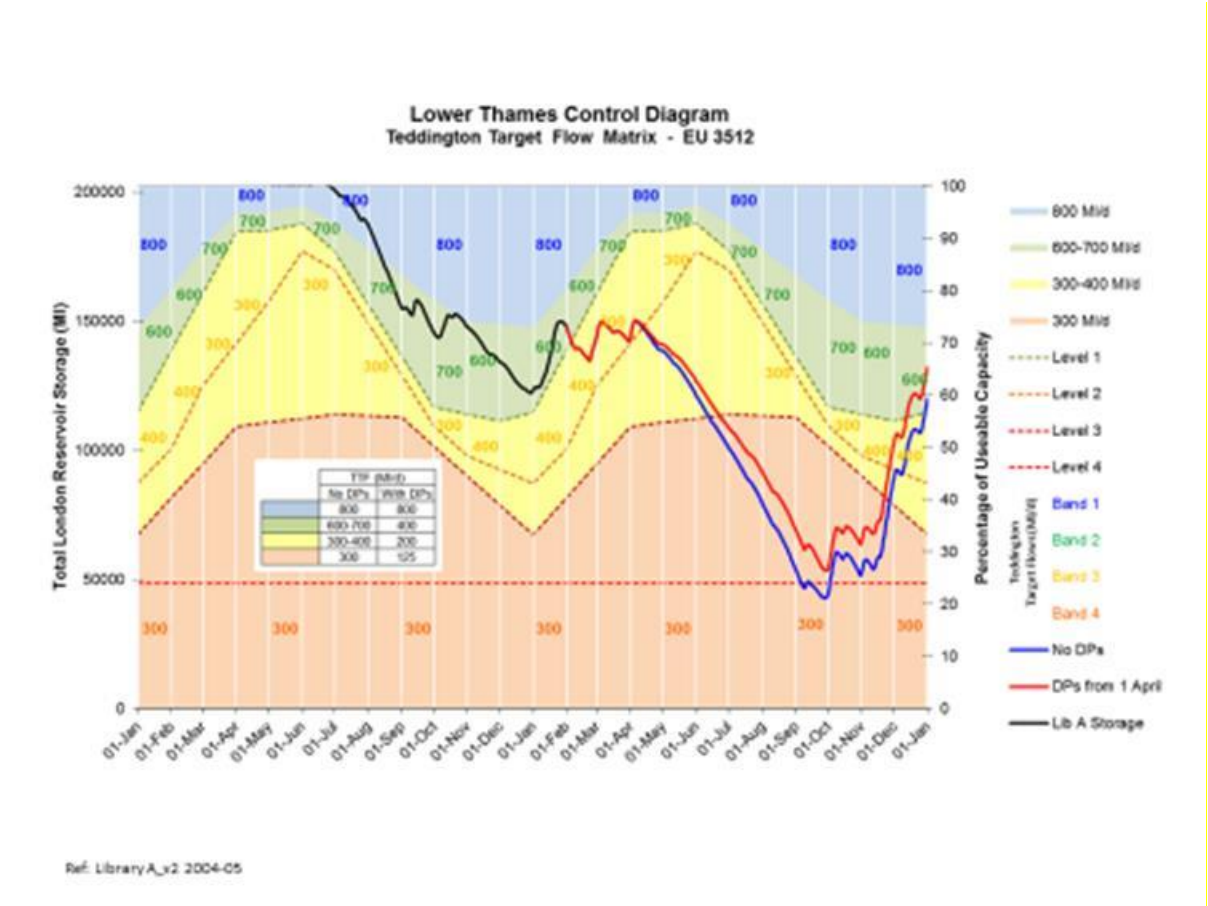


Figure 16 Impact of the Generated 'Extreme' Drought Event 3 (modelled 1 in 500 Return Period) on Aggregated London Reservoir Storage

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 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 benefit of the Drought Permits are variable and depend upon the nature and pattern of the drought, and was smallest for the more severe (1 in 500) event. These graphs also indicate that, although the permits are potentially effective, 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).

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, even under an extreme scenario not seen in the historic record, although to the significant detriment of the environment. The examples demonstrate all the effectiveness criteria listed above, 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. 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.

The full analysis of the stochastic assessment of droughts for the drought plan is given in Appendix N. 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 three droughts selected for analysis in the London WRZ were

also run through the SWOX component of WARMS. The results of the analysis are shown in Figure 17-19

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 1932-34. A comparison of the available abstraction during the 1921 and 1976 events at Farmoor (taken from the WARMS2 model) are provided in Figures 20 and 21 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.

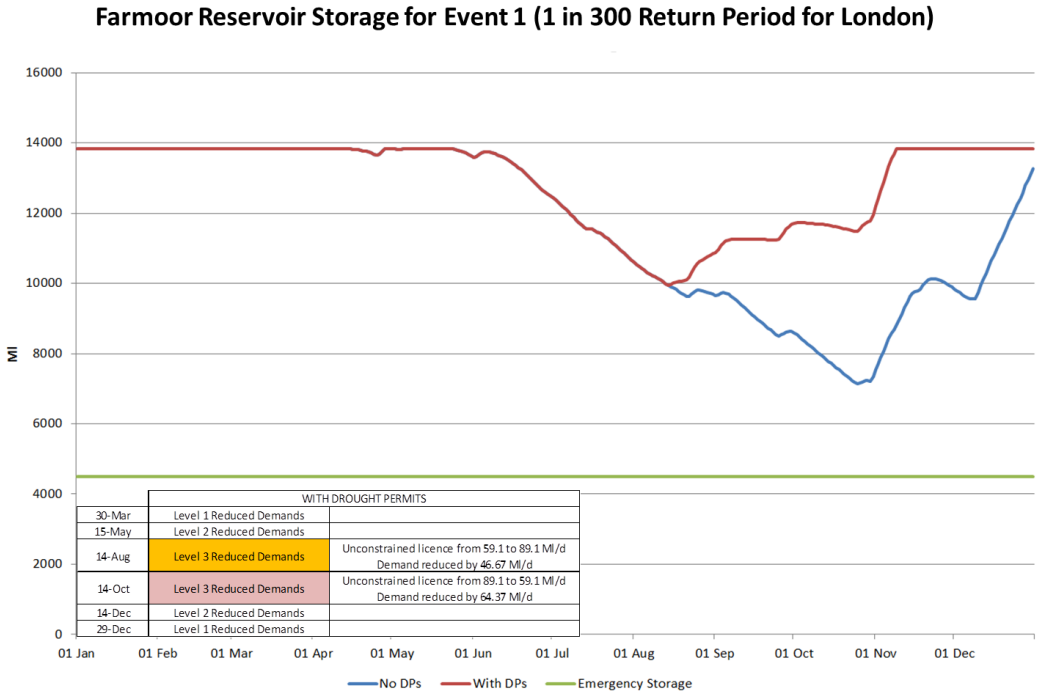


Figure 17 Impact on Farmoor Reservoir Storage of the Severe Events Generated for London, 1 in 300 return period

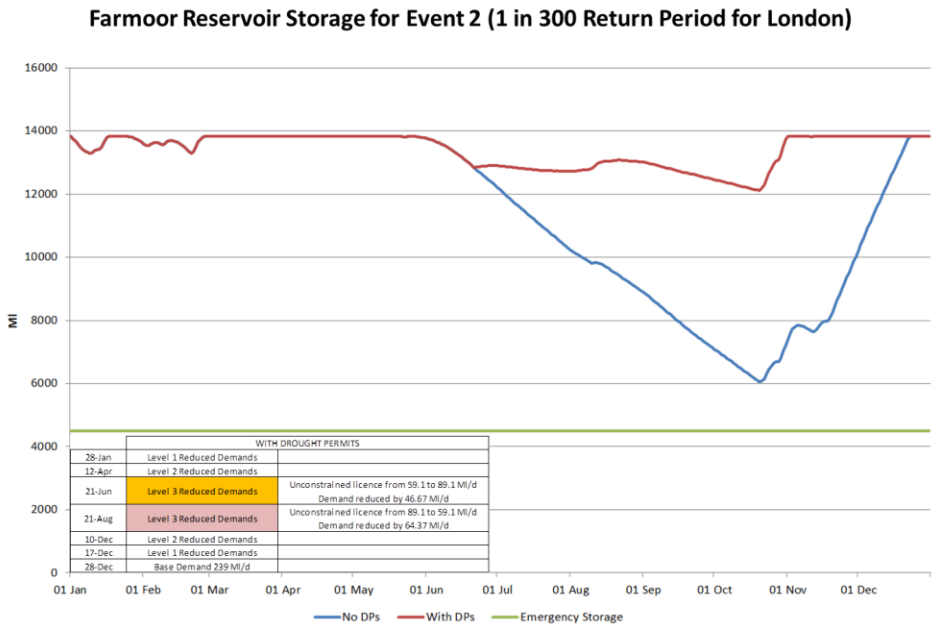


Figure 18 Impact on Farmoor Reservoir Storage of the Severe Events Generated for London, 1 in 300 return period

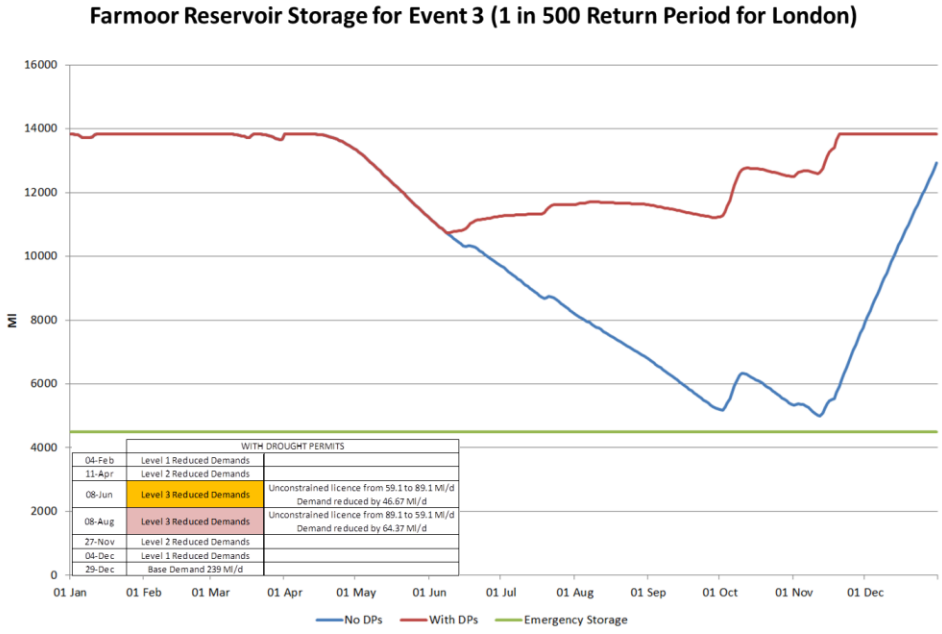


Figure 19 Impact on Farmoor Reservoir Storage of the Severe Events Generated for London, 1 in 500 return period

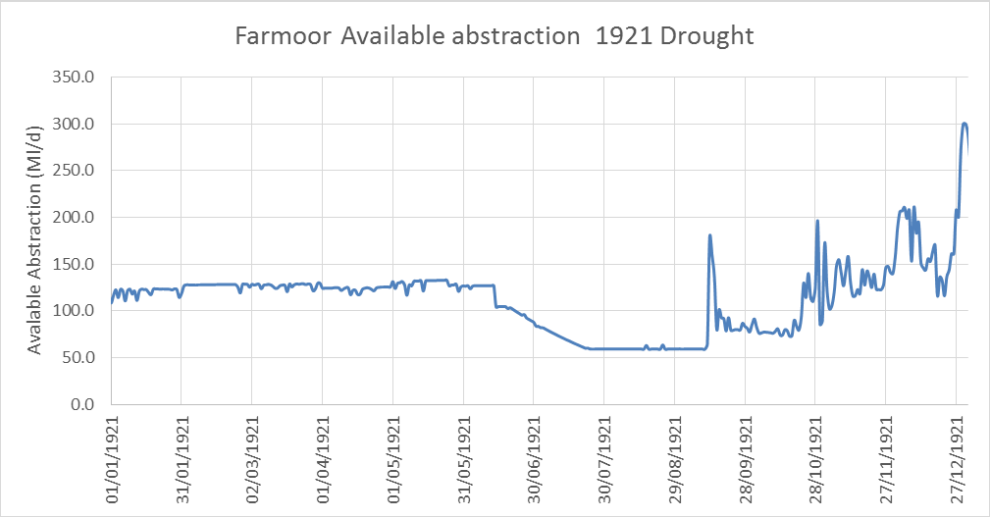


Figure 20 Farmoor available abstraction during the 1921 Drought

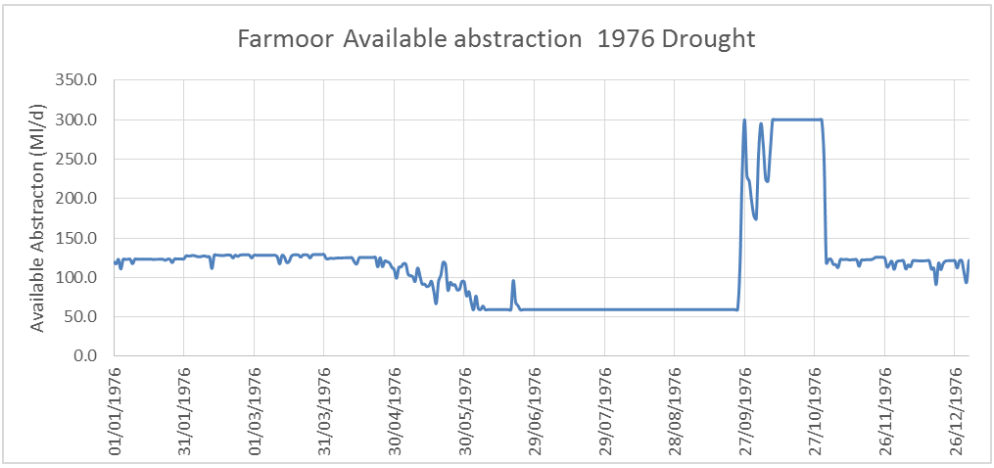


Figure 21 Farmoor available abstraction during the 1976 Drought

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 22 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.

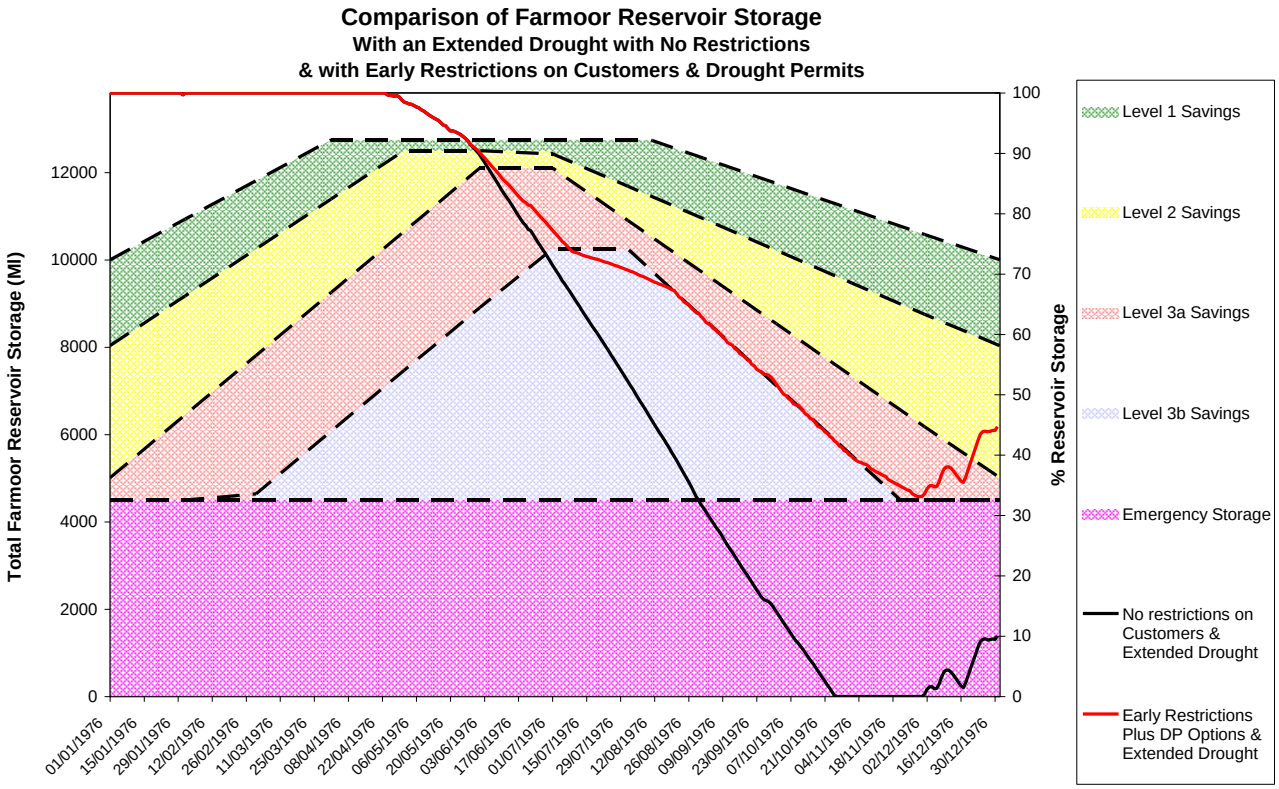


Figure 22 Farmoor reservoir storage for an *extended* 1976 test scenario

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 2016 Drought Plan. Therefore an 'extended 1976 drought', which was included in the 2013 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 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. However, because rainfall-runoff models were not available for the two key main surface water resources in these WRZs (the River Kennet at Theale and the River Wey at Tilford), a fully stochastically based analysis, as carried out for the London reservoirs, could not be carried out. However, by using Extreme Value Analysis (EVA), based on the rainfall and Potential Evapotranspiration (PET) outputs from the stochastic weather generator, it was possible to analyse the severity of the simple generated events described in the sections below.

8.3.1. 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 WTW 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. Therefore, 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 23 below. It can be seen that during the lowest flow period from July through to the end of August, the flow past Fobney WTW 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).

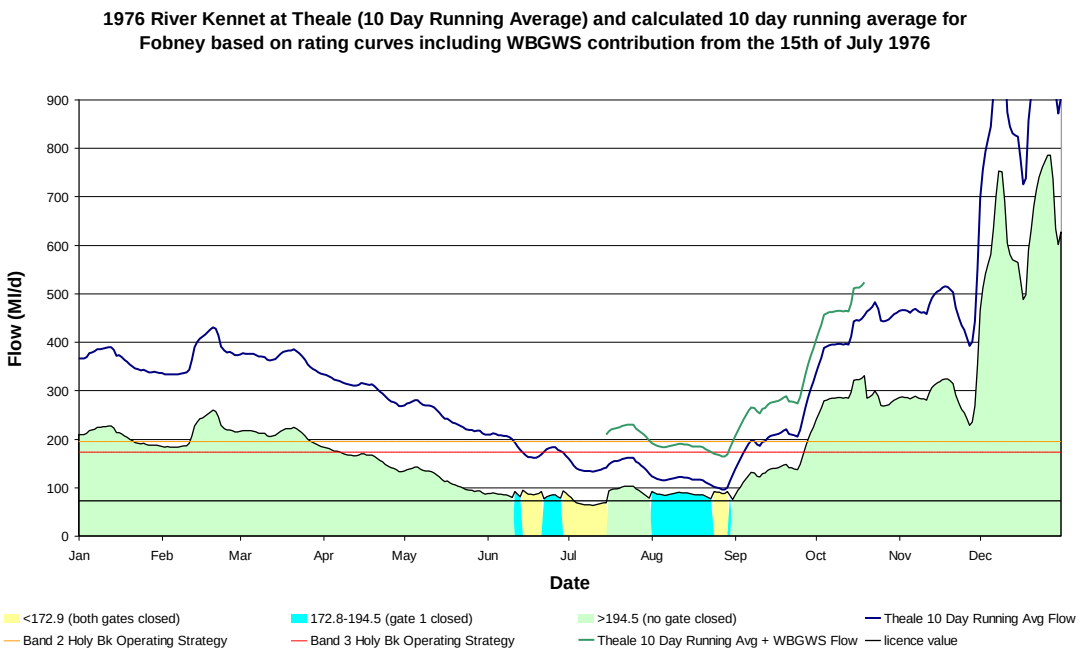


Figure 23 Flows at Theale and Fobney WTW for 1976 test scenario

Impact of worst case scenario of extended 1976 drought

As in the London and SWOX examples, Figure 24 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.

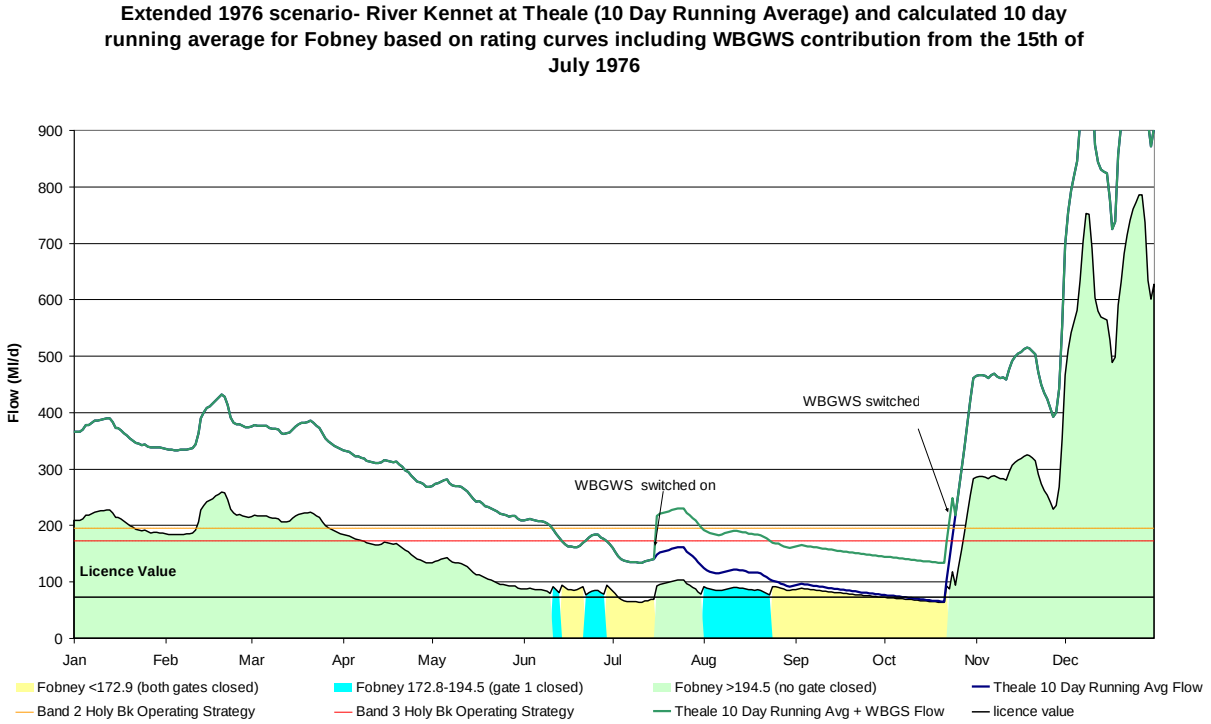


Figure 24 Flows at Theale and Fobney WTW for an *extended* 1976 test scenario

Drought Permits

Because of the inadequate flows past the Fobney WTW during extremely low flow periods with WBGWS in operation, to ensure that Fobney WTW and the Kennet Valley WRZ can meet demand, drought permit options would be made operationally available by the closure of Gate 2.The contribution from drought permits for these groundwater sources is estimated to 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 above Figure 24. 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 historic record in order to demonstrate the resilience of the Drought Plan for those areas not supplied by the surface water abstraction. This analysis was based directly on observed groundwater hydrographs and did not incorporate the stochastic weather generation. If the risk to water resources in these WRZs is considered significant in the future then this analysis could be extended to include distributed groundwater modelling based on the stochastically generated weather data sets.

There are three groundwater sources within the Kennet Valley WRZ that have a Source Deployable Output (SDO) that is potentially vulnerable to drought severity. Where possible, 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 WRMP. This relies on the anticipated change in groundwater levels at an indicator borehole during the analysed relevant drought, which is then translated into an impact on SDO through curve shifting in the source DO diagram. The drought vulnerable sources and associated indicator boreholes that were examined in this analysis for the Kennet Valley WRZ were:

- The Bishops Green source (Briff Lane composite OBH)
- The Fognam Down source (Sparsholt composite OBH)
- The Pangbourne source (Bucklebury composite OBH)

The analysis of expected OBH groundwater levels for severe droughts was carried out using conventional extreme value analysis techniques that allow the extrapolation of recorded groundwater levels based on the observed groundwater level/return period relationship. This approach relies on fitting probability distributions to observed minimum groundwater levels, and using those probability distributions to estimate what the expected groundwater level would be at a given drought Return Period.

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

- 1 in 200 groundwater level (GWL) return period drought = 3.1 Ml/d lower than the 'baseline' and 2.3 Ml/d lower than the worst historic (i.e. WRMP14 hindcast source DO)
- 1 in 500 GWL return period drought = 6.2 Ml/d lower than the 'baseline' and 5.4 Ml/d lower than the worst historic

In the event of a drought of this severity occurring (i.e. greater than 1:200 yr return period) the shortfall in PDO would need to be made up through a combination of demand reductions and the provision of resource 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 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 WTW.

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 WTW. 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 WTW. 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).

The results of the EVA analysis (based on a Standard Evaporation and Precipitation Index (SEPI) trend analysis) for the Kennet catchment indicates that the drought scenario that has been tested is extremely severe, with a likelihood of occurrence less than 0.002 (1 in 500 year Return Period). The Fobney source therefore appears to be very resilient to drought risk under the current climate. The full analysis of the EVA assessment of droughts for the Kennet Valley WRZ is given in Appendix N.

8.3.2. 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).

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 26 below.

As can be seen in Figure 25, 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 sprinkler and 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 26 Indicative Flow Triggers for Guildford WRZ

Measure	Flow rate
Sprinkler ban	90 Ml/d (on average for 5 days)
Temporary Use Ban	85 Ml/d (on average for 5 days)
DD11 order	75 Ml/d (on average for 5 days)
Drought permit	75 Ml/d (on average for 5 days)

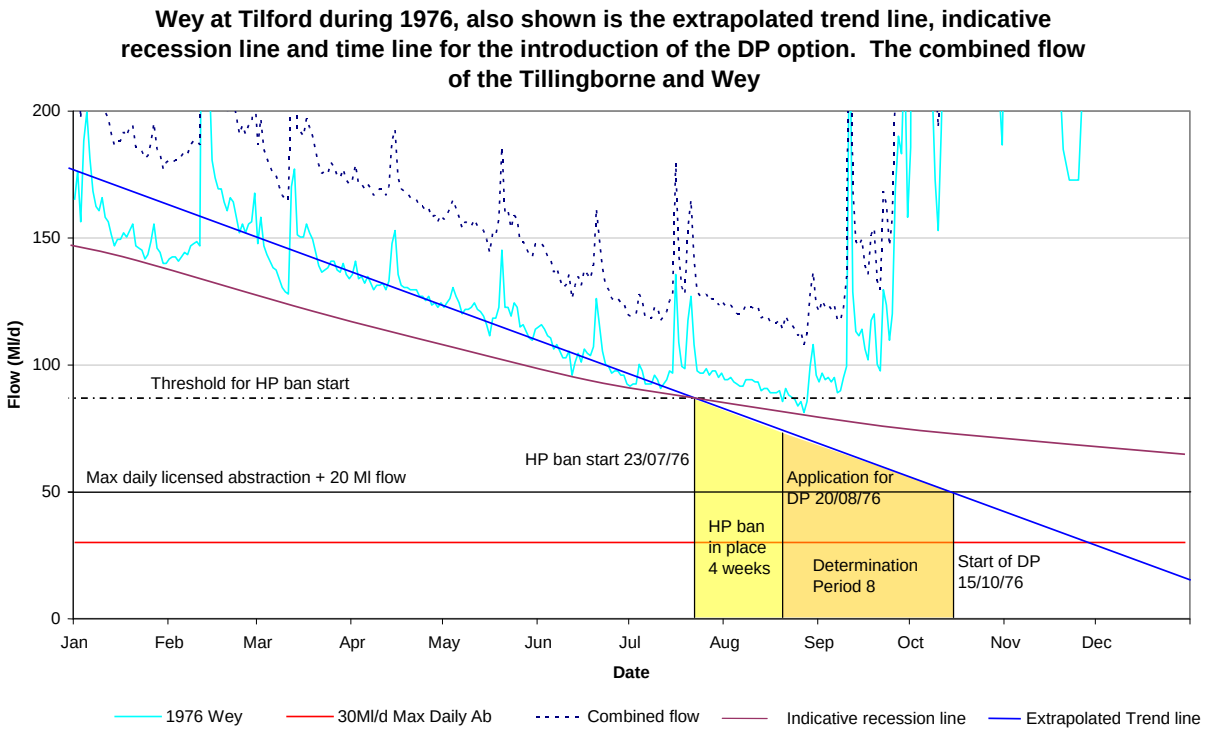


Figure 25 Wey at Tilford 1976 and drought permit options, also shown is the flow in the Wey combined with the flow in the Tillingbourne as a dashed line.

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 historic record in order to demonstrate the resilience of the Drought Plan for those areas not supplied by the surface water abstraction. This analysis was based directly on observed groundwater hydrographs and did not incorporate the stochastic weather generation. If the risk to water resources in these WRZs is considered significant in the future then this analysis could be extended to include distributed groundwater modelling based on the stochastically generated weather data sets.

There are two groundwater sources within the Guildford WRZ that have a Source Deployable Output (SDO) that is potentially vulnerable to drought severity. Where possible, 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 WRMP. This relies on the anticipated change in groundwater levels at an indicator borehole during the analysed relevant drought, which is then translated into an impact on SDO through curve shifting in the source DO diagram. The drought vulnerable sources and associated indicator boreholes that were examined in this analysis for the Guildford WRZ were:

- Ladymead source8 (Tile Barn Farm composite OBH)
- Sturt Road spring source (Frith Cottage composite OBH)

The analysis of expected OBH groundwater levels for severe droughts was carried out using conventional extreme value analysis techniques that allow the extrapolation of recorded groundwater levels based on the observed groundwater level/return period relationship. This approach relies on fitting probability distributions to observed minimum groundwater levels, and using those probability distributions to estimate what the expected groundwater level would be at a given drought Return Period.

This analysis indicated the following potential drought PDO reductions:

- 1 in 200 GWL return period drought = 1.4 Ml/d lower than the 'baseline' and 0.4 Ml/d lower than the worst historic
- 1 in 500 GWL return period drought = 1.6 Ml/d lower than the 'baseline' and 0.6 Ml/d lower than the worst historic

In the event of a drought of this severity occurring (i.e. greater than 1:200 yr return period) the shortfall in PDO 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 ample 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).

The results of the EVA analysis (based on a Standard Evaporation and Precipitation Index (SEPI) trend analysis) for the Wey catchment indicates that the drought scenario that has been tested is extremely severe, with a likelihood of occurrence less than 0.002 (1 in 500 year Return Period). The Shalford source therefore appears to be very resilient to drought risk under the current climate. The full analysis of the EVA assessment of droughts for the Guildford WRZ is given in Appendix N.

8.4. S/W/A and Henley

To demonstrate the effectiveness of the drought management protocol for the S/W/A 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. 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

[8] The Ladymead drought curve has been re-assessed since WRMP14, and is now considered by Thames Water to be more drought resilient than shown here, but a conservative assessment that is compatible with WRMP14 has been provided in this report to allow for direct comparison with the WRMP.

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 S/W/A 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 S/W/A and Henley drought protocol is the 1976 scenario.

Using 1976 historic groundwater conditions, the S/W/A and Henley protocol would have triggered various drought management measures as set out in Table 26. 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 S/W/A 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 summarized in Table 27, taking precedence over decisions made using the S/W/A and Henley protocol.

Table 27 Triggering of 1976 drought measures in S/W/A & Henley WRZs

Measures	Timing	
	S/W/A & Henley	London
Enhanced abstraction performance & demand monitoring	Early Feb 1976	Not defined
Sprinkler & 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 S/W/A 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 26. In this instance, with a drought permit application having been made by end 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 New Ground groundwater abstraction under a drought permit, an additional deployable output of around 6 Ml/d would be available, thus balancing the deployable output reduction at other sources.

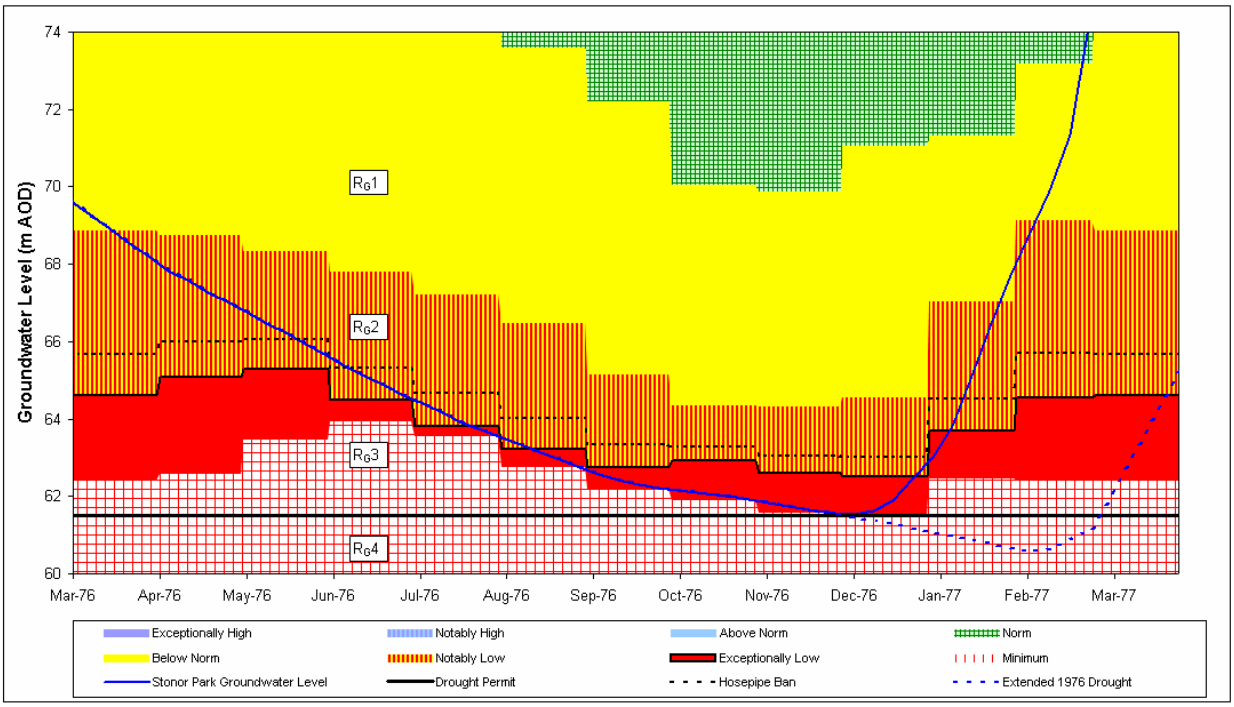


Figure 26 Groundwater Control Curves for Stonor Park OBH for extended 1976 drought

Extreme Value Analysis (EVA), based on the rainfall and Potential Evapotranspiration (PET) outputs from the stochastic weather generator has been used to analyse the severity of the simple generated events described in the sections above.

The drought resilience of these two WRZs was tested under the Source Peak Deployable Output (PDO) condition, based on return period analysis of groundwater minima. Following updates to DO in WRMP14, there is no identified drought vulnerability within the Henley WRZ. For SWA there are four sources that were identified as being potentially drought vulnerable under PDO conditions:

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

All of these sources are represented by the Champneys, Tring OBH. An extreme value analysis, similar to that carried out for the Henley and Guildford WRZs described above, was therefore carried out for the Champneys OBH in order to estimate the change in groundwater level and hence DO that could be expected during a 1 in 200 and 1 in 500 year drought event.

This analysis indicates the following potential drought PDO reductions for the SWA WRZ

- 1 in 200 GWL return period drought = 6.6 Ml/d lower than the 'baseline' and 3.5 Ml/d lower than the worst historic
- 1 in 500 GWL return period drought = 8.5 Ml/d lower than the 'baseline' and 4.4 Ml/d lower than the worst historic

In the event of a drought of this severity occurring (i.e. greater than 1:200 yr return period) the shortfall in PDO would need to be made up through a combination of demand reductions and the provision of resource 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 S/W/A and Henley WRZ protocol. A similar situation would have occurred in the extended 1976 drought scenario. Implementation of the S/W/A 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 EVA analysis for the S/W/A and Henley WRZs indicates that the drought scenarios that have been tested are extremely severe, with a likelihood of occurrence greater than 1 in 200 year Return Period. The S/W/A and Henley WRZs therefore appear to be very resilient to drought risk under the current climate. 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. The full analysis of the EVA assessment of droughts for the S/W/A and Henley WRZs is given in Appendix N.

8.5. Summary and conclusions

By simulating water resources conditions that are worse that any on historic record, the stochastic droughts are considered to be an exacting test for demonstrating the effectiveness of the plan. The tests for all six zones were shown to demonstrate their adherence 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. Further work is required to include the effects of forecast population increase and climate change and demonstrate the impact this has on results. This will be included in WRMP19.

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. 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. 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 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 300 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 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.

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, S/W/A and Henley WRZs against more severe droughts as required by the guidance. However, because rainfall-runoff models were not available for these WRZs a fully stochastically based analysis, as carried out for the London reservoirs, could not be carried out. However, by using Extreme Value Analysis (EVA), based on the rainfall and Potential Evapotranspiration (PET) outputs from the stochastic weather generator, it was possible to analyse the severity of the simple generated events described in the sections above. The results of the EVA analysis for the Kennet Valley, Guildford, S/W/A and Henley catchment indicate that the drought scenarios that have been tested are extremely severe. The surface water and groundwater sources therefore appear to be very 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 2013. This draft Drought Plan includes amendments to comply with the requirements of the Water Company Drought Plan Guideline 2015. The principal update to the plan is the inclusion of an assessment of how we would deal with droughts of greater severity than experienced in the hydrological record.

The draft Drought Plan retains the methodologies and protocols given in Drought Plan 2013, which, in turn, incorporated the lessons learnt from the 2012 and 2005/2006 droughts. 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 Thames Water's 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 L4
- Consultee representations from the December 2011 public consultation process and ongoing stakeholder dialogue.
- The experience gained from implementing a TUB in 2012

Thames Water retains the proposal to introduce all eleven categories of use of the Temporary Use Ban legislation in a single phase that replaces the previous hosepipe ban restrictions as part of Level 3 of the Company's Levels of Service. However, within this set of restrictions, exemptions will be for:

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 (n.b. a list of sporting events exempt under a TUB or

DD11 will be published on the Thames Water website and will be 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.

vi) 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.

Exemptions i), ii) and iv) will be allowed to run through the drought event.

Exemptions iii), v) and vi) will be removed if and when DD11 measures are introduced.

The new exemptions were supported by customers and their inclusion in the implementation policy represents an approach that minimises any complication to the message to customers and which is consistent with the 2nd principle of proportionality in the Code of Practice. 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.

DD11 restrictions ~~will~~ 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 uses in a single phase.

Thames Water has undertaken a Strategic Environmental Assessment (SEA) for its Drought Plan but does not consider that it is a statutory requirement that an SEA is completed. However the SEA has been undertaken in order to provide a formal review of the environmental impact of the options for drought management included within its 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. Thames Water has also undertaken a Habitats Regulations Assessment (HRA) of its 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 the Plan to be considered effective, or fit for purpose, Thames Water considers 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 revised 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. 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 Drought Direction 2011 order and drought permits, thereby addressing the principal concern of Defra and the EA on Drought Plan 2010.

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.

The stochastic analysis demonstrates that the S/W/A and Henley protocols provide a straightforward methodology for anticipating and managing drought measures. This enables early drought permit applications so as to allow their implementation at the time groundwater levels decline below the historic minimum for the Chilterns Chalk aquifer.

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, riverflows and associated reservoir storage.

Further to the testing described above and following guidance from the Environment Agency, Thames Water has 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 historical record. Unlike the 2013 Drought Plan 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.

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 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 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 300 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. 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.

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 h6ave 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, S/W/A and Henley WRZs against more severe droughts as required by the guidance. However, because rainfall-runoff models were not available for the two key main surface water resources in these WRZs (the River Kennet at Theale and the River Wey at Tilford), a fully stochastically based analysis, as carried out for the London reservoirs, could not be carried out. However, by using Extreme Value Analysis (EVA), based on the rainfall and Potential Evapotranspiration (PET) outputs from the stochastic weather generator, it was possible to analyse the severity of the simple generated events described in the sections below. The results of the EVA analysis for the Kennet Valley, Guildford, S/W/A and Henley catchment indicate that the drought scenarios that have been tested are extremely severe. The surface water and groundwater sources therefore appear to be very resilient to drought risk under the current climate within 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

DD11 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, riverflows, 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 historical 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.