Thames Water Utilities Limited

Environmental Assessment of Severe Droughts – Summary Report

Final

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*As part of a share purchase agreement in August 2015, Cascade Consulting (Environment & Planning) Ltd transferred its business to Ricardo plc. All employees transferred to Ricardo Energy & Environment, a trading name of Ricardo-AEA Ltd which is a wholly owned subsidiary of Ricardo plc. The work described in this report spanned the pre-acquisition and post-acquisition period and throughout this time the consultants involved maintained a continuity of service both as employees of Cascade Consulting and then subsequently as employees of Ricardo Energy & Environment.

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NON- TECHNICAL SUMMARY

Thames Water submitted its draft Drought Plan and associated documents to the Department of Environment, Food and Rural Affairs (Defra) for review. Following this review, Defra instructed Thames Water to undertake public consultation. The public consultation period was undertaken from 6th January for 6 weeks, ending on the 17th February 2017. The revised draft, including any changes related to consultation responses and associated documents were submitted to the Secretary of State on the 21st April 2017 for their review and approval. The final Drought Plan will be added to the website once it has been approved by Defra.

In April 2018, Defra reviewed the Thames Water draft plan, the representations received in response to the public consultation, the SoR, and the EA's advice to the Secretary of State. Thames Water is preparing the final draft of the Drought Plan taking into account the directions received from the Secretary of State. Following the review of the above documents Defra has indicated that it would like to see additional considerations made to the revised draft Plan. Defra indicated that it has made a recommendation to the Secretary of State that the revised draft Drought Plan should be published as a final plan. Defra has noted that Thames Water has provided further information on the timing and sequencing of its actions and provided detailed assessments for re-application of two of its drought permit options (Latton and Lower Thames options). Defra has, however, requested a high-level summary covering the remaining drought actions to understand the significance of the environmental impacts of these actions.

The purpose of this report is, therefore, to provide a high-level summary of the environmental impacts of Thames Water's drought actions in droughts worse than record ('severe droughts'). In the context of this report, severe droughts refer to droughts with a return period of 1:200 or greater. These droughts are considered to be multi-season droughts that could require a re-application for drought permits/orders beyond their original 6 months.

It is acknowledged that not all of the 51 drought options included in the Final Drought Plan 2018 would be available to Thames Water during a severe (multi-season) drought, this will require an assessment of the available yield for some drought options for continued abstraction beyond a six-month drought permit abstraction for drought permit re-application purposes. The summary of the potential impacts relating to a multi-season drought include a total of 20 drought options (as confirmed by Thames Water):

- Latton[1] and Lower Thames[2] (as already documented),

[1] Cascade Consulting (2017). Environmental Assessment of the Latton Drought Permit (re-application). Revised Draft. March 2017
[2] Cascade Consulting (2017). Environmental Assessment of the Lower Thames Drought Permit (re-application). Revised Draft. March 2017

- Baunton 2, Farmoor, Meysey Hampton, Pangbourne, Sundridge 2, Waddon, Ogbourne 1, Ogbourne Emergency Boreholes, Axford 2, M2 Licence, Eynsford, Horton Kirby, Fobney Direct, Harpsden & Sheeplands, New Ground, Shalford, Albury, and Pann Mill.

Overall findings of the environmental impacts of Thames Water's drought actions in 'severe droughts'

The Environmental Assessments Reports (EARs) of the drought options, which were prepared to support the Final Drought Plan 2018, have been used as a basis to inform this high level environmental assessment of the 20 drought permit options. The assessment has considered potential impacts on key physical environment features (e.g. hydrological, geohydrological, water quality, etc.) and key environmentally sensitive features (e.g. fish communities, designated sites and species, etc.).

The significance of the potential impacts associated with the re-application of drought permits/orders beyond their original 6 months, are summarised in **Appendix A**. It was concluded that additional impacts ranging from negligible to major adverse could be observed on both the physical environment and environmentally sensitive features. The most significant changes to the physical and environmental features following re-application of a drought permit are observed at:

- Lower Thames
- Baunton 2
- Sundridge 2
- Ogbourne 1
- Ogbourne Emergency Boreholes
- Axford 2
- Eynsford
- Pangbourne
- Meysey Hampton

The assessment of the potential changes in the significance of impacts on the environmental features did not consider any mitigation measures beyond those identified in the original EARs. Additional mitigation measures, over and above those stated in the EARs, have been identified for consideration. However, it should be noted that discussions would need to be held between Thames Water and the regulators to determine and agree the specific mitigation measures to be implemented, which would depend on the specific conditions in the event of a severe drought and the preceding antecedent conditions during the first application.

Implications of 'severe droughts' on the Habitat Regulations Assessment (HRA) of the Drought Plan

The screening exercise undertaken to inform the Habitat Regulations Assessment for the Final Drought Plan 2018 was reviewed to determine whether any changes in the impacts associated

with the re-application of a drought option could have implications on any European sites. The changes considered includes changes in: the likely periods (timing) for re-application; the extent of the study area associated with the selected drought options; the recovery periods; and the impacts on the physical and environmental features. The review indicated that no European sites (Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) and Ramsar sites) will be impacted by any drought options in a severe drought.

Implications of 'severe droughts' on the Strategic Environmental Assessment (SEA) of the Drought Plan

SEA provides information on the relative environmental performance of alternatives (i.e. individual drought options) and is intended to make the decision-making process more transparent. The SEA can, therefore, be used to support the timing and implementation of drought options within the DP.

SEA of Thames Water's Revised Draft DP has been reviewed, in order to determine the significance of the potential impacts associated with the re-application of a drought permit beyond a single six month period, i.e. for severe droughts. This review was informed by the high-level assessment of the environmental impacts of Thames Water's drought actions in 'severe droughts'. The SEA review indicated that certain drought options (including Baunton 2, Sundridge 2, Ogbourne 1, Ogbourne Emergency Boreholes, Axford 2, Eynsford, Pangbourne and Meysey Hampton) resulted in an increase in potential residual adverse effects for various SEA objectives, such as: biodiversity; population and human health; water; soil, geology and land use; and air and climate. It was considered that there will be no change to any beneficial effects.

Implications of 'severe droughts' on the Water Framework Assessment (WFD) of the Drought Plan

In the Environmental Assessment Reports (EARs) (which have been prepared for each of the supply side drought permit / order sites) for the first application drought permits, each relevant biological status element (for rivers these are fish, aquatic macroinvertebrates, macrophytes and diatoms) was included in the features screening. Where appropriate, these features were assessed in the EAR, including an assessment of the risk to Water Framework (WFD) status reduction, both in the short-term and over recovery timescales commensurate with the definition of temporary deterioration. The re-application assessments have considered this in the context of a multi-season drought, albeit at a higher, less detailed, level of assessment. Individual drought permit re-applications would likely lead to risk of temporary WFD status deterioration.

Extreme low flows as a result of an environmental drought (without drought permits) may have major effects on aquatic habitats, biota, and consequently ecosystem functions. It is generally recognised that multi-season droughts in sensitive water bodies could result in impacts on the ecological communities of a high magnitude with communities only recovering

in the long-term. Most water bodies within the Thames Water operational area have been physically modified. As such, these water bodies are less resilient to the impacts of environmental drought and sensitive to the extended implementation of drought permits. The re-application of some drought permits could result in some local populations being lost due to a lack of suitable habitat. As the duration and impacts associated with drought and drought permits increase, the effect on biota is likely to increase in severity from the individual to a catchment/regional level. As such, there is a high risk that temporary deterioration in WFD status associated with a severe environmental drought will be exacerbated through the re-application of individual drought permits, affecting several WFD elements with recovery only expected over the long term.

1 INTRODUCTION

1.1 BACKGROUND TO THAMES WATER DROUGHT PLAN

The Thames Water Utilities Ltd. (Thames Water) Final Drought Plan 2018 covers the next 5 years, up to 2023, and demonstrates how Thames Water will react to a period of unusually low rainfall. The Drought Plan meets the Environment Agency's (EA) Drought Plan Guidelines (DPG)[3] 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:

1. Its planned levels of service, for the twentieth century droughts in the historic record
2. A range of more severe drought scenarios, although with greater uncertainty and increased environmental and economic impact.

Because the plan is required to address the next 5 years only, it does not include allowance for 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.

Thames Water submitted its draft Drought Plan and associated documents to the Department of Environment, Food and Rural Affairs (Defra) for review. Following this review, Defra instructed Thames Water to undertake public consultation. The public consultation period was undertaken from 6th January for 6 weeks, ending on the 17th February 2017. The documents included in the consultation were the draft Drought Plan and associated appendices, the draft Strategic Environmental Assessment report and draft Habitats Regulations Assessment report and the drought permit Environmental Assessment Reports (EARs). Following the consultation period, Thames Water produced a Statement of Response (SoR). The revised draft, including any changes related to consultation responses and associated documents were submitted to the Secretary of State on the 21st April 2017 for their review and approval.

The Final Drought Plan will be added to the website once it has been approved by Defra.

1.2 PURPOSE OF THE REPORT

In April 2018, Defra reviewed the Thames Water revised draft Drought Plan, the representations received in response to the public consultation, the SoR, and the EA's advice to the Secretary of State. Thames Water is preparing the final draft of the Drought Plan taking into account the directions received from the Secretary of State.

Following the review of the above documents, Defra has indicated that it would like to see

[3] Environment Agency (2015) How to write and publish a Drought Plan, Updated April 2017. Available at https://www.gov.uk/government/collections/how-to-write-and-publish-a-drought-plan

additional considerations made to the revised draft Drought Plan. Defra indicated that it has made a recommendation to the Secretary of State that the revised draft Drought Plan should be published as a final plan, but with the inclusion of commitment to reducing leakage and minor updates to yields associated with the West Berkshire Groundwater Scheme.

In addition, Defra has noted that Thames Water has provided further information on the timing and sequencing of its actions and provided detailed assessments for re-application of two of its drought permit options (Latton and Lower Thames options). Defra has, however, requested a high-level summary covering the remaining drought actions to understand the significance of the environmental impacts of these actions.

Defra has also noted that the Drought Plan states: '*greater resource development is required in order to protect the environment from potentially severe damage in droughts of this return period (1:500 years)*.' Defra has indicated that insufficient justification was provided to support this statement. Defra indicated that any assessments should demonstrate that resource development is needed to protect the environment, including the expected frequency of such actions and the impacts compared to the baseline.

The purpose of this report is, therefore, to provide a high-level summary of the environmental impacts of Thames Water's drought actions in droughts worse than record ('severe droughts'). In the context of this report, severe droughts refer to droughts with a return period of 1:200 or greater. These droughts are considered multi-season droughts that could require a re-application for drought permits/orders beyond their original 6 months.

1.3 STRUCTURE OF THE REPORT

This report includes the following sections:

- A background to Thames Water's draft Drought Plan and the consultation process is provided in **Section 1**. Section 1 also includes information regarding the purpose of this report.

- The approach to the assessments undertaken in this report is provided in **Section 2**. This section also includes a brief summary of the approach included in the draft Drought Plan[4] for assessing severe droughts and includes a summary of the approach adopted within this report. This section also includes a summary of the key assumptions informing the assessments undertaken in this report.

- The key physical environment features (e.g. hydrological, geohydrological, water quality, etc.) that were considered in the assessment and the general impacts of a

[4] Thames Water Utilities Ltd (2017). Draft Drought Plan. Report Revised Draft April 2017.

severe drought are summarised in **Section 3**.

- The key environmentally sensitive features (e.g. fish communities, designated sites and species, etc.) that were considered in the assessment and the general impacts of a severe drought record are summarised in **Section 4**.

- **Section 5** provides more detail regarding the potential impacts specific to each drought permit option considered in this assessment. This includes the assumption regarding the timing associated with each drought permit option.

- **Section 6** considers actions that would be required to monitor and mitigate environmental impacts.

- **Section 7** provides a summary of the implications of severe droughts in relation to the Habitat Regulations Assessment (HRA), the Water Framework Directive (WFD) and Strategic Environmental Assessment (SEA).

2 APPROACH

2.1 DROUGHT OPTIONS CONSIDERED FOR DROUGHT PERMIT RE-APPLICATION

It is acknowledged that not all of the drought options included in the Final Drought Plan 2018 would be available to Thames Water during a severe (multi-season) drought, which will require an assessment of the available yield for some drought options and the continued abstraction beyond a six-month drought permit abstraction for drought permit re-application purposes. The summary of the potential impacts related to a multi-season drought include a total of 20 drought options (as confirmed by Thames Water):

- Latton[5] and Lower Thames[6] (as already documented),
- Baunton 2, Farmoor, Meysey Hampton, Pangbourne, Sundridge 2, Waddon, Ogbourne 1, Ogbourne Emergency Borehole, Axford 2, M2 Licence, Eynsford, Horton Kirby, Fobney Direct, Harpsden & Sheeplands, New Ground, Shalford, Albury, and Pann Mill.

The following drought permit options are considered to have an unreliable yield in a drought of greater than 6 months and so they have not been considered in this assessment:

- **Bibury**
  Yield would reduce due to likely very low groundwater levels in the Oolites in a prolonged drought. This drought permit option relies on continued discharge from an artesian borehole and natural spring discharges, augmented by abstraction from the production boreholes. Based on current spring flows, there is significant uncertainty that these flows plus the artesian flows would be sustained in an extended severe drought. This would likely require additional abstraction from the production boreholes and so impact the benefit of the proposed drought permit option.

- **Compton**
  The Compton source would provide no more yield in a severe drought as it would be at the expense of the WBGWS which would already be running. The yield of the WBGWS and Compton running concurrently would provide no more yield than WBGWS on its own and so it is very unlikely this option would be pursued in a severe drought.

- **Blewbury**
  Yield would reduce due to likely very low chalk groundwater levels in Chalk scarp slope location in a prolonged drought. Groundwater yield from these boreholes is strongly

[5] Cascade Consulting (2017). Environmental Assessment of the Latton Drought Permit (re-application). Revised Draft. March 2017
[6] Cascade Consulting (2017). Environmental Assessment of the Lower Thames Drought Permit (re-application). Revised Draft. March 2017

influenced by the defined Deepest Advisable Pumping Water Level (DAPWL) which was historically the constraint on deployable output. It is probable that in a severe drought, groundwater levels could decline further resulting in outputs declining below the potential deployable output.

- **Playhatch**
  Drought permit yield above licence would be potentially unrealisable due to very low groundwater levels in the Chalk in a prolonged drought. Groundwater yield from these boreholes is influenced by a hydrogeologically defined Deepest Advisable Pumping Water Level (DAPWL) and is the current constraint on the potential yield. The drought permit option seeks to take advantage of additional yield available above the current licence limit. However, it is probable that in a severe drought, groundwater levels could decline further resulting in outputs declining to or even below the current deployable output, which would impact the benefit of the proposed drought permit option.

- **Childrey Warren**
  Yield would reduce due to likely very low chalk groundwater levels in Chalk scarp slope in a prolonged drought. Groundwater yield from these boreholes is strongly influenced by a hydrogeologically defined Deepest Advisable Pumping Water Level (DAPWL) and is the current constraint on deployable output. Historically, this resulted in deployable output reductions when considering droughts that have lower groundwater levels. It is likely that in a severe drought, groundwater levels could decline further resulting in outputs declining below the potential deployable output.

- **Oxford Canal**
  Yield unlikely to be available from Canal and Rivers Trust without new resources to support the canal transfer. This option was not available in the 2012 drought due to the drought severity in the Midlands region.

- **Sor Brook**
  Yield unlikely to be available due to very low flows in the Sor Brook in a prolonged drought as the Sor Brook has very low baseflow component due to predominantly clay catchment.

- **Wansunt & Crayford**
  Drought permit yield above licence would be potentially unrealisable due to very low groundwater levels in the Chalk in a prolonged drought. There is very little knowledge of the hydrogeological performance of these abstractions beyond their licence limits. Test pumping is required to investigate and confirm their capability to deliver the

outputs proposed in the drought permit option. Until such test pumping is carried out, the extension of the option to beyond 6 months in a severe drought is not warranted.

- **Fobney Emergency boreholes**
  Drought permit yield would be potentially unrealisable due to very low groundwater levels in the gravels in a prolonged drought. The Superficial Gravels have higher groundwater storage potential relative to the Chalk but the aquifer in the Fobney area is thin. With normal groundwater levels, the Gravels would be expected to provide baseline to the Kennet and possibly the Holy Brook. As groundwater levels decline during a persistent, severe drought, it is possible that this connection will be lost and losses from the rivers would reach a minimum, as a result of low river bed permeability, while groundwater levels continue to decline.

2.2 STOCHASTIC APPORACH

Thames Water, in preparation for the draft Drought Plan and the Draft WRMP19, has already carried out detailed analysis of more severe droughts using a stochastic approach to generate a drought library of plausible more extreme droughts than occur in the historical record. Although this approach shows that Thames Water can maintain supply, the approach also shows that their current asset base will be placed under great strain, impacting the capability of the water system and would have a significant detrimental effect on the economy, environment and ecology. The return periods and risks considered within the 2013 and 2018 final Drought Plan are summarised in **Table 2.1**.

Table 2-1: Risk associated with the different return periods considered in the 2013 and 2018 Drought Plans respectively

	Historic Droughts	**Stochastic Drought Events**	
	1:125 year	1:300 year	1:500 year
	Drought Plan 2013	Drought Plan 2018*	
Hydrological Capability			
Drought Permit Acceptance			

* Final Drought Plan 2018 also still covers the 1:125 year (green, low risk; amber, moderate risk; red; high risk)

The 2018 Drought Plan guidance includes a requirement to examine drought risks beyond those seen in the historical record. A number of techniques were used for this analysis within the Thames Water Drought Plan. These included methods that rely on the outputs from the stochastic water resources modelling programme that has been undertaken for Thames Water as part of its draft 2019 Water Resource Management Plan (WRMP19) modelling investigations. Unlike the 2013 Drought Plan, the 2018 Final Drought Plan 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'.

2.3 FINAL DROUGHT PLAN 2018 SEVERE DROUGHT ENVIRONMENTAL IMPACTS

The final Drought Plan completed in 2018 included a proposed approach to producing Environmental Assessments Reports (EARs) in support of re-application of drought permits on expiry of their original six-month period of implementation. Such circumstances could occur in a prolonged environmental drought over multiple seasons, as demonstrated in the stochastic drought assessment.

As indicated in Section 2.2 above, the 'stochastic droughts' include droughts that are more severe than those seen in the historical record and therefore require implementation of drought permits for longer than previously assessed in the EARs that support the 2018 final Drought Plan. The analysis of 'stochastic droughts' identifies that extending those conditions does not necessarily lead to drought permit re-application, or where re-application is triggered that environmental drought conditions persist throughout the second six-month period.

The main focus of amending EARs in preparation of a re-application considered the following:

- Confirmation of the existing study area (reaches)
- Re-assessment of the hydrological impact in the study reaches
- Review of the effects on the physical environment in support of the features assessment
- Changes in the baseline to include appropriate antecedent conditions and representative reference conditions
- Changes in the assessment of the environmental features against the antecedent conditions and reference conditions
- Reconsideration of the mitigation options and their implications for the Environmental Monitoring Plan.

This approach was considered in the final Drought Plan 2018 in the context of the Latton and the Lower Thames drought permit EARs to provide an indication of the key findings and considerations for the re-application of drought permits in a severe drought. For both the Latton and Lower Thames drought permit EARs, it was assumed that the drought permit re-application could potentially start in any month of the year, although it is anticipated to be applied for during the hydrological winter (the months of October to March inclusive) following an original application in the hydrological summer (the months of April to September inclusive). It was assumed that the *revised* abstraction arrangements would remain in place for six months or less if water resources within the Thames Water supply area have returned to adequate levels to safeguard future water supplies, as agreed with the Environment Agency.

The approach highlighted that the re-assessment of hydrological impacts for re-application would not be limited to drought permits that are groundwater related only. Where the EAR for any drought permit has identified impacts below **major** in the original EAR (the most severe magnitude of effect in the assessment approach), re-assessment of the hydrological

impact could be required. This re-assessment of the hydrological impact would also be required in such cases to ensure that the extent of the study area (reaches) remain unchanged as this will determine the baseline data used to inform the environmental features assessment. At such time, it would also be important to identify additional in-drought monitoring that may be required to monitor changes in flow, water quality or to possibly collect additional biological data where changes in extent have resulted in a lack of data availability.

The approach also highlighted that the re-application of a drought permit could result in an extension of impacts over different periods included in the environmental features assessment of the original EAR (e.g. impacts could extend into winter or autumn periods). In such cases, careful consideration should be given to the assessment of environmental features outside main breeding/growth periods. Several macrophyte species, for example, require autumn/winter flushes of surface water bodies to improve growth during the main spring/summer growing season. Impacts during these periods may result in impacts outside the application and re-application periods effectively resulting in long term impacts. Similarly, impacts on macroinvertebrates during the autumn egg deposition period could impact on species that emerge during spring, also resulting in long term impacts. The migration and spawning periods of fish will also need to be reconsidered during a re-application period.

Assessment of the implications of a re-application of the Lower Thames and Latton EAR has identified that changes to the significance of impacts are very likely to occur. It is therefore, important to re-consider mitigation measures specifically aimed at the mitigation of impacts during this re-application period.

2.4 METHODOLOGY

2.4.1 Reference conditions considered

The assessment of environmental impact for the re-application of a drought permit during a multi-season drought have required consideration against appropriate reference conditions without a drought permit re-application in place. The severity of the ongoing drought (during the first application period) ultimately informs the reference conditions for the re-application, noting that this is likely over and above the baseline (without first drought permit) conditions included in the original EAR as well as noting the seasonality differences. However, this also needs to reflect any changes to the hydrological or ecological reference conditions that have been affected by the first drought permit.

The antecedent conditions will be different to the first drought permit application and will require careful consideration. The antecedent conditions for the first drought permit include the onset of environmental drought. The antecedent conditions for re-application are both the onset of environmental drought prior to the first drought permit and a six-month environmental drought period including with the original drought permit in place.

It should be noted that no further modelling (e.g. of hydrogeological changes) has been undertaken as part of the high-level assessment. The assumptions regarding the most likely

period for implementation of the first drought permit (as considered in the draft Drought Plan) and the expected period for any re-application are provided in **Appendix A**. This also includes any assumptions regarding the antecedent conditions and hydrological references conditions for the re-application.

2.4.2 Description of general physical environment effects

To provide a general description of the environmental impacts of Thames Water's drought actions in severe droughts (i.e. drought permit re-application), the existing examples for the Latton and Lower Thames Drought Options re-application were considered. The information provided in the Latton and Lower Thames examples were supplemented by:

- A review of available literature and existing studies regarding the general environmental impact of severe droughts
- Expert judgement and the project's team existing experience of the drought options and the study area, in particular, the antecedent conditions and the effects of the initial 6-month application of the selected permits.

This general description, included in Section 3, provides a summary of potential impacts related to hydrogeology and the hydrology of surface waters and the consequent potential impacts on geomorphology and associated processes, and the potential impacts on water quality as related to an ongoing severe drought, as potentially exacerbated by both a first drought permit and the re-application of a drought permit.

This general description and the assumptions regarding the hydrological reference conditions at the time of re-application were considered to inform the potential changes in the physical environment risks currently identified in the EARs of the drought options included in the assessment.

2.4.3 Description of key environmentally sensitive features

The outcomes of the screening undertaken for each of the drought permits considered in the original EARs were re-assessed following the outcomes of the high-level assessment of the potential changes in risk to the physical environment.

The re-assessment ensures that both the environmental features that require consideration and the potential changes in feature sensitivity as a result of changes in the risk to physical environmental features were considered.

As indicated above, the existing examples for the Latton and Lower Thames Drought Options were considered to inform the assessments of the drought permits identified as applicable in a severe drought (see Section 2.1). The information provided by the Latton and Lower Thames examples were further supplemented by:

- A review of available literature and existing studies regarding the general

environmental impact of severe droughts;

- Expert judgement and the project's team existing experience of the drought options and the study area, in particular, the sensitive features associated with each of the drought permits.

The general assessment focused on the key life stage for each feature (e.g. key migration periods, invertebrate emergence, growth period, etc.).

2.4.4 Summary per drought option

For an EAR, the DPG requires that the likely changes in flow/level regime associated with a drought permit are considered. As part of the final Drought Plan 2018, to achieve this, two hydrological methodologies have been developed, including one for watercourses that do not dry naturally (perennially flowing watercourses) and one for watercourses that naturally dry up for part of the year (intermittently flowing watercourses). The methodology was used to identify 1) the overall study area – which extends downstream of the abstraction until the hydrological impact has reduced to negligible; 2) reaches with similar scales of impact within the overall study area; and 3) the scale of hydrological impact within each reach (ranging from major to negligible).

The potential changes in risk as a result of re-application of a drought permit are based on the same methodologies considered in the final Drought Plan 2018. Details regarding these methodologies are provided in the individual EARs which informed the final Drought Plan 2018. For the re-application high-level assessment, this included reviewing the study area and reaches, and identifying any risks of change in spatial extent of effects. The nature and scale of hydrological impact in each reach was then reviewed, noting the antecedent and reference conditions appropriate for a multi-season drought, with consideration of changes to other physical environment effects.

This general assessment of impacts of a severe drought on the environmental features was used to inform the potential changes in the assessment of impacts associated with each environmental feature for the drought options included this assessment. In addition, potential changes in the significance of the impacts on environmental features for a re-application of a drought permit considered any changes in the magnitude of the impact identified in the original EARs. The assessment of the potential changes in the significance of impacts on the environmental features did not consider any mitigation measures beyond those identified in the original EARs.

This includes any changes in the duration, timing, reversibility and probability of the impacts as identified through the re-assessment of the impacts on physical environment features (described above). The assessment methodologies for each feature are detailed in the individual EARs completed to inform the final Drought Plan 2018 and the significance of impacts on the environmental features associated with each drought permit was determined following the Chartered Institute of Ecology and Environmental Management (CIEEM)

Ecological Impact Assessment (EcIA) guidance. This approach still considers the ecological (geographical) value of each environmental receptor.

The assessment outcomes associated with a re-application of *each* drought permit considered is summarised in Section 5 of this report. The summary confirms the original drought permit assumptions on the likely periods (timing) for application and sets out the assumptions on re-application periods. The summary also confirms the assumptions regarding study area, hydrology reference conditions and recovery periods associated with both the original application and those conditions expected at the time of re-application. Furthermore, each summary also considers any changes in the extent of the study area (reaches) associated with re-application. Where changes in the extent of the study area were identified, these changes were noted, but the additional assessments were limited to physical environment features within these reaches.

2.4.5 Mitigation measures

It should be noted that any changes in the assessment of the risk to the physical environment or impacts on environmental features for a severe drought record may trigger the need for changes to the monitoring and mitigation measures already considered. For example, the assessment of the implications of a re-application of the Lower Thames and Latton drought permits identified that changes to the significance of impacts are very likely to occur. It is, therefore, important to re-consider mitigation measures specifically aimed at the mitigation of impacts during a severe drought. The assessment of the potential changes in the significance of impacts on the environmental features did not consider any mitigation measures beyond those identified in the original EARs. A summary of those mitigation measures (in addition to those stated in the EARs) that can be considered during a multi-season drought and the likelihood of these being successfully implemented is provided in Section 6.

2.4.6 Potential impacts on WFD compliance, SEA and HRA

The screening exercise undertaken to inform the HRA for the draft Drought Plan 2017 was reviewed to determine whether any changes in the impacts associated with the re-application of a drought permit could have implications on any European sites. Furthermore, the potential changes in the physical environment risks and environmental impacts associated with each drought permit, as implemented for a severe drought, may have implications for each key issue identified in the SEA (biodiversity, population and human health, material assets and resource use, water, soil, geology and land use, air and climate, archaeology and cultural heritage and landscape).

The outcomes of the assessments in **Appendix A** were used to inform a high-level Strategic Environmental Assessment (SEA) to determine the potential implications of a "severe drought" on the SEA objectives. This assessment was required as the changes in risk could impact on both the order in which drought permits are applied and the extent to which drought permits could be included in the Drought Plan.

Section 7 also considers the potential implications of re-application for drought permits in a severe drought for compliance with the WFD: specifically the risk of deterioration in individual WFD biological status elements (i.e. fish, macroinvertebrates, macrophytes, diatoms in river water bodies); and any implications for WFD protected sites: specifically European designated sites (including the outcomes of the HRA). This follows the approach set out in the revised DPG[7].

[7] Environment Agency (2017) Drought Plan Guidance Extra Information: Environmental Assessment for Water Company Drought Plans. September 2017.

3 KEY PHYSICAL ENVIRONMENTAL EFFECTS

3.1 ENVIRONMENTAL AND WATER RESOURCE DROUGHTS

Drought is a sustained and regionally extensive occurrence of below-average precipitation, not to be confused with aridity which is a perennial state of water shortage[8]. There are many different ways of defining a drought, depending on purpose, and in the context of water company drought contingency planning we are concerned principally with environmental drought and water resources drought.

In this context, environmental drought is the effects of sustained below-average precipitation on the aquatic environment – in terms of water flows and levels and the resulting effects on sensitive aquatic ecology and other receptors as set out in the DPG. Noting that hydrological systems in Thames Water's area of operation in south-east England are not natural, as a result of anthropogenic influence on flows through abstraction pressures and discharge returns, and the channels themselves are routinely modified by historic or recent anthropogenic activities; environmental drought is, in effect, the reference condition for the aquatic environment from the continuation of normal activities, including permitted activities, during a period of sustained below-average precipitation.

In contrast, in this context, water resources drought is the result of sustained below-average precipitation on a water company's ability to maintain security of supply to its customers such that further measures are required to meet its levels of service commitments. This includes, but is not restricted to, the consideration of drought permits.

This assessment is of water resource drought within a multi-season environmental drought longer than those on historic measured record. In their final Drought Plan 2018, Thames Water has defined the severity of droughts based on the measured historic record as representing:

- a 1:100 year return period drought;
- a 1:300 year return period as representing a severe drought;
- a 1:500 year return period as representing an extreme drought.

As the condition of these severe and extreme droughts are beyond the measured record, they are not known – in terms of the timing (season), duration and severity of the below-average precipitation and their resultant effects on the hydrological cycle, including river flows and levels, the increased pressure on aquatic habitat quality and the consequent impacts on aquatic life there.

However, much is known of the hydrological cycle in south-east England and the importance of groundwater on surface water flows. Further, much is known of the normal flow regimes of

[8] Ward RC and Robinson M (2000) Principles of Hydrology. 4th Edition. McGraw-Hill, London

rivers in south-east England and the types of effects on river condition from reduction in flow. Section 3.2 below provides a general description of potential impacts related to hydrogeology and the hydrology of surface waters and the consequent potential impacts on geomorphology and associated processes. With understanding of the normal (non- drought) baseline physical environment for each potential drought permit option and the likely condition during a drought from the measured record and the potential effects on this from a first drought permit (each as set out in the EARs accompanying Thames Water's Drought Plan), the relevant key physical environment features considered in the context of the Thames Water drought permit re-application options are set out in Section 3.3 below. The per-option assessments are included in **Appendix A** and summarised in Section 5 below.

3.2 GENERAL PHYSICAL ENVIRONMENT EFFECTS ASSOCIATED WITH SEVERE DROUGHT

Regionally extensive sustained below-average precipitation, affects river flows through pathways involving impacts on groundwater balance on river baseflow and surface run-off/sub-surface throughflow. During drought, the main contribution to discharge is via the slow pathways of groundwater discharge (baseflow); the fast pathways that contribute to discharge during wetter periods (surface runoff, interflow) are usually limited during drought[9].

During prolonged multi-season droughts, the importance of surface run-off/sub-surface throughflow is diminished by increasing soil moisture deficit and river flows are typically very low and dependent on baseflow contribution from groundwater[10].

Much of south-east England is underlain by principal aquifers including Chalk, Oolite, Greensand bedrock aquifers or superficial aquifers of River Terrace Deposits. These play important roles in controlling flow rates from spring sources defining the perennial sources of many streams and rivers and headwater recession, the mobile source of seasonally flowing winterbournes. Further, they affect flow in rivers through connectivity with the surface water, both in terms of contributing flow accretion and flow reductions in losing reaches. Regional analysis of groundwater droughts in the UK[11] identify these as spatially and temporally variable phenomenon, where catchment and hydrogeological factors are primary functions, independent of the driving meteorology. These factors drive the nature of the drought, including the rate of the recovery period, but overall remain dependent on the precipitation pattern of the meteorological drought and its consequent period.

Reduction in flow initially results in a reduction in the wetted parameters of a channel, the wetted width and depth and flow velocity. Each of these play an important role in defining the

[9] Van Loon AF (2015) Hydrological drought explained. WIREs Water Volume2, Issue4 July/August 2015 pp 359-392
[10] British Geological Society: Groundwater drought research overview. http://www.bgs.ac.uk/research/groundwater/waterResources/drought_overview.html Accessed 21/6/2018
[11] Bloomfield JP, Marchant BP, Bricker SH, Morgan RB (2015) Regional analysis of groundwater droughts using hydrograph classification. Hydrology and Earth System Sciences, 19 (10). 4327-4344

range, extent and quality of usable habitat within the channel, but as part of a mosaic along the length of a reach and watercourse. The response in these hydraulic variables to reductions in flow is dependent on the channel geometry (width, bank slope, longitudinal slope and bed roughness) and downstream flow resistance such as caused by weirs[12]. In general terms, a reduction in flow will lead to, either or both, changes in maximum channel velocities or a lowering of the water surface, where lowering of the water surface will change the wetted width of the river (dependent on the bank slope) and reduce the range of wetted depths and change the location of certain wetted depths across the river. A reduction in water surface will also change the influence of transverse barriers, such as weirs, on the longitudinal connectivity of the watercourse, both in terms of wetted connectivity, but also useful connectivity for the movement of mobile species through changes in depth of water over structures and the head difference across the structure. Transverse connectivity with the riparian zone may also diminish as water surface lowers and margins become shallower or disconnected.

With severe reduction in river flow, flow may cease, or become ponded. Where this is not a normal pattern within a river (noting if it is a winterbourne) then this loss of wetted function equates to a severe impact. Interstitial flow may be retained in the hyporheic zone (region beneath and alongside a stream bed, where there is mixing of shallow groundwater and surface water) even in the absence of visible flow, but as conditions worsen then the bed too may desiccate. Where this is part of the normal pattern within a river, then the timing of both onset and recovery and duration become important factors on the range of effects.

The geomorphological effects of environmental drought are not well researched, noting that geomorphological action is mostly associated with high flow and flood events[13]. In terms of fine sediment dynamics, it is noted that lower flows associate with reduced stream power and lower energy systems, leading to the risk of increased deposition rate of suspended material[14]. However, in most drought circumstances, fine sediment is transport limited[15] and the risk of increased deposition is ameliorated by a significant reduction in the strength of pathways supplying sediment sources[16] into the watercourse. Where fine sediment supply is dominated by overland inputs during storm events, then this risk during drought is limited to short flash-flood events where desiccated material can be readily transported into the channel. Local sources to the channel itself may remain active, such as bank poaching by cattle, and may be exacerbated by significant reduction in soil moisture deficit leading to soft bank collapse. Source from discharges (such as sewage treatment works) will remain active and may be locally significant. The remobilisation of bed stores during high flow events is unlikely to be a

[12] Chanson H (2004) The hydraulics of open channel flow: An introduction. 2nd Edition. Elsevier. ISBN 0 7506 5978 5
[13] Bagnold RA (1966) An approach to the sediment transport problem from general physics. United States Geological Survey Professional Paper 422I (1966)
[14] Walling DE and Amos CM (1999) Source, storage and mobilisation of fine sediment in a chalk stream system. Hydrological Processes 13 (3)
[15] Naden PS, Murphy JF, Old GH, Newman J, Scarlett P, Harman M, Duerdoth CP, Hawczak A, Pretty JL, Arnold A, Laizé C, Hornby DD, Collins AL, Sear DA and Jones JI (2016) Understanding the controls on deposited fine sediment in the streams of agricultural catchments. Science of The Total Environment 547 366-381
[16] Collins AL and Walling DE (2007) Sources of fine sediment recovered from the channel bed of lowland groundwater-fed catchments in the UK. Geomorphology 88 (1-2) 120-138

risk, apart from in reaches that have dried where re-wetting can re-introduce this material[17].

Dependent on the composition and vegetation coverage of the banks and bed, there is risk of change in stability and condition as a result of exposure, vegetation die-back and desiccation. With prolonged riparian or bed exposure, there is a risk of long-term change in channel form and function and the habitats it provides on re-wetting.

In terms of water quality, a river with reduced flow has less buffering capacity to accept water quality pressures. Further, the underlying water chemistry may be amended by the prolonged baseflow dominance and reduction in surface and sub-surface flow inputs – with the water chemistry more reflecting that of the groundwater and the influence of the aquifer on ionic composition, impacting the pH and conductivity and reflecting the extent of any contamination of the aquifer, such as elevated nitrate concentrations. Conversely, the sources of diffuse surface-originating contamination (e.g. of nutrient, sanitary and chemical inputs) will be transport limited during sustained below-average precipitation, particularly those which are sediment associated; albeit episodic rainfall and first flush into the watercourse will be of increased consequence. First flush pollution is a particular risk in urban catchments, from direct road and surface runoff, surface water drains and especially combined sewer overflows; with risk of deoxygenation, toxic levels of ammonia, and elevated concentrations of chemicals[18]. Where a watercourse has dried, there are direct first flush inputs from the bed-accumulated material. With reduced buffering capacity, there is enhanced risk of response to continuous point source inputs of contamination. Further, sewage treatment works may be discharging lower flows (than consented dry weather flows) and be of higher strength, reducing the overall dilution effect on mixing in a watercourse of reduced buffering capacity. Also with reduced flow, particularly exaggerated where water is ponded, there is risk of water temperature mimicking air temperature – in terms of elevated temperatures on hot days, cooler temperatures on colder nights and an increased pattern of diurnal variability[19].

3.3 KEY PHYSICAL ENVIRONMENT EFFECTS CONSIDERED IN THE CONTEXT OF THE THAMES WATER DROUGHT PERMIT RE-APPLICATION OPTIONS

Of the general physical environment effects associated with severe drought, the key physical environment effects considered in the context of the Thames Water drought permit re-application options to support the assessment of sensitive features are listed as:

- Changes in hydrogeology:
    - groundwater levels – changes in location of river source, effect on losing reaches

[17] Wood PJ and Armitage PD (1997) Biological Effects of Fine Sediment in the Lotic Environment. Environmental Management 21 (2) 203-217
[18] Ellis B (1991) Urban runoff quality in the UK: problems, prospects and procedures. Applied Geography11 (3) 187-200
[19] Webb BW, Clack PD and Walling DE (2003) Water–air temperature relationships in a Devon river system and the role of flow. Hydrological Processes 17 (15) 3069-3084

    - groundwater recovery period
- Changes in surface flow:
    - channel drying / flow reduction
    - lower flow from reduction in baseflow contribution or increased abstraction
    - Legacy effects of first drought permit application
- Changes in wetted habitat:
    - wetted width and depth
    - velocity
    - longitudinal connectivity, including the impacts of in-channel structures
    - connectivity with riparian zone
- Changes in geomorphological activity:
    - fine sediment dynamics
    - bank stability
    - bed stability
- Changes in water quality or water temperature:
    - buffering capacity (flow related)
    - dilution of point source pressures
    - first-flush (urban pollution and remobilisation from dry channels).

This list is derived from an understanding of the normal (non - drought) baseline physical environment for each potential drought permit option and the likely condition during an environmental drought from the measured record, as set out in the EARs accompanying Thames Water's Drought Plan. This is not an exhaustive list and for individual options other features may be key. For example, different flow control characteristics (e.g. Fobney Direct) could be of importance or where the drought permit would follow but not overlap with an environmental drought (e.g. M2 licence).

It is noted that although important to describe the nature, magnitude and duration of physical environment effects during environmental drought and to differentiate those of drought permit re-application, within the requirements of the DPG, this physical environment assessment is specifically in support of the assessment of the potential impacts on key environmentally sensitive features. Therefore, the identification and assessment of key physical environment effects is proportionate to that task, and is targeted at presenting information of importance to the features assessment.

4 KEY ENVIRONMENTALLY SENSITIVE FEATURES

4.1 FEATURES CONSIDERED

Table 4.1 identifies each of the key environmentally sensitive features identified for assessment in the EARs. Details of these and the designated sites of concern are presented in **Appendix A**.

A discussion of the generic impacts of a severe drought on these features is provided in Section 4.2.

Table 4-1 Key environmental features identified for assessment for the drought permit re-application options

	Latton	Lower Thames	Baunton 2	Farmoor	Meysey Hampton	Pangbourne	Sundridge 2	Waddon	Ogbourne 1 and EBH*	Axford 2	M2 Licence	Eynsford	Horton Kirby	Fobney Direct	Harpsen & Sheeplands	New Ground	Shalford	Albury	Pann Mill
Designated site																			
Special Area of Conservation (SAC)	■	■	■	■						■									
Special Protection Area (SPA)		■																	
Ramsar		■																	
Site of Special Scientific Interest (SSSI)	■		■	■	■	■	■		■	■	■				■		■	■	
Key Wildlife Site (KWS)	■		■		■														
National Nature Reserve (NNR)	■		■																
Local Nature Reserve (LNR)		■		■			■	■				■							
Proposed marine Conservation Zone (pMCZ)		■																	
Site of Nature Conservation Interest (SNCI)				■														■	
NERC Species - Freshwater Macroinvertebrates																			
Fine-lined pea mussel (*Pisidium tenuilineatum*)	■	■	■	■	■														
Cranefly (*Lipsothrix nervosa*)		■									■								
Two-lipped door snail (*Balea biplicata*)		■									■								
Depressed river mussel (*Pseudanodonta complanata*)				■							■								
Thames Ram's Horn Snail (*Gyraulus* acronicus)				■															
Club-tailed dragonfly (*Gomphus vulgatissimus*)				■															
Mud shrimp (*Corophium lacustre*)		■																	
German hairy snail (*Perforatella rubiginosa*)		■																	
NERC Species - Fish																			
Brown trout (*Salmo trutta*)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■
European eel (*Anguilla anguilla*)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■		
Lamprey sp.	■	■		■	■						■			■	■				
Atlantic salmon (*Salmo salar*)		■									■				■				
Smelt (*Osmerus eperlanus*)		■																	
NERC Species - Mammals																			
Otter (*Lutra lutra*)	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■
Water vole (*Arvicola amphibious*)	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■

	Latton	Lower Thames	Baunton 2	Farmoor	Meysey Hampton	Pangbourne	Sundridge 2	Waddon	Ogbourne 1 and EBH*	Axford 2	M2 Licence	Eynsford	Horton Kirby	Fobney Direct	Harpsen & Sheeplands	New Ground	Shalford	Albury	Pann Mill
NERC Species - Birds																			
Greater scaup (*Aythya marila*)								■											
Reed bunting (*Emberiza schoeniclus*)								■											
Grasshopper warbler (*Locustella* naevia)								■											
Northern lapwing (*Vanellus vanellus*)								■											
NERC Species - Macrophytes																			
Flowering rush (*Butomus umbellatus*)				■															
NERC Habitats																			
Coastal and floodplain grazing marsh	■	■	■	■	■	■	■		■	■	■			■	■	■			
Mudflats		■																	
Lowland fens		■	■			■									■		■		
Reedbeds		■																	
Notable Habitats																			
Chalk stream						■	■	■	■	■		■	■			■			■
Notable Macrophytes																			
Ranunculus species (*Ranunculus* sp)	■		■	■	■	■	■	■	■	■		■		■	■		■	■	■
Notable Freshwater Macroinvertebrates																			
Aquatic beetles	■	■	■	■	■				■	■				■					
Caddisfly	■	■	■	■	■				■	■				■			■		
Mayfly	■	■		■	■				■	■									
Crustacean	■																		
Alderfly	■				■														
European leech	■				■														
Lacewing		■																	
Damselfly									■	■									
Snipefly														■					
Brackish-water shrimp		■																	
Notable Fish																			
Barbel (*Barbus barbus*)	■	■	■	■	■			■	■	■	■			■	■				
Bullhead (*Cottus gobio*)	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■		

	Latton	Lower Thames	Baunton 2	Farmoor	Meysey Hampton	Pangbourne	Sundridge 2	Waddon	Ogbourne 1 and EBH*	Axford 2	M2 Licence	Eynsford	Horton Kirby	Fobney Direct	Harpsen & Sheeplands	New Ground	Shalford	Albury	Pann Mill
Brook Lamprey			■			■								■					
Invasive Species - Invertebrates																			
Zebra mussel (*Dreissena polymorpha*)		■	■				■				■	■			■				
Chinese mitten crab (*Eriocheir sinensis*)		■					■				■	■			■				
Spionid worm (*Marenzelleria wiréni*)		■													■				
Asian clam (*Corbicula fluminea*)		■																	
Amphipod (*Chelicorophium curvispinum*)		■														■	■	■	
Freshwater jellyfish (*Craspedacusta sowerbyi*)		■																	
Signal crayfish (*Pacifastacus* leniusculus)			■			■			■	■				■	■	■	■	■	■
Northern River Crangonyctid (*Crangonyx pseudogracilis*)			■			■								■			■		■
Flatworm (*Dugesia tigrina*)			■					■						■					■
Acute bladder snail (*Physella acuta*)			■			■		■	■	■				■			■	■	■
New Zealand mud snail (*Potamopyrgus antipodarum*)						■			■	■				■			■	■	■
Spiny cheek crayfish (Orconectes limosus)							■					■							
Invasive Species - Flora																			
Japanese knotweed (*Fallopia japonica*)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Giant hogweed (*Heracleum mantegazzianum*)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Himalayan balsam (*Impatiens glandulifera*)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Australian swamp stonecrop (*Crassula helmsii*)		■			■		■		■	■	■	■			■	■	■		
Parrot's feather (*Myriophyllum aquaticum*)		■			■		■		■	■	■	■			■	■	■		
Floating pennywort (*Hydrocotyle ranunculoides*)		■			■		■	■	■	■	■	■		■	■	■	■		
Water fern (*Azolla filiculoides*)					■			■	■	■								■	
Nuttall's pondweed (*Elodea nuttallii*)					■			■	■	■									
Least duckweed (*Lemna minuta*)														■				■	■
Canadian pondweed (*Elodea candensis*)																		■	■
Monkey-flowers (*Mimulus*)																		■	
Cyanobacteria																			
Blue-green algae		■		■							■				■				

Note: * Ogbourne 1 and EBH comprises two separate drought options (Ogbourne 1, and Ogbourne Emergency Boreholes)

4.2 GENERAL IMPACTS EXPECTED IN SEVERE ENVIRONMENTAL DROUGHT (WITHOUT DROUGHT PERMITS)

Extreme low flows as a result of an environmental drought may have major effects on aquatic habitats, biota, and consequently ecosystem functions[20]. Whilst the effects of drought conditions are dependent on the duration and the intensity of the drought, it is generally recognised that multi-season droughts in sensitive water bodies can result in long-term recovery periods of ecological communities[21]. Compared to short term drought (less than 1 year duration), multi-season droughts are more likely to result in persistent habitat changes, a reduction in re-colonisation from nearby sources (characteristic of higher flows), and result in some local populations being lost due to a lack of suitable habitat[22]. As the duration and impacts associated with drought increase, the effect on biota is likely to increase in severity from the individual to a catchment/regional level.

Reduction in flow initially results in a reduction in habitat availability and quality (e.g.. degradation), but as the magnitude of reduction increases, a series of thresholds are reached; the loss of riparian habitat, the loss of longitudinal connectivity and desiccation of flow (the absence of surface water throughout the channel)[23].

Stress, brought about by changes in the environment, including the potentially adverse impacts associated with drought, determine how biota react to such changes. The flora and fauna associated with aquatic environments possess variable spatial and temporal responses to abiotic changes that occur during drought, depending on species resistance and resilience, competitive and predatory interactions and the timing and characteristics of the drought[24]. However, elevated levels of stress may result in the interruption of the normal life-history of the organism[25], therefore impacting upon the integrity of the population in question. An increase in the duration of drought conditions may result in impacts from one season carrying over into the next (e.g. poor feeding in winter impacts upon spring reproduction success[26]). If the intensity of the stressor, such as those associated with drought is severe or long-lasting, the well-being of the organism may be impacted[27]. This in turn may increase the severity of the effect from an individual level to population level.

[20] Riis, T., Levi, P.S., Baattrup-Pedersen, A. et al. (2017) Experimental drought changes ecosystem structure and function in a macrophyte-rich stream. Aquatic Sciences 79, 841
[21] Environment Agency (2013) Monitoring and Assessment of Environmental Impacts of Droughts Literature Synthesis. Report: SC120024/R1
[22] Lake, P. S. (2003) Ecological effects of perturbation by drought in flowing waters. Freshwater Biology 48 1161-1172
[23] APEM (2017) Literature review of short-term flow reduction ecological impacts and recovery: R16115QQ. APEM Scientific Report P00001488. Scottish Environment Protection Agency. pp 81
[24] Environment Agency (2013) Monitoring and Assessment of Environmental Impacts of Droughts Literature Synthesis. Report: SC120024/R1
[25] Wingfield J.C. (2013) Ecological process and the ecology of stress: the impact of abiotic environmental factors. Functional Ecology, 27, 37-44
[26] Sapolsky, R.M., Romero, L.M. and Munck, A.U. (2000) How do glucocorticosteroids influence stress responses? Integrating permissive, suppressive, stimulatory and preparative actions. Endocrine Reviews 21: 55-89
[27] Barton, B.A. (2002) Stress in fish: a diversity of responses with particular references to changes in circulating corticosteroids. Integrative and Comparative Biology 42, 517-525.

During the initial stages of drought, impacts are most likely to be manifested by behavioural changes in the ecological community (as described in the relevant Thames Water EAR reports). With the implementation of a multi-season drought permit, the main thresholds for the ecological community may be exceeded[28], with impacts increasing in severity, such as those associated with a cessation in flow. Studies in the River Thames Basin note river discharge as the most influential variable in biological community composition[29], therefore re-application impacts are likely to affect the biota in a number of these drought permits accordingly.

The impacts outlined below summarise the impact and the pathway associated with environmental drought, which leads to the effect on the ecological feature in question, informed by expert judgement and relevant scientific literature. The complex food-web interactions between each ecological receptor (e.g. reduction in macrophyte cover impacting negatively upon fish habitat) are not detailed in this report.

In terms of recovery, there is a threshold where the extent of terrestrialisation of the river channel is such that the physical habitat is changed when flows return, and the river will not return to pre-drought conditions[30], resulting in irreversible impacts.

4.2.1 General Impacts Expected in Severe Drought - Fish

The potential impacts associated with severe drought outlined in Section 4.2 are likely to result in a range of impacts on fish, depending on the nature of the species and dynamics of the population in question. In general, these effects are likely to operate at varying scales and differing complexities, such as those at the individual level (e.g. mortality as a result of channel drying and/or lack of physiological tolerances) to the local assemblage (e.g. a change in the composition of the fish community)[31]. Impacts are also likely to be compounded during multi-season droughts, with the effect of one impact resulting in the exacerbation of another. For example, the loss of a successfully recruited year class of brown trout due to the sedimentation of key spawning gravels may be impacted further by the effects of increased habitat fragmentation preventing adult fish from reaching suitable spawning grounds upstream. As a result, the following year class (of fish) may also be reduced/lost, and the integrity of the brown trout population in the impacted reach reduced over the medium to long term.

A reduction in flow may cause a variety of individual stressors (e.g. crowding, starvation, exposure to predators and pathogens, alteration of temperature, connectivity loss and water

[28] Environment Agency (2013) Monitoring and Assessment of Environmental Impacts of Droughts Literature Synthesis. Report: SC120024/R1
[29] Westwood C.G., et al. (2017) An approach to setting ecological flow thresholds for southern English chalk streams. Water and Environment 31, 528-536
[30] Environment Agency (2013) Monitoring and Assessment of Environmental Impacts of Droughts Literature Synthesis. Report: SC120024/R1
[31] Matthews W.J. & Marsh-Matthews E. (2003) Effects of drought on fish across axes of space, time and ecological complexity. Freshwater Biology 48, 1232–1253

quality changes[32]), all of which are likely to have an adverse impact on fish.

As flows recede, fish are likely to seek refuge in deeper areas of the channel, such as pools. Here, they are likely to be exposed to prolonged periods of stress throughout the duration of the drought permit. If the intensity of the stress experienced by fish is severe or long-lasting, such as those posed by multi-season drought, the health of the fish is likely to be impacted, either directly (mortality), or by inhibiting key stages of the life-history, including growth[33], feeding[34] and reproduction[35]. For example, extended periods of low flows can cause high levels of stress which can lead to reduced growth and recruitment for some species of riverine species of fish[36]. As the duration spent by fish within pool refugia increases, so does the risk of predation (by other fish, birds and mammals) and parasitism and disease[37]. Juvenile life stages are particularly susceptible to predation in such pool refugia.

A reduction in flow velocity and/or a reduction in the wetted width of the river over multiple seasons may favour the most tolerant, limnophilic/eurytopic species (e.g. perch, roach and bream species), whilst the flow sensitive (rheophilic) species (e.g. salmonids, dace and barbel) may be impacted to a greater extent. As a result, the post-drought assemblage is likely to be determined by the prevailing species[38], which depending on fish population dynamics, may be associated with a medium to long term change in the fish community, including a reduction in species richness. The loss of important habitats, such as spawning gravels (required by lithophilic species) over multiple spawning seasons may result in the loss of multiple year classes entering the population, potentially resulting in a reduction in the abundance of these species and the integrity of the population.

The impacts associated with multi-season drought may affect the reproductive cycles of fish at any given stage, from spawning migration right through to juvenile development. Many different pathways could lead to the disruption of fish's reproductive cycles, including the sedimentation of spawning gravels (required by lithophilic species, e.g. salmonids[39], dace, barbel, bullhead and lamprey species), longitudinal and lateral habitat fragmentation, and the loss of juvenile habitat (e.g. juvenile coarse fish require shallow, slow flowing and well-protected marginal areas to avoid predation and feed in safety). The abundance of lithophilic spawning species may be reduced, whilst the more generalist (eurytopic) species may prosper

[32] APEM (2017) Literature review of short-term flow reduction ecological impacts and recovery: R16115QQ. APEM Scientific Report P00001488. Scottish Environment Protection Agency. pp 81
[33] Pickering, A.D. (1990) Stress and the suppression of somatic growth in teleost fish. In Progress in Comparative Endocrinology (A. Epple, C.G. Scanes and M.H. Steton eds) pp. 473-479
[34] Rice, J.A. 1990. Bioenergetics modelling approaches to evaluation of stress in fish. American Fisheries Society Symposia 8, 80-92
[35] Schreck, C.B., W. Contreras-Sanchez, M.S. Fitzpatrick (2001) Effects of stress on fish reproduction, gamete quality, and progeny. Aquaculture 197: 3-24
[36] Matthews, W. J. & Marsh-Matthews, E. (2003) Effects of drought on fish across axes of space, time and ecological complexity. Freshwater Biology 48, 1232–1253
[37] Medeiros E. S. F. & Maltchik L. (1999) The effects of hydrological disturbance on the intensity of infestation of *Lernaea cyprinacea* in an intermittent stream fish community. Journal of Arid Environments 43: 351–356
[38] LAKE, P. S. (2003) Ecological effects of perturbation by drought in flowing waters. Freshwater Biology, 48, 1161 1172
[39] Salmon & Trout Conservation (2014) The impact of excess fine sediment on invertebrates and fish in riverine systems Literature Review

(exacerbated by a reduction in inter-specific competition), ultimately resulting in a change to the assemblage of the fish community.

As habitats become increasingly fragmented during extended periods of low flows, anadromous (e.g. Atlantic salmon and river lamprey) and catadromous (e.g. European eel) fish may not be able to successfully migrate beyond barriers (e.g. weir structures or excessively shallow areas of the channel), or detect cues for migration in the first place. As a result, fish may not be able to complete their life cycles, resulting in a reduction in recruitment and ultimately the localised extinction of the species. It should be noted that many of the populations of anadromous and catadromous fish in UK rivers are currently under threat, or have experienced multi-decadal decline (e.g. European eel are a IUCN Red List Critically Endangered species[40]). The impacts associated with barriers to migration are not just limited to the aforementioned species; coarse fish, such as barbel[41] and dace are also known to migrate within their natal rivers in search of feeding and breeding grounds, and refugia. Re-colonisation in the upper reaches of riverine watercourses may take considerable time following the cessation of flows[42], therefore resulting in an impoverished community over the long term.

If the water temperature increases during the warmer months of the year, the more sensitive species (e.g. salmonids) may be subject to reduced levels of recruitment, manifested by the loss of a year class[43].

A number of the impacts associated with multi-season drought may lead to the direct mortality of fish, resulting in a reduction in the population at a river, or even catchment scale, depending on a range of other factors, such as habitat fragmentation (which may determine post-drought re-colonisation) and recruitment success, as described above. The cessation of flows for extended periods associated with a multi-season drought may result in the direct mortality of fish (due to the loss of wetted habitat).

A reduction in water quality over multiple seasons is likely to affect fish. Prolonged periods of reduced dissolved oxygen may result in fish kills[44], particularly the most oxygen sensitive species (e.g. salmonids, minnow and bullhead). This is most likely to occur in pools during periods of low flows as areas of the channel dry up and fish accumulate in the deeper areas of the channel (density dependent impacts). Water quality of pools during drought is often

[40] Jacoby, D. & Gollock, M. (2014) *Anguilla anguilla*. The IUCN Red List of Threatened Species 2014: e.T60344A45833138. http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T60344A45833138.en. Downloaded 31 May 2018

[41] Twine, K. G. (2013) Conservation of barbel (*Barbus barbus*) in the River Great Ouse [online]. Thesis (PhD). University of Hull

[42] Davey, A.J. & Kelly, D.J., (2007) Fish community responses to drying disturbances in an intermittent stream: a landscape perspective. Freshwater Biology 52, 1719-1733

[43] Cowx I. G., Young W. O., Hellawell J. M. (1984) The influence of drought on the fish and invertebrate populations of an upland stream in Wales. Freshwater Biology 14, 165-177

[44] Environment Agency (2006) The impact of climate change on severe droughts Major droughts in England and Wales from 1800 and evidence of impact. Science Report: SC040068/SR1

reduced[45], which could impact the more sensitive species of fish, ultimately resulting in mortality, particularly where fish become trapped in these areas of the channel. For example, a reduction in oxygen levels in pools can be exacerbated by accumulations of decomposing organic matter (e.g. riparian leaves)[46]. Elevated water temperatures during multi-season droughts can result in fish mortalities[47]. As flows recede and the channel becomes laterally disconnected from the riparian and marginal zones, fish may be left exposed (through a lack of cover/shading) to higher temperatures, resulting in water temperature potentially exceeding the upper threshold limits for fish[48].

Where surface water abstraction is occurring as a result of operation of the drought permit, entrainment of fish may increase, potentially increasing the mortality of individuals, particularly in the 0+ (young of year) age range, as has been identified in the Lower Thames drought permits.

4.2.2 General Impacts Expected in Severe Drought - Macrophytes

At the individual level, the physiological stress exerted by drought events on macrophyte communities is likely to lead to a reduction in growth rate, morphological change or ultimately mortality[49]. Macrophytes provide higher life forms (such as fish and macroinvertebrates) with a valuable source of both food and habitat, therefore the effects of multi-season drought events are likely to impact upon the wider ecology of the waterbody. For example, many families of macroinvertebrates, such as Baetidae and Simuliidae require faster current flows and large areas of submerged macrophytes in order to develop healthy densities and fulfil their important role in the functioning of the ecosystem[50].

Water velocity is a crucial factor in determining macrophyte growth[51], therefore any changes to this aspect of the flow regime over the prolonged period associated with multi-season droughts is likely to have an adverse impact on the community.

Multi-season drought events, such as those observed in the River Kennet and Lambourn in the 1990's, recorded the rapid recovery of *Ranunculus* sp. post drought, however, such recovery may be supported by other important factors, such as a quick return to the normal

[45] Magalhaes M. F., Beja, P., Schlosser, I. J., Collares-Pereira, M. J. (2007) Effects of multi-year droughts on fish assemblages of seasonally drying Mediterranean streams. Freshwater Biology, 52, 1494-1510
[46] Gehrke, P. C., M. B. Revell & A. W. Philbey, 1993. Effects of river red gum, *Eucalyptus camaldulensis*, litter on golden perch, *Macquaria ambigua*. Journal of Fish Biology 43, 265–279
[47] Cowx, I. G., Young, W. O., Hellawell, J. M. (1984) The influence of drought on the fish and invertebrate populations of an upland stream in Wales. Freshwater Biology 14, 165-177
[48] Tramer, E., (1977) Catastrophic mortality of stream fishes trapped in shrinking pools. American Midland Naturalist 97, 469–478
[49] Mainstone, C.P. (2010) An evidence base for setting flow targets to protect river habitat. Natural England Research Reports, Number 035. Natural England, Sheffield
[50] Institute of Freshwater Ecology (2000) A Investigation of Ecological Change in the Rivers Kennet and Lambourn
[51] APEM (2017) Literature review of short-term flow reduction ecological impacts and recovery: R16115QQ. APEM Scientific Report P00001488. Scottish Environment Protection Agency. pp 81

flow regime, or riverine management practices (mitigation)[52].

High flow events in lentic environments act as a disturbance for macrophytes and riparian vegetation, removing dead growth and flushing the surrounding substrate clear of excess sediments[53], enabling fresh growth. Reductions in the magnitude and/or frequency of these events may allow a greater accumulation of algal biomass[54] and silt, interrupting the life-cycle of the macrophyte and potentially favouring more tolerant species. As a result, a change in the assemblage of the community may occur. As well as a lack of flushing events, a reduction in flow during multi-season droughts is likely to favour species associated with slower flowing conditions[55], again resulting in changes to the community[56].

Low flows during drought events may result in an increase in the growth of filamentous algae, associated with high epiphytic cover and reduced growth of *Ranunculus* sp.[57], especially where water quality/nutrients are below standard. Prolonged periods of low flows may, therefore, result in the mortality of rheophilic species of macrophytes via smothering of the plants and preventing effective photosynthesis.

Drought can lead to a gradual shift from fully aquatic to semi-aquatic to terrestrial plants, largely determined by the intensity of the drought and the extent of the drying of the river channel bed. As duration increases, non-aquatic and limnophilic species become established, with the physical habitat increasingly modified, and therefore harder for the aquatic plant community to return to the pre-drought state[58].

Studies have shown that a cessation of flow during the summer months in the headwaters of winterbournes caused non-aquatic plants and the least flow sensitive of the macrophyte community to increase, whilst the most flow sensitive species decreased (e.g. *Berula erecta*, and *Ranunculus penicillatus* subsp. *Pseudofluitans*)[59]. Where sub-surface moisture dries up, the re-colonisation of macrophyte species may be limited, resulting in a change to the coverage and/or community assemblage. During prolonged periods of low flow, filamentous algae may proliferate in pools, especially if there are high levels of nutrients in the groundwater[60]. As these features may be important refugia for fish and macroinvertebrates, algae may impact

[52] Institute of Freshwater Ecology (2000) A Investigation of Ecological Change in the Rivers Kennet and Lambourn
[53] Bilby, R. (1977) Effects of a spate on the macrophyte vegetation of a stream pool. Hydrobiologia 56 109-112
[54] Rose, P., Metzeling, L., Catzikiris, S. (2008) Can macroinvertebrate rapid bioassessment methods be used to assess river health during drought in south eastern Australian streams? Freshwater Biology, 53, 2626-2638
[55] Westwood C. G., Teeuw R. M., Wade P. M., Holmes N. T. H., P. Guyard (2006) Influences of environmental conditions on macrophyte communities in drought-affected headwater stream. River Research and Applications 22, 703-726
[56] Holmes N.T.H. (2005) Draft River Darent Restoration Strategy: Volume 1: Environmental Quality Appraisal. Environment Agency, Kent Area
[57] Wright, J.F., Gunn, R.J.M., Winder, J.M., Wiggers, R., Vowles, K., Clarke, R.T. And Harris, I. (2002) A comparison of the macrophyte cover and macroinvertebrate fauna at three sites on the River Kennet in the mid 1970s and late 1990s. Science of the Total Environment, 282-283, 1-3, 121- 142
[58] DEFRA (2013) The impacts of drought in England R&D Technical Report WT0987/TR
[59] Westwood C. G., Teeuw R. M., Wade P. M., Holmes N. T. H., P. Guyard (2006) Influences of environmental conditions on macrophyte communities in drought-affected headwater stream. River Research and Applications 22, 703-726
[60] Dahm, C., M. A. Baker, D. I. Moore & J. R. Thibault, 2003. Coupled biogeochemical and hydrological responses of streams and rivers to drought. Freshwater Biology 48, 1219–1231

negatively upon the water quality of these important features.

An increase in the deposition of sediments can alter habitat structure[61], and reduce macrophyte growth (through limiting photosynthesis). If the drought period results in the prolonged deposition and accretion of sediments, macrophyte beds can eventually become buried, resulting in the loss of the community in question[62]. As a result, sedimentation impacts may cause changes to the community assemblage and a reduction in macrophyte coverage.

Deterioration in water quality, manifested by an increase in nutrient availability may result in changes to the natural macrophyte community assemblage. Increasing nutrient availability encourages succession towards more rapidly growing species, which in the medium to long term causes a decline in species richness as the most nutrient tolerant/competitive species prosper[63]. For example, *Potamogeton pectinatus* replaced *Ranunculus penicillatus* subsp. *pseudofluitans* under increased concentrations of phosphorus[64].

Sensitive macrophytes of conservation interest, such as *Ranunculus penicillatus* subsp. *Psuedofluitans* require a minimum of 0.1 m/s flow velocity to maintain growth and are likely to be lost from the community as a result of a reduction in velocity over the prolonged periods associated with the multi-season drought permits, especially during the most crucial months of spring and summer[65].

4.2.3 General Impacts Expected in Severe Drought - Macroinvertebrates

In rivers, the ecological effects of drought typically result in gradual adjustments of the macroinvertebrate community structure and functioning, punctuated by sudden changes as key habitats, such as wetted width are reduced and margins become dry[66]. The loss of habitats through a reduction in flow is most likely to result in a reduction in the total abundance of macroinvertebrates, rate of drift (important to re-colonisation following drought events), and an increase in predation (invertebrates become concentrated in higher densities within refugia, e.g. pools)[67].

A reduction in the wetted width, and loss of the marginal habitats which are of particular importance to certain species of macroinvertebrates is likely to reduce species richness. The

[61] Jones, J. I., Collins, A. L., Naden, P. S., & Sear, D. A. (2012) The relationship between fine sediment and macrophytes in rivers. River Research and Applications 28, 1006–1018
[62] Edwards, D. (1969) Some effects of siltation upon aquatic macrophyte vegetation in river. Hydrobologia 34, 29-37
[63] Bornette, G., Tabacchi, E., Hupp, C., Puijalon, S. & Rostan, J. C. (2008) A model of plant strategies in fluvial hydrosystems. Freshwater Biology 53, 1692-1705
[64] Spink, A.J., Murphy, K.J., Smith, S.M. & Westlake, D.F. (1993) Effects of eutrophication on Ranunculus and Potamogeton. Journal of Aquatic Plant Management 31, 113-117
[65] APEM (2017) Literature review of short-term flow reduction ecological impacts and recovery: R16115QQ. APEM Scientific Report P00001488. Scottish Environment Protection Agency. pp 81
[66] Chadd R., et al. (2017) An index to track the ecological effects of drought development and recovery on riverine invertebrate communities. Ecological Indicators 82, 344-356
[67] Mainstone, C.P. (2010) An evidence base for setting flow targets to protect river habitat. Natural England Research Reports, Number 035. Natural England, Sheffield

loss of refuge habitats, such as the drying out of sub-surface sediments[68] (hyporheic zone) may limit re-colonisation of key species, such as Gammarids[69], from occurring post drought, therefore potentially resulting in population and community level impacts[70].

Whilst macroinvertebrate assemblages have been shown to be resilient to drought events, resilience declines with increasing disturbance frequency[71] and the level of flow reduction/drying of the river channel. Macroinvertebrate communities subject to multi-season droughts have demonstrated a variety of responses, ranging from rapid recovery at the family level[72], significant degradation at the community level (reduction in density and species richness)[73], to a complete lack of recovery (i.e. no return to the pre-drought community composition)[74]. As observed with the macrophyte community of lowland chalk streams, a return to normal flow regimes and lack of drying is likely to be key in assisting the recovery of the community to pre-drought status.

Multi-season drought events are likely to alter the assemblage of the macroinvertebrate community, characterised by an increase in the density of less flow sensitive families (e.g. Gastropods, Chironomidae and Ceratopogonidae) and a reduction in the densities of rheophilic species (e.g. Baetidae, Caenidae and Simullidae)[75,76,77]. Whilst macroinvertebrate communities can recover in the short term (within 1 year), a multi-season drought is more likely to increase the risk of the macroinvertebrate assemblage recovery capacity being exceeded, with a reduction in species richness and a community dominated by the aforementioned (most tolerant) species.

Multi-season droughts are likely to impact upon the recruitment of macroinvertebrates, as drying during the months of spring may impact upon the larval stages and their emergence phase. As a result, the cohort for the year may be reduced/lost.

Deterioration in water quality during low flow events over the course of a year-long drought has been shown to result in a reduction in species richness and changes to the assemblage of

[68] Vadher, A.N. et al. (2018) Drying duration and stream characteristics influence macroinvertebrate survivorship within the sediments of a temporary channel and exposed gravel bars of a connected perennial stream. Hydrobiologia 814, 121-132
[69] Vadher, A.N. et al. (2018) Drying duration and stream characteristics influence macroinvertebrate survivorship within the sediments of a temporary channel and exposed gravel bars of a connected perennial stream. Hydrobiologia 814, 121-132
[70] Stubbington, R. & Datry T. (2013) The macroinvertebrate seedbank promotes community persistence in temporary rivers across climatic zones. Freshwater Biology 58, 1202–1220
[71] Ledger, M.E., Brown, L.E., Edwards, F.K., Milner, A.M. & Woodward, G. (2013) Drought alters the structure and functioning of complex food webs. Nature Climate Change 3, 223- 227
[72] Lake S.P. (2011) Drought and Aquatic Ecosystems: Effects and Responses. Wiley-Blackwell Publishing
[73] Lake S.P. (2011) Drought and Aquatic Ecosystems: Effects and Responses. Wiley-Blackwell Publishing
[74] Beche, L.A., Connors, P.G., Resh V.H., Merenlender, A.M. (2009)Resilience of fishes and invertebrates to prolonged drought in two California streams. Ecography 32, 778-788
[75] Extence, C.A. (1981) The effect of drought on benthic invertebrate communities in a lowland river. Hydrobiologia, 83, 217–224
[76] Wright, J. F., Gunn, R. J. M., Winder, J. M., Wiggers, R., Vowles, K., Clarke, R. T., & Harris, I. (2002) A comparison of the macrophyte cover and macroinvertebrate fauna at three sites on the River Kennet in the mid 1970s and late 1990s. Science of the Total Environment 282, 121–142
[77] Mullen C (2016) An Investigation Into The Effects Of Drought And Drought Recovery On Macroinvertebrate Communities. Thesis. University of Birmingham October 2016

the community, characterised by an increased abundance of organic pollution tolerant species and a reduction in the more sensitive species[78].

[78] Boulton, A.J. & Lake, P.S., (1992) The ecology of two intermittent streams in Victoria, Australia. Freshwater Biology 27, 99-121

5 POTENTIAL IMPACTS FROM PERMITS

The significance of the potential impacts associated with the re-application of each drought permit is described in **Appendix A**. A summary of the assessment is provided below. The summary takes into account the increased risks associated with a re-application only, not those based on the first application and does not consider any additional mitigation measure beyond those considered for a first application.

For context, the summary below identifies the worst case physical environment effect (e.g. moderate or major) and the worst case impacts to environmentally sensitive features (e.g. moderate, major). The extent of any changes within the aquatic communities will ultimately be driven by the environmental preferences and resilience of the baseline communities associated with each of the hydrological reaches identified. As such, major impacts on the physical environment will not necessarily result in major impacts on environmental features.

Following the re-application for drought permits/orders beyond their original 6 months, **major** physical environmental impacts and **major** environmental feature effects could be observed for the following drought permits:

- Lower Thames
- Baunton 2
- Sundridge 2
- Ogbourne 1
- Ogbourne Emergency Boreholes
- Axford 2
- Eynsford
- Pangbourne
- Meysey Hampton

The extent of any changes within the aquatic communities will ultimately be driven by the environmental preferences and resilience of the baseline communities associated with each of the hydrological reaches identified. As such, major impacts on the physical environment will not necessarily result in major impacts on environmental features. Following the re-application, **major** physical environmental impacts and **moderate** environmental feature effects could be observed for:

- Waddon
- Fobney Direct
- New Ground
- Farmoor
- Albury
- Pann Mill.

In addition, moderate physical environmental impacts and moderate environmental feature effects could be observed for the Latton drought permit.

With regards to the M2 Licence, Harpsden and Sheeplands, and the Shalford drought permits, impacts on both the physical environment and environmental features have been determined to be negligible.

Apart from the M2 Licence, Harpsden and Sheeplands and Shalford drought permits, a moderate to major risk to WFD status/potential deterioration has been identified for the drought permits considered in this report. However, the time scale that deterioration relates to (i.e. the duration of the recovery period) cannot be accurately defined by feature assessment. This is due to a combination of factors, including a lack of data and evidence documenting the recovery of such severe drought events, and the importance of abiotic conditions following cessation of the drought permit being a key factor.

As indicated in Section 2.4.2, this high-level assessment of the environmental impacts associated with a severe drought also considered the risk of change in spatial extent of effects. The assessment of the drought options considered in this report identified that for the re-application, a change in the spatial extent of effects could be observed for the following drought options:

- Baunton 2
- Axford 2
- Pann Mill
- New Ground
- Pangbourne
- Meysey Hampton.

6 MONITORING AND MITIGATION

The DPG requires consideration of mitigation for potentially significant impacts to environmental features**.**

The assessment of the potential changes in the significance of impacts on the environmental features did not consider any mitigation measures beyond those identified in the original EARs. The monitoring and mitigation measures in Table 6.1-6.2 are targeted to address the impacts that arise specifically as a result of the re-application only (as opposed to those arising due to environmental drought pressures).

The additional mitigation measures outlined in **Table 6.1** and **Table 6.2** can be implemented in the event of re-application in accordance with the feature/reach specific measures described in the relevant drought permit EARs. However, discussions would need to be held between Thames Water and the regulators to determine and agree the specific mitigation measures to be implemented, which would depend on the specific conditions in the event of a severe drought.

Regular walkover assessments by an ecologist and geomorphologist during re-application of the drought permit are advised, helping identify the co-ordination of mitigation measures being implemented in accordance with the relevant responsible bodies.

The focus of the mitigation measures will involve undertaking actions within the watercourse to reduce the pressure at sensitive locations, and where necessary involving direct action to manage impact by movement or management of the receptor/feature itself.

It is worth noting prior to the onset of a drought that the most resilient watercourses (to the effects of drought) are those which possess the greatest level of geomorphological/habitat diversity, and the least artificial modification. Within the Thames Water operational areas, many rivers have been highly modified. Physical modifications of rivers within the catchment via flood defences and weirs, and changes to the size and shape of natural river channels for land drainage and navigation, has resulted in altered natural flows, causing excessive build-up of sediment and the loss of habitats. Within the South East, it is estimated that nearly half (43%) of water bodies are affected by physical modification[79], making the catchment generally less resilient to the impacts associated with environmental drought. The extensive physical modification of surface water bodies within the catchment and resulting reduced resilience would exacerbate any impacts associated with re-application of a drought permit in severe droughts.

[79] Environment Agency (2016). Part 1: South East river basin district River Basin Management Plan. Report nr LIT 10317)

Table 6-1: During Re-application Drought Permit Monitoring and Mitigation recommendations

Action	Purpose	Action Description	Responsibility
Walkover/patrol impacted reaches	Prevent exploitation/poaching of sensitive habitats and species under stress from drought conditions	Regular patrol of the most impacted sections of the watercourse/site, such as key refuge habitats (identified during initial drought permit implementation).	Thames Water/EA
Limit angling/commercial fishing pressure	Reduce stress on impacted fish population/species	Contact with local angling clubs to raise the issue of angling on impacted fish populations. Limit any commercial fishing pressures. Patrol key refuge sites (e.g. pools where fish may be grouped) and notify any anglers of the risks to the fishery as a result of angling	EA/Local Angling Clubs
Oxygenation of impacted reaches	Reduce oxygen stress on biota	Targeted, localised aeration using either chemical application (e.g. peroxide) and/or compressed air or oxygen if drought permit monitoring identifies a significant reduction in dissolved oxygen saturation in the impacted reaches	Thames Water/EA
Fish rescue and relocation	Re-locate vulnerable fish to limit mortality events, and maintain local population integrity	If deemed appropriate/safe to do so (from a fish welfare perspective), remove and re-locate fish that are deemed at risk from mortality to more suitable reaches of the watercourse.	Thames Water/EA
Maintain fish pass operation	Maintain fish passage	In collaboration with the Environment Agency, consider temporary modification of any fish passes the drought permit monitoring identifies as a particular risk to fish passage.	Thames Water/EA
Fine-lined pea mussed and depressed river mussel rescue and relocation	Re-locate vulnerable protected species to limit mortality events, and maintain local population integrity	If drought permit monitoring identifies a major risk to fine-lined pea mussed and depressed river mussel (e.g. observed to be outside of the watercourse), consider the rescue and relocation of individuals, in consultation with the Environment Agency, to nearby suitable habitat	Thames Water/EA
Reduce geomorphological pressures	Limit excessive erosion of the river banks/beds to limit sedimentation etc	Where banksides are subject to excessive drought related erosion (and potential deposition impacts post drought), stabilise using geotextiles, coir rolls and planting of appropriate vegetation.	Thames Water/EA
Maintain/restore key habitats for fish, macroinvertebrate and macrophyte habitats	Provide ecological features with key functional riffle habitats required to complete life stages	Consider the removal of fine silt by manual raking riffle/shallow runs. Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)[80] Clear excessive algal growth and invasive flora/macrophytes where excessive encroachment is occurring Consider targeted installation of woody debris features to increase localised flow velocity/scour at impacted spawning gravels (to aide sediment transport and increase water depth for spawning depth) Consider targeted installation of woody debris features to increase flow heterogeneity/scour and marginal cover in shallow areas of the channel[81]	Thames Water/EA/Local Stakeholder Groups
	Provide ecological features with key functional pool/deep glide refuge habitats	Consider the use of large woody debris, brash and vegetative planting in and around refuge habitats to shade (maintain stable temperature), and provide shelter from predators	
Maintain spatial spread and abundance of macroinvertebrate 'fly-life' community	Create a transferable source population of macroinvertebrates for re-stocking into impacted reaches post drought	Consider installing fly boards in less impacted watercourses within the local catchment (e.g. tributaries) can help with the post drought re-colonisation process. Fly boards are floating wooden boards installed in the river which fly life (e.g. mayfly) can lay their eggs upon. The board are then transferred to the impacted reaches of the river accordingly, aiding re-colonisation. Checks for INNS should be undertaken prior to any movement and introduction.	Thames Water/Local Stakeholder Groups (e.g. Local Riverfly Partnerships/Angling Clubs)

[80] Wild Trout Trust Habitat Management Sheet – Gravel Cleaning
http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf

[81] Wild Trout Trust Chalkstream Habitat Manual – Use of Large Woody Debris
http://www.wildtrout.org/sites/default/files/library/Large_Woody_Debris.pdf

Table 6.2: Post Re-Application Drought Permit Implementation - Monitoring and Mitigation

Action	Purpose	Action Description	Responsibility
Ecological Monitoring Programme	To inform post drought management and restoration options	Following the cessation of the re-application drought permit, consider undertaking the following ecological monitoring and assessment where necessary. Survey sites should replicate those surveyed during pre-drought (for impact assessment purposes): Macroinvertebrates: up to three years of annual 3-minute kick sampling and mixed taxon level analysis at five routine baseline monitoring sites. To be carried out in Spring and Autumn macroinvertebrate sampling seasons. Macrophytes: up to three years of annual LEAFPACS2 macrophyte surveys at two baseline monitoring sites to be undertaken in the June to September monitoring period. Fish: up to three years of annual post-drought fish population surveys at baseline monitoring sites to determine any changes in population dynamics both temporally and spatially, including fish ageing (scale) analysis. In addition, assessment of drought on recruitment – juvenile fish surveys (ID of the young of year population dynamics). RHS surveys: Undertake RHS surveys at baseline monitoring sites in order to understand and quantify changes in habitat post drought. INNS Flora: Mapping of terrestrial INNS flora Water Quality: Undertake appropriate water quality monitoring at baseline monitoring sites for a period of 1 year. Hydrology: Spot flow monitoring to be undertaken where necessary at up to five sites in order to quantify flow dynamics during return of the normal hydrological regime. Designated site condition assessments: Depending on the type of feature/habitat, Common Standards Monitoring	Thames Water/EA/Local Stakeholder Groups
Re-seeding/planting of macrophytes	Restoration of the native macrophyte community	If existing macrophyte community has significantly deteriorated, consider reseeding /replanting where possible to promote recovery (e.g. species such as *Ranunculus*[82]). Replanting of macrophyte community composition to be informed by pre-drought community recorded in baseline assessments.	Thames Water/EA
Address key barriers to fish passage	Restore longitudinal connectivity, remove bottlenecks and promote restoration of native fish community	Ease barriers to fish passage – consider removal/easement (e.g. fish and eel pass installation) of key barriers that have been identified as preventing the effective re-colonisation/migration of the native fish community.	Thames Water/EA
Fish stocking	Restoration of the native fish community	Consider annual re-stocking of the native fish population in impacted reaches.	Thames Water/EA
Habitat restoration	Restore/improve the post drought watercourse to support the recovery of native biota	Consider restoration projects of key areas most impacted by the drought permit. 'Maintain/restore key habitats for fish, macroinvertebrate and macrophyte habitats' in the **Table 6.1** above.	Thames Water/EA/Local Stakeholder Groups
In-channel vegetation management	Maintain the channel/stillwater width/size to provide suitable wetted width for ecological purposes	Consider maintenance of both aquatic and terrestrial vegetation so that it provides a suitably diverse hydrological regime as normal flow regime returns to the channel/stillwater. For example, clearance of terrestrial vegetation which has inundated the channel bed (terrestrialisation).	Thames Water/EA/ Local Stakeholder Groups

[82] The Sheffield Partnership for Rivers in Town Environments – Ranunculus planting: https://www.wildtrout.org/blog/sprite-method-re-establishing-ranunculus-post-industrial-rivers

7 OTHER IMPLICATIONS

7.1 CONSIDERATION OF WHICH DROUGHT PERMITS WOULD BE IMPLEMENTED IN A SEVERE DROUGHT

During a drought, the implementation of options will depend upon the development of the drought situation and its impact in different water resource zones. It is important to retain flexibility in the choice of options that will be taken forward to application during a drought.

The drought permit options that may need to be implemented in the London and SWOX WRZs and their timing will be determined through using the control diagrams for guidance. The trigger for the implementation of this set of options is the Level 3 control curve for London and for SWOX the Level 3b control curve or reaching at Farmoor a trigger threshold flow of 100Ml/d, whichever is the earliest, as described in our Drought Plan.

For the other zones the implementation of Category 1 drought permits would be consistent with a Level 3 control curve trigger.

Drought permits are categorised into Category 1 and Category 2 in the Drought Plan. Category 1 is generally less environmentally damaging than Category 2 and therefore more likely to be implemented before Category 2 options. 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 of the Drought Plan would form the basis of the order in which options are used in a drought.

Thames Water would also take into consideration the outcomes of the HRA, SEA and WFD assessments of implementing options in a severe drought. These issues are considered in further detail below.

During a severe drought, where the reapplication of drought permits is required, it is anticipated that the water resource situation would be so severe that all drought permit options that are viable to implement would be implemented; therefore, the reapplication would be dictated by the phasing of the first application and the need to review these.

7.2 IMPLICATIONS FOR THE HRA

A water company must ensure its Drought Plan meets the requirements of the Habitats Regulations before implementation. The requirement for a Habitat Regulation Assessment (HRA) is established through Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (referred to as the 'Habitats Directive') in Articles 6(3) and 6(4). The Habitats Directive is transposed into national legislation by the Conservation of Habitats and Species Regulations 2017. Under Regulations 63 and 105, any plan or project which is likely to have a significant effect on a European site (either alone or in-combination

with other plans or projects) and is not directly connected with, or necessary for the management of the site, must be subject to a HRA to determine the implications for the site in view of its conservation objectives. In the context of the Habitats Directive, European sites include Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) (also known as Natura 2000 sites) and Ramsar sites. HRA Guidance for the appraisal of Plans[83], summarises the Habitats Regulations. Regulation 63(5) states that the Plan making authority (in this case Thames Water) shall adopt, or otherwise give effect to, the Plan only after having ascertained that it will not adversely affect the integrity of a European site, subject to Regulation 64 or 105 of the Habitats Regulations.

Thames Water has undertaken the first stage in the HRA process, Screening, on its draft Drought Plan options. The screening stage establishes whether any schemes have the potential for a Likely Significant Effect (LSE) on the integrity of a European site. Following the process, it was concluded that no options included in the draft Drought Plan 2017, are considered to have LSE on European sites, either alone or in combination with other drought options included in the Drought Plan. In-combination effects of draft Drought Plan 2017 with Thames Water's WRMP14, the EAs regional Drought Plans, the Thames River Basin Management Plan 2015, and other water company WRMPs and drought plans, are not considered likely to have significant adverse effects on European sites.

The screening exercise undertaken to inform the HRA for the draft Drought Plan 2017 was reviewed to determine whether any changes in the impacts associated with the re-application of a drought permit could have implications on any European sites. The changes considered includes changes in:

- The likely periods (timing) for re-application,
- The extent of the study area associated with the selected drought permits,
- The recovery periods, and
- The impacts on the physical and environmentally sensitive features.

The screening outcomes for the following options were reviewed: Lower Thames, Latton, Baunton 2, Farmoor, Meysey Hampton, Pangbourne, Sundridge 2, Waddon, Ogbourne 1, Ogbourne Emergency Boreholes, Axford 2, M2 Licence, Eynsford, Horton Kirby, Fobney Direct, Harpsden and Sheeplands, New Ground, Shalford, Albury, and Pann Mill.

Although potential changes in the extent of impacts associated with Baunton 2, Axford 2, Pann Mill and New Ground have been identified, no European sites within the zone of influence of the schemes have been identified (i.e. the area over which the scheme could affect groundwater and surface water). However, based on the potential changes in time periods associated with the re-application of some drought permits and the potential changes in the impact on the physical and environmental features, the LSE on designated features and conservation

[83] Tyldesley, D. & Chapman, C. (2015) The Habitats Regulations Assessment Handbook. DTA Publications. Version 4.

objectives of some European sites were considered in more detail. It is considered that the European sites that could potentially be affected by the drought permits in a **multi-season drought** include the Kennet and Lambourn Floodplain SAC and the Oxford Meadows SAC.

7.2.1 Kennet and Lambourn Floodplain SAC

The Review of Consents for the Kennet and Lambourn Floodplain SAC concluded that the potential operation of the West Berkshire Groundwater Scheme (WBGWS) in a prolonged drought could lead to lowering of groundwater levels under the Thatcham Reedbeds, with the potential for adverse impact on the surface water regime on which the habitat assemblage in the Reedbeds is dependent. The Appropriate Assessment identified two measures to avoid or mitigate this impact. The first was the reduction of the Speen licence, which has been implemented by Thames Water (April 2015).

The second was augmenting the groundwater supply to Thatcham Reedbeds. Thames Water have implemented the latter in the form of a sluice to allow a small offtake from the Kennet into the Kennet and Lambourn Floodplain SAC. This sluice was completed in 2015 and will be operated by the Wildlife Trust according to an agreed set of criteria, which are that the Enborne wellfield of the WBGWS is in operation and the groundwater level has fallen below the prescribed level at Newbury STW observation borehole. The criteria for use of the augmentation are flexible such that it could also be used under other circumstances to support the wetland and so could be used to provide mitigation support to the wetland if required during a drought in the unlikely event that the Enborne well field of the WBGWS is not in use. The Environmental Assessment Report for the Axford 2 drought permit indicated that the site is designated for the Annex II species Desmoulin`s whorl snail *Vertigo moulinsiana*. The cluster of sites selected in the Kennet and Lambourn valleys supports one of the most extensive known populations of Desmoulin's whorl snail in the UK and is one of two sites representing the species in the south-western part of its range in the important chalk stream habitat.

Humidity is important to all whorl snails (*Vertigo* spp.) and the different species achieve their requirements by occupying different levels (i.e. vertical movement) within their microhabitats. The maximum reproductive activity for the species is known to occur in spring and early summer. Desmoulin's whorl snail achieves its desired humidity by climbing above wet vegetation during warm periods and descending in cooler parts of the year. In spring, the snails are found low down, principally on the stems and leaves of monocotyledons, and then ascend the plants throughout the summer and autumn, reaching a height of over 2 m above ground level[84]. Within the River Kennet floodplain and ditch environment, high groundwater levels throughout the year are considered to be one of the most important factors influencing the distribution of Desmoulin's whorl snail, and high populations are observed where water levels rarely fall below ground level.

The assessment undertaken as part of the Axford 2 EAR indicates that Desmoulins's whorl

[84] Killeen IJ (2003). Ecology of Desmoulin's Whorl Snail. Conserving Natura 2000 Rivers Ecology Series No. 6. English Nature, Peterborough

snail is not directly associated with surface water flow, apart from periods of high flows when they can be immersed, transported or washed away. Groundwater levels are the main hydrological driver of concern for this species and the supplementary advice on conservation objectives indicate that, maintenance of appropriate groundwater water levels have been identified as particularly important. The EAR for the Axford 2 drought permit identified that the SAC is located outside the zone of influence of the groundwater drawdown associated with the drought permit and as such, groundwater levels will not be impacted by the implementation of the drought permit.

As indicated above, the Thames Water has installed a sluice to allow a small offtake from the Kennet into the Kennet and Lambourn Floodplain SAC. The Axford 2 EAR identified that the reduction in flows during the operation of the drought permit and delay to recovery in groundwater is unlikely to lead to any significant changes in wetted width or wetted perimeter beyond that which is experienced in the normal range of hydrological variation. The EA and Natural England are working together to ensure that all parts of the SAC have appropriate water levels, through measures such as the production of water level management plans and regular monitoring of water quality. Several of the weirs identified in the associated reach are operated to ensure that flow is maintained with the ditches and channels in the SAC. At Eddington Mill the River Kennet splits into several channels through historic sluices with a smaller channel ensuring flow to the SAC. Connectivity with the River Kennet will have to be maintained during the implementation of the drought permit.

During a multi-season drought and a re-application of the Axford 2 drought permit, the hydrological impacts would be an exacerbation of flow reduction and reduction in wetted habitat and velocities as baseflow from contributing catchment reduces with environmental drought. Full flow recovery is unlikely until late in the following winter. Assuming that the West Berkshire Groundwater Scheme (WBGWS) will be operational at the same time as Axford 2 during a multi-season drought or the WBGWS was operating prior to re-application, it is likely that water levels within the SAC will not be sufficiently managed to prevent habitat loss. The operation of the new sluice will, however mitigate against this impact and no impact on the conservation objectives of this site are expected.

A major concern with regards to the qualifying feature is the moderate risk to water quality associated with a re-application. Desmoulin's whorl snail populations are potentially at risk from water quality issues, particularly elevated phosphate and nitrate levels, and organic pollution. They are also vulnerable to poor water quality if it affects their habitat. The habitat on which Desmoulin's whorl snail depends can be impacted by pollution if it results in changes to the plant community. Elevated levels of nutrients, particularly phosphates and nitrates, are likely to be detrimental if changes result in the vegetation community. This is particularly relevant to snail habitat in river margins and drains as identified in Killeen (2003)[85]. Increased Soluble Reactive Phosphorus (SRP) concentrations in the impacted reaches could increase

[85] Killeen IJ (2003). Ecology of Desmoulin's Whorl Snail. Conserving Natura 2000 Rivers Ecology Series No. 6. English Nature, Peterborough

macrophyte growth rates species and increase the occurrence of epiphytes and algae potentially resulting in impacts on slow growing species. The changes in water quality could result in changes in the supporting habitat, ultimately impacting on the distribution and continuity of the Desmoulin's whorl snail. The main supporting species, *Glyceria maxima*, is not sensitive to eutrophication. However, increased nutrients could result in rapid growth and excessive shading altering the microhabitat required to maintain current populations and adult/juvenile ratios.

Water quality changes could, therefore, result in changes in vegetation communities as a result of the drought permit implementation and this could impact on the supporting habitat for the designated species. This could impact on the population of the qualifying feature and the distribution of the qualifying features within the SAC. During the summer and early autumn months the snail ascends the vegetation reaching a height of up to 2m and the potential shading caused by the increased growth in vegetation should have a limited impact on the designated feature. However, the snails tend to descend during the cooler months. The ascending and descending of vegetation by the snails is aimed at achieving the desired humidity. During winter, the snails are found amongst the litter and decaying vegetation.

Changes in water level, water quality and the delay in baseflow recovery within the catchment could result in changes in the supporting processes on which the habitats of the qualifying features rely which in turn, will impact on the population and distribution of the qualifying feature. With the new sluice operational it can be concluded that there will be no LSE on the designated features and the associated conservation objectives of the Lambourn Floodplain SAC.

7.2.2 Oxford Meadows SAC

Oxford Meadows SAC comprises a series of lowland hay meadows, which are an Annex I habitat, in the Thames Valley which includes vegetation communities that are perhaps unique in the world in reflecting the influence of long-term grazing and hay-cutting. The site is comprised of a number of component SSSI sites, which include Cassington SSSI, Pixey and Yarnton SSSI, Wolvercote Meadow SSSI and Port Meadow with Wolvercote Common and Green SSSI. The Oxford Meadows SAC is also designated for the presence of the Annex II species creeping marshwort (*Apium repens*), with Port Meadow the larger of only two known sites for this species in the UK.

The Oxfordshire Biodiversity Action Plan identifies that the lowland meadows are sensitive to changes in hydrology and nutrient status, with grassland of this type identified under the National Vegetation Classification as MG4 (meadow foxtail (*Alopecurus pratensis*) and red thunder (*Sanguisorba officinalis*)) significantly reliant on winter flooding. Many parts of the site are not considered to be significantly hydraulically linked to the River Thames, with water levels primarily linked to groundwater levels in the underlying gravels.

The hydrological assessment undertaken for the Farmoor drought permit (for a first

application) has identified that the main channel of the River Thames will be subject to reductions in velocity whilst the distributaries (including the Oxford Watercourses), notably Wolvercote Stream and Castle Mill Stream for the Oxford Meadows SAC, will be subject to a reduction in velocity, or level and velocity, due to lower flows. The lowland meadows are reliant on winter flooding, although many parts of the site are not considered to be significantly hydrologically linked with the River Thames – water levels are primarily linked to groundwater levels. It was concluded that the Farmoor drought permit will have no impact on flood flows overwinter. The hydrological reference conditions associated with the re-application for the Farmoor drought permit would be low autumn/winter flows. As the main concern associated with the SAC is the potential impact on winter flooding, and the drought permit re-application will not result in a reduction in flooding there is no risk associated with the drought permit. There is a low risk to changes in the nutrient status of the meadows as flow in a multi-season drought will not be sufficient to result in flooding of the meadows.

Therefore, no significant effects on the qualifying features are anticipated on the designated features of the SAC associated with the re-application of the drought permit.

7.2.3 Summary of the implications of a severe drought on the HRA

The screening exercise undertaken to inform the HRA for the final Drought Plan 2018 was reviewed to determine whether any changes in the impacts associated with the re-application of a drought permit could have implications on any European sites. The changes considered includes changes in: the likely periods (timing) for re-application; the extent of the study area associated with the selected drought permits; the recovery periods; and the impacts on the physical and environmental features. The review indicated that no European sites (Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) and Ramsar sites) will be impacted by any drought permits in a severe drought.

7.3 IMPACT ON SEA

SEA of certain plans and programmes is a statutory requirement under Directive 2001/42/EC, as transposed into UK law by the Environmental Assessment of Plans and Programmes Regulations 2004. The purpose of SEA is to provide high level and strategic protection of the environment by incorporating environmental considerations into the preparation of plans and policy. The nature of TWUL's Final Drought Plan 2018 means that SEA is not a mandatory requirement in this case. However, the company has undertaken SEA to assist in the identification of the likely significant environmental effects of its drought options and to determine how any adverse impacts might be avoided or mitigated.

The SEA provides information on the relative environmental performance of alternatives (i.e. individual drought options) and is intended to make the decision-making process more transparent. The SEA can, therefore, be used to support the timing and implementation of drought options within the final Drought Plan 2018.

SEA of TWUL's Final Drought Plan 2018, including the approach and methodology, is

documented separately and has included the assessment of 51 individual drought options comprising 10 supply side options, six demand options and 35 drought permit/order options. This considered implementation of a drought option for a single six month period only. The purpose of this section of the report is to consider the implications of the high-level assessment of the environmental impacts of TWUL's drought actions in severe droughts on the SEA.

The significance of the potential impacts associated with the re-application of a drought permit are summarised for each drought permit in **Appendix A**. As summarised in Section 5, the most significant changes to the physical and environmental features following re-application of a drought permit are observed at the following nine options:

- Lower Thames
- Baunton 2
- Sundridge 2
- Ogbourne 1
- Ogbourne Emergency Boreholes
- Axford 2
- Eynsford
- Pangbourne
- Meysey Hampton

The potential changes in the physical environment risks and environmental impacts associated with each drought permit, as implemented for a severe drought, may have implications for each key issue identified in the SEA (biodiversity, population and human health, material assets and resource use, water, soil, geology and land use, air and climate, archaeology and cultural heritage and landscape). A high-level assessment of the potential implications of a severe drought for the SEA objectives has therefore been undertaken on those 9 drought options identified above. The findings of this are set out in **Table 7.1**. An explanation of the SEA objectives and colour-coded visual evaluation used in the table is provided below.

In **Table 7.1**, for each drought option, the original SEA findings are summarised, which considered the implementation of a drought option for a single six month period; and the findings of the high-level assessment of the potential implications of a severe drought are set out in each corresponding row below the original SEA findings.

Table 7.2 sets out the SEA topics and objectives which are identified in **Table 7.1**.

Table 7-1 Overview of SEA Outcomes for Selected Drought Options in a Severe Drought

		SEA Topic																						Commentary
		Biodiversity				Population and Human Health			Material Assets and Resource Use		Water				Soil, Geology and Land Use			Air and Climate			Archaeology and Cultural Heritage		Landscape	
SEA Objective		1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	4.1	4.2	4.3	4.4	5.1	5.2	5.3	6.1	6.2	6.3	7.1	7.2	8.1	
London Resource Zone																								
Sundridge 2 first application	Adverse																							Major short-term hydrological effects may occur due to reductions in flows, velocities and levels in three reaches of the River Darent (Impacts are major on one reach and minor on two other reaches). This would also result in moderate adverse effects to water quality, as one reach may have higher SRP concentrations associated with low river flow. A moderate short-term impact on the feasibility of surface water abstraction at Sevenoaks Wildfowl Reserve may occur with the drought order in place. Moderate adverse short-term effects associated with reduced lake levels on the Sevenoaks Gravel Pits SSSI are possible, as are impacts on breeding birds and a reduction in suitability or distribution of habitats which support *Cordulia aenea*. The significance of impacts on NERC fish species are likely to be major for brown/sea trout and eels based on the fragmentation of habitats, with reduced river flows inhibiting migration. Major adverse impacts may occur on WFD status due to the impact of the drought option on fish. Major adverse effects due to the possibility that an implementation of the drought order could encourage movement of the invasive species signal crayfish in the catchment, increasing the likelihood of interaction between signal and the native white clawed crayfish (NERC species), resulting in a high magnitude impact that is considered irreversible. Minor adverse short term effects may occur on landscape values, as a significant reduction in river or lake level will have a visual impact on the landscape setting of the area and the Darent Valley Path National Trail, which may be noticeable by walkers.
	Beneficial																							Beneficial effects associated with the maintenance of essential public water supplies during times of drought, and improved resilience to the drought effects.
Sundridge 2 re-application	Adverse																							The hydrological effects associated with a re-application are expected to be a continuation of flow reduction and reduction in wetted habitat and velocities. The hydrological impact relate to the risk that full flow recovery unlikely until late in the following winter. There is risk of impact further upstream on the River Darent (Reach 1). The re-application of the Sundridge drought permit will not result in changes in the assessment of impacts on biodiversity as these are considered to be of major significance for a 6-month application and will remain major for the re-application. This extended application of a drought permit may result in further impacts on angling and the amenity value of the study area. The significance of impacts associated with NERC species and WFD status is considered to be major all year round and re-colonisation post drought is likely to be limited due to the already impacted nature of the aquatic communities. The major risk associated with most features would be applicable to all reaches associated with the drought permit.
	Beneficial																							If implemented, the drought permit would have a major beneficial effect for populations and human health in terms of ensuring supply of water and other customers/businesses. Major beneficial effects are also expected in regard to improved resilience of water supplies to drought.
Lower Thames – first application	Adverse																							If implemented, the drought permit would have major adverse effects on flows in the lowest reaches of the fluvial Thames, mainly in terms of velocity reduction. Freshwater flows to the upper Thames Tideway will reduce, potentially completely. Adverse effects are predicted on water quality in the fluvial Thames (reduced dissolved oxygen saturation and reduced phosphate dilution) which may exacerbate water quality issues in the upper Tideway with the potential for major adverse effects. Minor to major adverse effects are expected on a range of aquatic ecological receptors, such as macroinvertebrates, macrophytes, fish and algae. The major adverse effects are predominantly associated with adverse effects to fish, including migration. Adverse effects also identified with respect to Langham Pond SSSI, Dumsey Meadow SSSI and Syon Park SSSI. Major adverse effects may occur on navigation. The combination of maintenance of water levels, restrictions on lock use, and small restrictions regarding navigability in the Thames Tideway would result in major adverse effects on boats that are navigating between the Tideway and the fluvial River Thames.

		SEA Topic																						
		Biodiversity				Population and Human Health			Material Assets and Resource Use		Water				Soil, Geology and Land Use			Air and Climate			Archaeology and Cultural Heritage		Landscape	Commentary
SEA Objective		**1.1**	**1.2**	**1.3**	**1.4**	**2.1**	**2.2**	**2.3**	**3.1**	**3.2**	**4.1**	**4.2**	**4.3**	**4.4**	**5.1**	**5.2**	**5.3**	**6.1**	**6.2**	**6.3**	**7.1**	**7.2**	**8.1**	
	Beneficial																							If implemented, the drought permit would have a major beneficial effect for populations and human health in terms of ensuring supply of water and other customers/businesses. Major beneficial effects are also expected in regard to improved resilience of water supplies to drought.
Lower Thames re-application																								The re-application of the drought permit will result in an extension of the hydrological impacts identified for the Lower Thames drought option. In addition, there is a moderate risk of saline intrusion, particularly in the lower reaches of the River Thames. The significance of impacts is likely to increase from moderate to major for several NERC species and will also increase from moderate to major for the WFD status of the macroinvertebrate community and the fish community. As the impacts on the biodiversity objective has already been assessed as major, the re-application will not result in any changes in the assessment. The significance of impact is likely to increase from moderate to major for the fish community which includes Smelt (*Osmerus eperlanus*) and European eel (*Anguilla anguilla*). This could impact on the proposed Thames Estuary Marine Conservation Zone (pMCZ).
	Beneficial																							If implemented, the drought permit would have a major beneficial effect for populations and human health in terms of ensuring supply of water and other customers/businesses. Major beneficial effects are also expected in regard to improved resilience of water supplies to drought.
Eynsford – first application	Adverse																							Major adverse short-term effects are predicted on one reach of the River Darent as part of it could dry up as a result of drought option implementation. This would result in major, short-term adverse effects to water quality. Short-term effects are possible on NERC fish species (brown trout, eels, sea trout - major) due to fragmentation of habitats and reduced river flows inhibiting migration. Major adverse impacts on WFD status are anticipated based on the impact of the drought option on fish and macroinvertebrates. Moderate adverse effects associated with the spread of the invasive species (Australian swamp stonecrop, parrots feather and floating pennywort) are possible. Minor adverse short-term visual impact may occur on the landscape setting of the area and the Darent Valley Path National Trail reduction in river level will have, which may be noticeable by walkers.
	Beneficial																							If implemented, the drought permit would have moderate beneficial effects for populations and human health in terms of ensuring supply of water and other customers/businesses. Minor beneficial effects are also expected in regard to improved resilience of water supplies to drought
Eynsford re-application	Adverse																							The hydrological impacts associated with the re-application are considered to be of major significance and have been assessed as a risk of continuation of a dry river, particularly in upper and middle reaches. There is also a major risk to geomorphology (extended period of fine sediment deposition and impacts associated with drying/return to flow) and water quality deterioration. Water quality risks include reduced buffering capacity for diluting continuous and intermittent discharges) and elevated temperature together with likely first flush of pollution during re-wetting. The re-application of the Eynsford drought permit will not result in changes in the assessment of impacts on biodiversity as these are considered to be of major significance for a 6-month application and will remain major for the re-application. The re-application of the Eynsford drought option will, however, result in an increase in the significance of impacts associated with the fish community, including NERC Act and other notable fish. Drying of the river bed and anticipated deterioration to the natural environment likely to be of great concern to the public. As such, the impact on amenity and angling will increase from minor to major resulting in a change in the assessment of this objective.
	Beneficial																							If implemented, the drought permit would have moderate beneficial effects for populations and human health in terms of ensuring supply of water and other customers/businesses. Minor beneficial effects are also expected in regard to improved resilience of water supplies to drought

		SEA Topic																						Commentary
		Biodiversity				Population and Human Health			Material Assets and Resource Use		Water				Soil, Geology and Land Use			Air and Climate			Archaeology and Cultural Heritage		Landscape	
SEA Objective		1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	4.1	4.2	4.3	4.4	5.1	5.2	5.3	6.1	6.2	6.3	7.1	7.2	8.1	
SWOX Resource Zone																								
Baunton 2 – first application	Adverse																							Major adverse, short-term effects are predicted on five reaches, as they may remain dryer for longer as result of the drought option. Moderate, adverse, short-term effects on NERC fish species are possible. Negligible, adverse, short-term landscape and visual effects may occur as the drought option is located in Cotswolds AONB. However due to the natural drying of the reaches in natural drought conditions, it is unlikely that drought permit implementation will have significant impacts on the local distinctiveness of the landscape. Effects are similar to those associated with the Baunton 1 option.
	Beneficial																							If implemented, the drought permit would have moderate beneficial effects for populations and human health in terms of ensuring supply of water and other customers/businesses. Minor beneficial effects are also expected in regard to improved resilience of water supplies to drought
Baunton 2 – re-application	Adverse																							Study area reviewed and considered there are uncertainties in extent. There is risk of impact further upstream on the river Churn (Reach 1), River Frome (Reach 5) and River Coln (Reach 7), either in terms of extending the recovery to a wetted channel, or to full flow recovery. This delay in full flow recovery could extend to the Daglingworth Stream and Elkstone Brook local to the Baunton boreholes, through groundwater connectivity with uncertainty around the effects of faulting. The extended drying of banks associated with the decrease in wetted width could result in major geomorphological impacts in several reaches. The re-application of the Baunton 2 drought option could also result in major risk to aquatic communities, including NERC Act and Notable species and WFD status.
	Beneficial																							If implemented, the drought permit would have moderate beneficial effects for populations and human health in terms of ensuring supply of water and other customers/businesses. Minor beneficial effects are also expected in regard to improved resilience of water supplies to drought
Meysey Hampton – first application	Adverse																							Major adverse, short-term effects are predicted on four reaches of river as they may remain dryer for longer as result of the drought option. This would result in minor short-term effects to water quality as dissolved oxygen saturation levels may be affected by lower river flow. Moderate adverse, short-term effects on NERC fish species are predicted, comprising increased stress and predation on species in refuges as a result of delay in recovery of flows, reduction in species abundance or distribution as a result of changes in water quality, and impacts on spawning potential.
	Beneficial																							Beneficial effects include maintenance of essential public water supplies during times of drought.
Meysey Hampton re-application	Adverse																							The hydrological impacts of a re-application will be a significant extension of the period the reach is dry including seasons where this would not normally be the case. Full flow recovery unlikely until late in the following winter. The re-application could also result in a major risk to geomorphology (duration of dry channel will have long-term and potentially irreversible effects on the bed and banks). Water quality effects are also possible likely from the first flush of pollution during re-wetting. The re-application of the drought option could also result in major risk to aquatic communities, including NERC Act and Notable species and WFD status.
	Beneficial																							Beneficial effects include maintenance of essential public water supplies during times of drought.
Ogbourne – first application	Adverse																							Moderate adverse, short-term effects are anticipated with respect to biodiversity, flora and fauna. Impacts on fish may occur due to an extension in duration of River Og being dry, and a reduction in flows in the River Kennet. Changes in flow in the River Kennet (a designated SSSI) also have potential for moderate adverse, short-term effects on macroinvertebrates. The Middle Kennet water body is considered at moderate risk of short-term deterioration of WFD status for macroinvertebrates and fish. Minor adverse, short-term effects on angling and recreation are possible due to impacts on fish communities. Moderate adverse, short-term effects to water are likely as the abstraction will cause the River Og to remain dry for longer. Flow changes in the River Kennet are considered minor, however there is a high risk to water quality associated with the Marlborough STW discharge due to reduced dilution in the River Kennet during drought permit implementation.

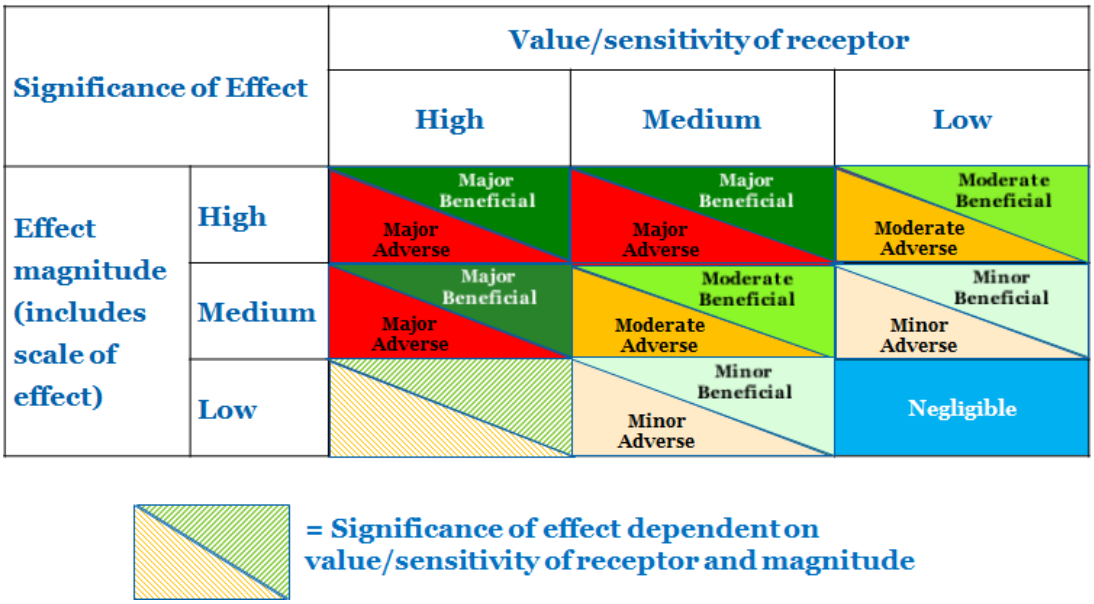
		SEA Topic																						Commentary
		Biodiversity				Population and Human Health			Material Assets and Resource Use		Water				Soil, Geology and Land Use			Air and Climate			Archaeology and Cultural Heritage		Landscape	
SEA Objective		1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	4.1	4.2	4.3	4.4	5.1	5.2	5.3	6.1	6.2	6.3	7.1	7.2	8.1	
	Beneficial																							Moderate beneficial effects are expected due to provision of additional water supply. Minor beneficial effects are associated with improving the resilience of water supplies to drought.
Ogbourne re-application	Adverse																							The hydrological effects associated with a re-application is expected to be major as a result of a significant extension of the period the reach is dry including seasons where this would not normally be the case. Full flow recovery is unlikely until late in the following winter. Up to major risks to geomorphology (duration of dry channel will have long-term and potentially irreversible effects on the bed and banks) and water quality effects from likely first flush of pollution during re-wetting. Changes in flow in the River Kennet (a designated SSSI) could result in major impact on the designated site. The re-application of the drought option could also result in major risk to aquatic communities, including NERC Act and Notable species and WFD status. The major impacts on the fish community will also result in moderate impacts on angling within the study area.
	Beneficial																							Moderate beneficial effects are expected due to provision of additional water supply. Minor beneficial effects are associated with improving the resilience of water supplies to drought.
Kennet Valley Water Resource Zone																								
Pangbourne – first application	Adverse																							Negligible hydrological effects are anticipated on the River Pang from the Blue Pool to the confluence with River Thames. However, temporary adverse impacts ranging from major to negligible are anticipated on Sulham Brook. Major adverse hydrological effects are predicted due to extension of the period Sulham Brook would be dry, and major effects on water quality in Sulham Brook are also expected due to low dissolved oxygen saturation and reduced dilution of Pangbourne STW discharges. Sulham Brook has high sensitivity for WFD status. Short-term major impacts on one other abstraction from Sulham Brook are also possible. Moderate impacts on the geomorphology of Sulham Brook are possible, associated with reduced flows in areas where bank slope is shallow. Minor, short-term impacts on the Sulham and Tidmarsh Woods and Meadows SSSI, NERC fish species (brown trout and European eel) and notable county and regional level species (bullhead and brook lamprey) are possible.
	Beneficial																							Moderate beneficial impacts are expected with regard to ensuring supply of water to local population and other customers/businesses. There is also likely to be a minor beneficial effect associated with improving the resilience of water supplies to drought.
Pangbourne re-application	Adverse																							Study area was reviewed for a re-application and additional risk to the upper reaches of Reach 2 was identified. There is also uncertainty over risk to the River Bourne, a tributary of the River Pang in Reach 1. The hydrological impacts associated with a re-application will be a major risk with a potential for dry reaches or significant flow reduction and reduction in wetted habitat and velocities as baseflow from contributing catchment reduces and influence of losing reaches increases with environmental drought. There is also a major risk risks to geomorphology (from channel drying in atypical locations; extended period of fine sediment deposition in reaches with continuous flow) and water quality deterioration. Full flow recovery is unlikely until late in the following winter. The lack of surface water inundation over multiple winters, combined with groundwater abstraction pressures is likely to impact severely on the ecological integrity of the Sulham and Tidmarsh Woods and Meadows SSSI. The re-application of the drought option could also result in moderate risk to aquatic communities, including NERC Act and Notable species and WFD status
	Beneficial																							Moderate beneficial impacts are expected with regard to ensuring supply of water to local population and other customers/businesses. There is also likely to be a minor beneficial effect associated with improving the resilience of water supplies to drought.

Table 7-2 SEA topics and objectives

Topic	SEA objective
Biodiversity fauna and flora	1.1 To conserve and enhance biodiversity, including designated sites of nature conservation interest and protected habitats and species (with particular regard to avoiding the effects of over-abstraction on sensitive sites, habitats and species).
	1.2 To protect, conserve and enhance natural capital and the ecosystem services from natural capital that contribute to the economy.
	1.3 To strengthen the connections between people and nature and realise the value of biodiversity and ecosystem services.
	1.4 To avoid introducing or spreading INNS.
Population and human health	2.1 To protect and enhance health and well-being (including raising awareness of the importance and value of the water environment for health and well-being).
	2.2 To protect and enhance the water environment for other users including recreation, tourism and navigation, as well as terrestrial recreational resources (including National Trails and Public Rights of Way).
	2.3 To promote a sustainable economy with good access to essential services, including a resilient, high quality and affordable supply of water over the long term.
Material assets and resource use	3.1 To reduce, and make more efficient, the domestic, industrial and commercial consumption of resources, minimise the generation of waste, encourage its re-use and eliminate waste sent to landfill.
	3.2 To promote the sustainable management of natural resources including efficient and sustainable use of water; ensure resilient water supplies for homes and industry in the area is maintained.
Water	4.1 To avoid adverse impact on surface and groundwater levels and flows, including when this impacts on habitats and/or navigation.
	4.2 To protect and enhance surface and groundwater quality and protect and enhance estuarine waterbodies.
	4.3 To ensure appropriate and sustainable management of abstractions to maintain water supplies whilst protecting ecosystem functions that rely on water resources including contributing to the achievement of WFD objectives.
	4.4 To promote measures to enable and sustain long term improvement in water efficiency.
Soil, geology and land use	5.1 To protect and enhance geology, geomorphology and the quality and quantity of soils.
	5.2 To protect and enhance the ecosystem services functions of land, soils and geology, including carbon sequestration, flood attenuation, pollutant filtration and nutrient cycling.
	5.3 To promote a catchment-wide approach to catchment land management.
Air and climate	6.1 To reduce air pollutant emissions.
	6.2 To reduce greenhouse gas emissions.
	6.3 To adapt and improve resilience to the threats of climate change.
Archaeology and cultural heritage	7.1 To conserve and enhance the historic environment, heritage assets and their settings and protect archaeologically important sites.
	7.2 To protect, enhance and manage the character and appearance of historic and cultural assets and their settings including maintaining and strengthening local distinctiveness and sense of place.
Landscape and visual amenity	8.1 To protect, enhance the quality of and improve access to designated and undesignated landscapes, townscapes and the countryside.

For each SEA objective, a residual effects assessment was determined against a significance matrix (**Figure 7 1**) which took into account the value/sensitivity of the receptor (e.g. air quality, river water quality, landscape value) and the magnitude of the assessed effect. This significance matrix comprised effects from 'major beneficial' to 'major adverse'. For the box signifying low magnitude and high receptor value/sensitivity, this could result in a greater than 'moderate' effects being assigned dependent on the sensitivity/value of the receptor. This colour coding was used to complete the columns for residual effects in the appraisal framework summarised in **Table 7.1**.

Figure 7-1 Significance matrix



The definitions for 'significance' ratings as identified in Figure 7.1 are provided as follows:

Major - effects represent key factors in the decision-making process. They are generally associated with sites and features of international, national or regional importance. If adverse, such resources/features are generally those which cannot be replaced or relocated.

Moderate - effects are likely to be important considerations at a regional or district scale. If adverse, they are likely to be of potential concern.

Minor - effects are not likely to be decision-making issues. Nevertheless, the cumulative effect of such issues may lead to an increase in the overall effects on a particular area or on a particular resource.

Negligible - effects which are not perceptible, being within normal bounds of variation or the margin of forecasting error.

For the '**high' effect magnitude** (top row), a major effect significance is assigned for both high and medium value receptors to reflect the magnitude of the effect.

For the **'low' effect magnitude and 'high' value receptor** (bottom left box), the significance of effect could be minor, moderate or major dependent on the precise nature of the impact or benefit.

It can be seen from **Table 7.1** that implementing drought actions for multi-season droughts that could require a re-application for drought permits/orders beyond their original 6 months has certain implications for the SEA. Of the 9 options considered, the residual effects assessment resulted in an increase in potential adverse effects for various SEA objectives (including biodiversity; population and human health; water; soil, geology and land use; and air and climate) for the following:

- Baunton 2
- Sundridge 2
- Ogbourne 1

- Ogbourne Emergency Boreholes
- Axford 2
- Eynsford
- Pangbourne
- Meysey Hampton

It should be noted that the potential adverse effects for some SEA objectives, for example biodiversity, remains unchanged when considering the impacts of the re-application of drought permits. Due to the increase in the likely period of impacts (medium to long-term compared to short term) this may result in further impacts on other objectives, such as amenity, which would not occur as a result of the first application of a drought option.

It was considered that there will be no change to any beneficial effects.

7.4 IMPACTS ON WFD COMPLIANCE

The DPG requires that a water company must ensure its Drought Plan includes an assessment of the effect of the plan on WFD status or potential and consider the effects the actions might have on environmental objectives and measures set out in River Basin Management Plans. For Thames Water's Drought Plan as a whole and the first application of drought permits as set out in the draft Drought Plan, this WFD compliance risk is considered in Appendix B of the Drought Plan.

The main risk to WFD compliance from drought permit re-application is associated with temporary status deterioration. This relates to compliance with the requirements of the WFD including Articles 4.6 to 4.9. Extra DPG information provided by the EA[86] clarifies the meaning of temporary deterioration and appropriate WFD provisions.

Deterioration is identified as a drop in status class of any element set out in Annex V of the WFD, irrespective of whether this causes a deterioration in status of the water body overall. The appropriate timescale for defining deterioration is a 6-year river basin planning cycle, where deterioration is a drop in status class reported for a status element in a water body in one River Basin Management Plan when compared with the reported status of that element in the same water body in the previous River Basin Management Plan.

In the EARs for the first application drought permits, each relevant biological status element (for rivers these are fish, aquatic macroinvertebrates, macrophytes and diatoms) was included in the features screening, and where appropriate, assessed in the EAR, including an assessment of the risk to status reduction, both in the short-term and over recovery timescales commensurate with the definition of temporary deterioration. The re-application assessments have considered this in the context of a multi-season drought, albeit at a higher level of assessment. Individual drought permit re-applications would likely lead to a risk of temporary

[86] Environment Agency (2017) Drought Plan Guidance Extra Information: Environmental Assessment for Water Company Drought Plans. September 2017

WFD status deterioration, in accordance with the definition above, as summarised in Section 5 above.

It is noted that these WFD compliance risks have been identified prior to the inclusion of mitigation measures, as introduced in Section 6 above, and that these measures may, in some circumstances successfully remove the risk.

8 CONCLUSION

The focus of this report has been to document the findings of a high-level assessment of the environmental impacts of Thames Water's drought actions in droughts worse than in the historical record ('severe droughts'). In the context of this report, these droughts are considered multi-season droughts that could require a re-application for drought permits/orders beyond their original 6 months.

It is acknowledged that not all of the 51 drought options included in the Drought Plan would be available to Thames Water during a severe (multi-season) drought. A total of 20 drought options have been identified by Thames Water and subsequently assessed.

The Environmental Assessments Reports (EARs) of the drought options, which were prepared to support the Final Drought Plan 2018, have been used as a basis to inform this high level environmental assessment of the 20 selected options. The assessment has considered potential impacts on key physical environment features (e.g. hydrological, hydrogeological, water quality, etc.) and key environmentally sensitive features (e.g. fish communities, designated sites and species, etc.).

It was concluded that following the re-application for drought permits/orders beyond their original 6 months, additional impacts ranging from negligible to major adverse could be observed on both the physical environment and environmentally sensitive features.

The assessment of the potential changes in the significance of impacts on the environmental features did not consider any mitigation measures beyond those identified in the original EARs. Additional mitigation measures, over and above those stated in the EARs, have been identified for consideration. However, it should be noted that discussions would need to be held between Thames Water and the regulators to determine and agree the specific mitigation measures to be implemented, which would depend on the specific conditions in the event of a severe drought.

During a drought, the implementation of options will depend upon the development of the drought situation and its impact in different water resource zones. Thames Water will need to retain flexibility in the choice of options that will be taken forward to application during a drought. Other considerations will also take into account the outcomes of the HRA, SEA and WFD assessments of implementing options in a severe drought.

The screening exercise undertaken to inform the HRA for the final Drought Plan 2018 was reviewed to determine whether any changes in the impacts associated with the re-application of drought options could have implications on any European sites. This review concluded that no European sites (Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) and Ramsar sites) will be impacted by any drought options in a severe drought.

SEA of Thames Water's Revised Draft DP has been reviewed, in order to determine the

significance of the potential impacts associated with the re-application of a drought permit beyond a single six month period, i.e. for severe droughts. This review was informed by the high-level assessment of the environmental impacts of Thames Water's drought actions in severe droughts. The SEA review indicated that certain drought options resulted in an increase in potential residual adverse effects for various SEA objectives, such as: biodiversity; population and human health; water; soil, geology and land use; and air and climate. It was considered that there will be no change to any beneficial effects.

The implications of severe droughts on the WFD of the Drought Plan has been considered. Extreme low flows as a result of an environmental drought (without drought permits) may have major effects on aquatic habitats, biota, and consequently ecosystem functions. It is generally recognised that multi-season droughts in sensitive water bodies could result in impacts on the ecological communities of a high magnitude with communities only recovering in the long-term. Most water bodies within the Thames Water operational area have been physically modified. As such, these water bodies are less resilient to the impacts of environmental drought and sensitive to the extended implementation of drought permits. The re-application of some drought permits could result in some local populations being lost due to a lack of suitable habitat. As the duration and impacts associated with drought and drought permits increase, the effect on biota is likely to increase in severity from the individual to a catchment/regional level. As such, there is a high risk that temporary deterioration in WFD status associated with a severe environmental drought will be exacerbated through the re-application of individual drought permits, affecting several WFD elements with recovery only expected over the long term.

APPENDIX A: HIGH LEVEL SUMMARY OF DROUGHT OPTIONS CONSIDERED

Table A.1 Latton Summary of Severe Drought High Level Assessment

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Suspension of the 15Ml/d average annual abstraction licence condition, enabling abstraction at the peak daily rate of 20Ml/d. Increase annual licence limit from 5,475Ml to up to 6,390Ml</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Environmental Assessment of Latton Drought Permit
Stated, and assessed, as most likely in period April – September, with assessment including a delay to recovery of river levels of up to 34 days with full recovery not anticipated until March.
Five reaches assessed (Figure 4.1) in Ampney Brook and its tributary the Poulton Stream; Marston Meysey Brook and its tributary Blackford Barn Stream; and a reach of the River Thames.
Significance of impacts as stated in Table 5.5 and Table 4.33 to Table 4.38 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assessed in Environmental Assessment of Latton Drought Permit (re-application)
Stated, and assessed, as most likely in period October - March, following continuously from first application period.
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be dry reaches or prolonged low river flows. Hydrological reference conditions (i.e. without a re-application) would likely be dry reaches or very low flows, with significant legacy effects on groundwater levels and river flows following expiry of first application.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>The drought permit is likely to increase the duration that annual groundwater recovery occurs leading to the watercourse remaining drier for longer. Assessment of the delay in flow recovery, utilising five historic drought periods, indicated further delay caused by re-application, but very low risk that recovery would not occur during the hydrological winter the re-application would be during.
Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: Ampney Brook (from Ampney Park Fault to confluence River Thames)</td><td>Moderate; extension of the recovery period to later in the hydrological winter (mid-December to late March.</td><td>Up to Moderate risks to water quality including from reduced dilution of STW effluent. Minor risks to geomorphology.</td></tr>
<tr><td>2-4: Poulton Stream, Marston Meysey Brook and Blackford Barn Stream (from Ampney Park Fault to their confluence with the River Thames</td><td>Minor; extension of dry period.</td><td>Minor risks to geomorphology of continued reduction in wetted and water quality.</td></tr>
<tr><td>5: River Thames (confluence Ampney Brook to confluence River Ray)</td><td>Moderate; extension of period of extreme low flows locally and suppressing full flow recovery for a period of potentially several months in late winter and early spring at times of low-moderate flows, depending on the hydrological conditions at the time of the break of drought.</td><td>Up to Moderate risks to water quality from reduced dilution of continuous and intermittent discharges. Minor risks to geomorphology.</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 6 in the EAR remain unchanged.
Macrophyte community
Reach 1 – Potential impacts on the WFD status/potential of the Macrophyte classification of the Ampney and Poulton Brooks (Source to Thames) (GB106039030300)- Increased risk of deterioration from Minor to Moderate
Diatom community
Reach 1 – Potential impacts on the WFD status/potential of the Diatom classification of the Ampney and Poulton Brooks (Source to Thames) (GB106039030300)- Increased risk of deterioration from Minor to Moderate
NERC Act Species – Fish
Reach 2-5 – Brown trout Salmo trutta - Significance of impact likely to increase from Minor to Moderate.</td></tr>
</table>

		Reach 2-5– Brook lamprey *Lampetra planeri*- Significance of impact likely to increase from Minor to **Moderate**. Reach 2-5– European eel *Anguilla anguila* - Significance of impact likely to increase from Minor to **Moderate** Reach 1 – Bullhead *Cottus gobio* - Significance of impact likely to increase from minor to **Moderate**. **Invasive Non-Native Species** Reach 1-5 – Increase risk of Invasive Non-Native Vegetation species increase in distribution from negligible to **minor**

Table A.2 Lower Thames Summary of Severe Drought High Level Assessment

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Reduction of the minimum pass-forward flow over Teddington Weir (River Thames) to 100Ml/d (Scenario 1) or 0Ml/d (Scenario 2) depending on agreement with the Environment Agency.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Environmental Assessment of the Lower Thames Drought Permit Report.
Stated, and assessed, as most likely in period April-September.
Three reaches assessed (Figure 4.1) in the freshwater River Thames and estuarine Thames Tideway. Significance of impacts as stated in Table 5.8 and Table 6.59 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assessed in Environmental Assessment of the Lower Thames Drought Permit (re-application) Report.
Stated, and assessed, as most likely in period October - March, following continuously from first application period.
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be extended periods of extremely low flows resulting in prolonged low velocities, elevated water temperatures and water quality effects in the freshwater reaches; and changes in the extent of saline intrusion in the estuary as well as a period of low water levels, increased inter-tidal exposures, and reduced dissolved oxygen concentration.
Hydrological reference conditions (i.e. without a re-application) would likely be very low river flows and very low pass-forward flow from the river to the estuary (200Ml/d minimum pass-forward flow over Teddington Weir), with significant legacy effects on saline intrusion in the estuary following expiry of the first application.</td></tr>
<tr><td rowspan="7">Assessment of re-application</td><td rowspan="7">Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
Scenario 1 – 100Ml/d minimum pass-forward flow over Teddington Weir
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: Freshwater: Datchet Intake to Sunbury Lock</td><td>Minor; extension of low velocity period</td><td>Minor risks to geomorphology and water quality</td></tr>
<tr><td>2: Freshwater: Sunbury Lock to the tidal limit at Teddington Weir</td><td>Major; extension of low velocity period</td><td>Up to Moderate risks to water quality, particularly dissolved oxygen and ammonia from reduced velocities and dilution of consented discharges. Minor risks to geomorphology.</td></tr>
<tr><td>3: Tidal: Teddington Weir to London Bridge</td><td>Minor; continued risk to small level changes and further localised shoaling (at high risk areas); this is predicted to be worst downstream of Richmond Sluice and improves with distance downstream</td><td>Up to Major risks to water quality, specifically dissolved oxygen linked to Mogden STW discharge. Up to Moderate risks for phosphorus concentration (effluent dilution/dispersion) and exacerbation of saline intrusion). Minor and temporary exacerbation of geomorphology risks.</td></tr>
</table>
Scenario 2 –0Ml/d minimum pass-forward flow over Teddington Weir
<table>
<tr><td>1: Freshwater: Datchet Intake to Sunbury Lock</td><td>Major; extension of low velocity period</td><td>Up to Moderate risks to water quality, particularly dissolved oxygen and ammonia from reduced dilution of consented discharges. Minor risks to geomorphology.</td></tr>
<tr><td>2: Freshwater: Sunbury Lock to the tidal limit at Teddington Weir</td><td>Major; extension of low velocity period</td><td>Up to Moderate risks to water quality, particularly dissolved oxygen and ammonia from reduced velocities and dilution of consented discharges. Minor risks to geomorphology.</td></tr>
<tr><td>3: Tidal: Teddington Weir to London Bridge</td><td>Moderate; continued risk to small level changes and further localised shoaling (at high risk areas); this is predicted to be worst downstream of Richmond Sluice and improves with distance downstream</td><td>Up to Major risks to water quality, specifically dissolved oxygen linked to Mogden STW discharge. Up to Moderate risks for phosphorus concentration (effluent dilution/dispersion) and exacerbation of saline intrusion). Minor and temporary exacerbation of geomorphology risks.</td></tr>
</table></td></tr>
</table>

	Features	Unless described below, the significance of the impacts on all features stated and assessed in **Section 6** in the EAR remain unchanged. **Designated Sites** Proposed Marine Conservation Zone – Potential impacts on Smelt increase from Moderate to **Major** **Macroinvertebrate community** Reach 1 (both scenarios) – Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the Thames - Cookham and Egham (GB106039023231) - Increased risk of deterioration from Moderate, to **Major**. Reach 2 (both scenarios) - Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the Thames - Egham to Teddington (GB106039023232) - Increased risk of deterioration from Moderate, to **Major**. Reach 3 Thames (both scenarios) - Egham to Teddington (GB106039023232) - Increased risk of deterioration from Minor, to **Moderate**. **Fish community** Reach 1-3 (both scenarios) – Potential impacts on the **WFD status/potential** of the fish classification likely to increase to **Major** in all reaches. **NERC Act Species – Macroinvertebrates** Reach 2 – Depressed river mussel *Pseudanodonta complanata* - Significance of impact likely to increase from Moderate to **Major**. Reach 3 - Large mouthed valve snail *Valvata macrostoma* - Significance of impact likely to increase from Moderate to **Major**. **NERC Act Species – Fish** Reach 1 - Lamprey sp. and European eel *Anguilla Anguilla* - Significance of impact likely to increase from Moderate to **Major**. Reach 2 – Brown trout *Salmo trutta*, Lamprey sp. and European eel *Anguilla Anguilla* - Significance of impact likely to increase from Moderate to **Major**.

Table A.3 Baunton 2 Summary of Severe Drought High Level Assessment

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Temporary suspension of the 32Ml/d flow constraint on the River Churn at Cirencester, enabling abstraction to a maximum rate of 17Ml/d.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Swindon and Oxfordshire Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options.
Stated, and assessed, as most likely in period April – September, with assessment including a delay to recovery of river levels of up to 30 days with full recovery not anticipated until March.
Seven reaches assessed (Figure 4.1) in River Churn, Cirencester Watercourses, River Frome, Ampney Brook and River Coln.
Significance of impacts as stated in Table 4.6 and Table 4.33 to Table 4.38 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as November (earliest) to May, following continuously from first application period.
Study area reviewed and considered there are uncertainties in extent. There is risk of impact further upstream on the river Churn (Reach 1), River Frome (Reach 5) and River Coln (Reach 7), either in terms of extending the recovery to a wetted channel, or to full flow recovery.
Further there is risk of impacts extending to the Daglingworth Stream and Elkstone Brook local to the Baunton boreholes, through groundwater connectivity with uncertainty around the effects of faulting.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be dry reaches or prolonged low river flows. Hydrological reference conditions (i.e. without a re-application) would likely be dry reaches or very low flows, with significant legacy effects on groundwater levels and river flows following expiry of first application.</td></tr>
<tr><td rowspan="9">Assessment of re-application</td><td rowspan="9">Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Churn (upstream North Cerney to Stratton)</td><td>Major; significant extension of the period the reach is dry including seasons where this would not normally be the case.
Full flow recovery unlikely until late in the following winter.</td><td>Up to Major risks to geomorphology (duration of dry channel will have long-term and potentially irreversible effects on the bed and banks). Water quality effects from likely first flush of pollution during re-wetting.</td></tr>
<tr><td>2: River Churn (Stratton to Siddington)</td><td>Major; significant extension of the period parts of the reach are dry/extension of dry area including seasons where this would not normally be the case.
Full flow recovery unlikely until late in the following winter.</td><td>Up to Major risks to geomorphology (duration of dry channel will have long-term and potentially irreversible effects on the bed and banks). Water quality effects from likely first flush of pollution during re-wetting.</td></tr>
<tr><td>3: River Churn (Siddington to confluence River Thames)</td><td>Up to Moderate; exacerbation of flow reduction and reduction in wetted habitat and velocities. Full flow recovery unlikely until late in the following winter.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration</td></tr>
<tr><td>4: Cirencester Watercourses (Gloucester Street sluices to confluence with the River Churn)</td><td>Negligible</td><td>No risks</td></tr>
<tr><td>5: River Frome (upstream Edgeworth to Ebley)</td><td>Major; significant extension of the period parts of the reach are dry/extension of dry area including seasons where this would not normally be the case.
Full flow recovery unlikely until late in the following winter.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration</td></tr>
<tr><td>6: Ampney Brook (upstream Ampney Park Fault to confluence with River Thames)</td><td>Major; significant extension of the period parts of the reach are dry/extension of dry area including seasons where this would not normally be the case.
Full flow recovery unlikely until late in the following winter.</td><td>Up to Moderate risks to water quality from reduced dilution of continuous and intermittent discharge and elevated temperature.</td></tr>
<tr><td>7: River Coln (Ablington to confluence with River Thames)</td><td>Up to Moderate; exacerbation of flow reduction and reduction in wetted habitat and velocities. Full flow recovery unlikely until late in the following winter.</td><td>Up to Major risks to water quality from reduced dilution of continuous and intermittent discharge and elevated temperature.</td></tr>
<tr><td>8: Daglingworth Stream (Duntisbourne Leer to confluence River Churn, 7.9km)</td><td>Uncertain; likely extension of the period parts of the reach are dry/extension of dry area including seasons where this would not normally be the case.</td><td>Uncertain risks to geomorphology and water quality deterioration</td></tr>
</table></td></tr>
</table>

			Full flow recovery unlikely until late in the following winter.	
		9: Elkstone Brook (source to confluence River Churn, 5.8km)	Uncertain; likely extension of the period parts of the reach are dry/extension of dry area including seasons where this would not normally be the case. Full flow recovery unlikely until late in the following winter.	Uncertain risks to geomorphology and water quality deterioration
	Features	Unless described below, the significance of the impacts on all features stated and assessed in **Section 4.6** in the EAR remain unchanged. Reach 8 and 9 were added to the re-application in the physical environment assessment, therefore no assessment of the baseline ecological conditions was undertaken. **Macroinvertebrate community, including NERC Act and Notable species of macroinvertebrates** Reach 1 – Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the River Churn – source to Perrott's Brook (GB106039029810) - Increased risk of deterioration from Moderate, to **Major**, due to the Major hydrological and geomorphological risks. Reach 2 - Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the Churn - Baunton to Cricklade (GB106039029750) - Increased risk of deterioration from Moderate, to **Major**, due to the Major hydrological and geomorphological risks. Reach 3 - Significance of impact likely to increase from Minor to **Moderate**, due to the Moderate hydrological, geomorphological and water quality risks. Recovery from upstream source populations is considered unlikely, due to the anticipated High magnitude of impacts associated with the macroinvertebrate community of Reach 1 and 2 of the Churn. Reach 5 - Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the Frome - source to Ebley Mill (GB109054032470)[87] - Increased risk of deterioration from Minor, to **Major**, due to the Major hydrological and Moderate geomorphological and water quality risks. Reach 6 - Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the Ampney and Poulton Brooks (Source to Thames) water body (GB106039030300) - Increased risk of deterioration from Moderate, to **Major**, due to the Major hydrological and Moderate water quality risks. Reach 7 - Significance of impact likely to increase from Minor to **Moderate**, due to Moderate hydrological and Major water quality risks. Reach 7 – Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the Coln (Source to Coln Rogers (GB106039029990) and Coln (from Coln Rogers) and Thames (Coln to Leach) (GB GB106039029992) - Increased risk of deterioration from Negligible, to **Moderate**, due to Moderate hydrological and Major water quality risks. **Macrophyte community, including NERC Act and Notable species of macrophytes** Reach 1 – 3 – Significance of impact likely to increase from Negligible (Reach 3) and Negligible/Minor (Reach 1 and 2), to **Moderate** (Reach 1-3), due to the risks associated with the key physical environment. Recovery from upstream source populations is considered unlikely, due to the impacts associated with all reaches of drought permit catchment. Reach 5 and 6 – Significance of impact likely to increase from Minor (both reaches), to **Moderate**, due to the risks associated with the key physical environment. Reach 1 – Potential impacts on the **WFD status/potential** of the Macrophyte classification of the River Churn – source to Perrott's Brook (GB106039029810) - Increased risk of deterioration from Minor, to **Major**, due to the Major hydrological and geomorphological risks. Reach 2 and 3 - Potential impacts on the **WFD status/potential** of the Macrophyte classification of the Churn - Baunton to Cricklade (GB106039029750) - Increased risk of deterioration from Negligible (Reach 3) and Minor (Reach 2), to **Major** (both reaches), due to the Major hydrological and geomorphological risks. Reach 5 - Potential impacts on the **WFD status/potential** of the Macrophyte classification of the Frome - source to Ebley Mill (GB109054032470)[88] - Increased risk of deterioration from Minor, to **Major**, due to the Major hydrological and Moderate geomorphological risks. Reach 6 - Potential impacts on the **WFD status/potential** of the Macrophyte classification of the Frome - source to Ampney and Poulton Brooks (Source to Thames) water body (GB106039030300) - Increased risk of deterioration from Moderate, to **Major**, due to the Major hydrological and Moderate geomorphological risks.	

[87] EAR incorrectly assessed Reach 5 location as Frome - Ebley Mill to Severn confluence (GB109054032470) WFD waterbody.
[88] EAR incorrectly assessed Reach 5 location as Frome - Ebley Mill to Severn confluence (GB109054032470) WFD waterbody.

		Reach 7 - Significance of impact likely to increase from Negligible to **Moderate**, due to the Moderate hydrological and Major geomorphological risks. **Fish community, including NERC Act and Notable species of fish** Reach 1 – Potential impacts on the **WFD status/potential** of the Fish classification of the River Churn – source to Perrott's Brook (GB106039029810) - Increased risk of deterioration from Minor, to **Major**, due to the Major hydrological, geomorphological and water quality risks. Reach 2 and 3 - Potential impacts on the **WFD status/potential** of the Fish classification of the Churn - Baunton to Cricklade (GB106039029750) - Increased risk of deterioration from Minor, to **Moderate/Major** (uncertain) (depending on the recovery of the fish population in the less impacted Reach 3), due to the risks associated with the key physical environment. Reach 3 - Significance of impact likely to increase from Minor to **Moderate**, due to the Moderate hydrological and geomorphological risks. Recovery from upstream source populations is considered unlikely, due to impacts associated with these reaches of the watercourses. Reach 5 - Potential impacts on the **WFD status/potential** of the Fish classification of the Frome - source to Ebley Mill (GB109054032470)[89] - Increased risk of deterioration from Moderate, to **Major** (uncertain) (depending on the capacity for re-colonisation from upstream sources in the watercourse), due to the Major hydrological and Moderate geomorphological risks. Reach 6 - Potential impacts on the **WFD status/potential** of the Fish classification of the Ampney and Poulton Brooks (Source to Thames) (GB106039030300) - Increased risk of deterioration from Moderate, to **Major**, due to the Major hydrological and Moderate geomorphological risks. Reach 7 - Significance of impact likely to increase from Minor to **Moderate** (uncertain) (depending on the capacity for re-colonisation from upstream sources in the watercourse), due to the Moderate hydrological and Major water quality risks. Recovery from upstream source populations is considered unlikely, due to the impacts associated with these reaches of the watercourses. Reach 7 – Potential impacts on the **WFD status/potential** of the Fish classification of the Coln (Source to Coln Rogers (GB106039029990) and Coln (from Coln Rogers) and Thames (Coln to Leach) (GB GB106039029992) - Increased risk of deterioration from Minor, to **Moderate** (uncertain) (depending on the capacity for re-colonisation from upstream sources in the watercourse), due to the Moderate hydrological and Major geomorphological risks.

[89] EAR incorrectly assessed Reach 5 location as Frome - Ebley Mill to Severn confluence (GB109054032470) WFD waterbody.

Table A.4 Farmoor Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Change in river abstraction licence clauses, specifically at any time when naturalised flow at Farmoor flow gauging station, downstream of the abstraction, is between 136.4Ml/d and 346.4Ml/d the drought permit allows for abstractions at a level that ensures a residual flow of more than 46.4Ml/d (compared to a residual flow of 77.3Ml/d under normal operating conditions).
As part of the Farmoor drought permit implementation, back-pumping of river flows from further downstream is proposed to help maintain a minimum flow (or level) in the River Thames and distributaries downstream of King's Weir Lock.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Environmental Assessment of Farmoor Drought Permit.
Stated, and assessed, as most likely in period April – September, with the assessment indicating no delay to river flow recovery following cessation of the drought permit.
Two reaches assessed (Figure 4.1) in the River Thames. Significance of impacts as stated in Table 5.6 and Table 6.49 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low river flows also reduced significantly in the preceding spring/summer by the first application. Hydrological reference conditions (i.e. without a re-application) would be low autumn/winter flows with continued limited flow accretion into the study area but without legacy effects on river flows following expiry of first application.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Thames and its distributaries from Northmoor Lock to Sandford Lock</td><td>Major; continuation of reduction in velocities for those watercourses where water levels are controlled including the mainstem of the River Thames. Continued reduction in velocity and level for those distributaries that are not level controlled.</td><td>Up to Major risks to water quality (including from reduced buffering capacity for diluting continuous and intermittent discharges) and elevated temperature</td></tr>
<tr><td>2: River Thames (Sandford Lock to Caversham Lock)</td><td>Minor; continued reduction in velocities with sufficient flow to retain level</td><td>Up to Major risks to water quality (including from reduced buffering capacity for diluting continuous and intermittent discharges) and elevated temperature</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 6.3 in the EAR remain unchanged.

Macroinvertebrates
Reach 1 – Significance of impact likely to increase from Minor to Moderate – Impacts most likely to result in changes to the assemblage of the community, characterised by a reduction in rheophilic, sensitive taxa, and a proliferation of limnophilic, tolerant taxa. Re-colonisation post drought anticipated to occur from various upstream sources in the Thames catchment.

Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Thames (Leach to Evenlode) (GB106039030333), and Thames (Evenlode to Thame) (GB106039030334) – Increased risk of short term deterioration from Minor to Moderate.

Fish
Reach 2 - Significance of impact likely to increase from Minor to Moderate – Impacts most likely to result in changes to the assemblage of the community, including a reduction in rheophilic, sensitive species, and a proliferation of limnophilic/eurytopic tolerant species. Re-colonisation post drought anticipated to occur from various upstream sources in the Thames catchment.

Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Thames (Wallingford to Caversham) (GB106039030331) – Increased risk of short term deterioration from Minor, increasing to Moderate.

Recreation – Angling
Reach 1 and 2 – Significance of impact likely to increase from Minor to Moderate – The key physical environment effects associated with Reach 1 and 2 are likely to impact the angling amenity.</td></tr>
</table>

Table A.5 Meysey Hampton Summary of Severe Drought High Level Assessment

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Abstraction from the Great Oolite boreholes at a rate of 11.37 Ml/d when preceding flow (mean 5 days before) in the River Coln at Bibury is less than 68 Ml/d.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Environmental Assessment of Meysey Hampton Drought Permit.
Stated, and assessed, as most likely in period April – September, with assessment including a delay to recovery of river flows of up to 39 days limited to the hydrological winter.
Five reaches assessed (Figure 4.1) – in Ampney Brook and its tributary the Poulton Stream; Marston Meysey Brook and its tributary Blackford Barn Stream; and a reach of the River Thames. Significance of impacts as stated in Table 5.7 and Table 6.12 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be dry reaches or prolonged low river flows. Hydrological reference conditions (i.e. without a re-application) would likely be dry reaches or very low flows, with significant legacy effects on groundwater levels and river flows following expiry of first application.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: Ampney Brook (source to confluence River Thames)</td><td rowspan="4">Major; significant extension of the period the reach is dry including seasons where this would not normally be the case.
Full flow recovery unlikely until late in the following winter.</td><td rowspan="4">Up to Major risks to geomorphology (duration of dry channel will have long-term and potentially irreversible effects on the bed and banks). Water quality effects from likely first flush of pollution during re-wetting.</td></tr>
<tr><td>2: Poulton Stream (source to confluence Ampney Brook)</td></tr>
<tr><td>3: Marston Meysey Brook (source to confluence River Thames)</td></tr>
<tr><td>4: Blackford Barn Stream source to confluence Marston Meysey Brook)</td></tr>
<tr><td>5: River Thames (confluence Ampney Brook to confluence River Ray)</td><td>Minor; continuation of flow reduction and reduction in flow velocities in a reach of the river with maintained water levels.</td><td>Up to Moderate risks to water quality from reduced dilution of continuous and intermittent discharge and elevated temperature.</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 6.3 in the EAR remain unchanged.

Designated Sites
Reach 1 - Down Ampney Pits KWS - Significance of impact likely to increase from Minor to Minor-Moderate (Uncertain) (requires further investigation to understand links between the habitat and local groundwater connectivity) – the Major risks to hydrology and geomorphology are likely to increase the risk of deterioration to the ecological integrity of the site.

Macroinvertebrate community
Reach 1-4 - Significance of impact likely to increase from Minor to Moderate - The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the macroinvertebrate community being significantly impacted. Re-colonisation following cessation of the drought permit is likely to be limited due to the impacted nature of the surrounding watercourses in the drought permit catchment.

Reach 1 and 2 – Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Ampney and Poulton Brooks (Source to Thames) (GB106039030300) - Increased risk of deterioration from Minor, to Major, associated with the severe nature of the impacts predicted to effect the community in Reach 1 and 2.

Reach 3 and 4 – Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Marston Meysey Brook water body (GB106039023860)- Increased risk of deterioration from Minor, to Major, associated with the severe nature of the impacts predicted to effect the community in Reach 3 and 4.

Macrophyte community, including Ranunculus sp.
Reach 1-4 - Significance of impact likely to increase from Minor (Macrophyte community) and Negligible (Ranunculus sp.) to Moderate - The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the macrophyte community being significantly impacted.

Reach 1 and 2 – Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Ampney and Poulton Brooks (Source to Thames) (GB106039030300) - Increased risk of deterioration from Minor, to Major, associated with the severe nature of the impacts predicted to effect the community in Reach 1 and 2.

Reach 3 and 4 – Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Marston Meysey Brook water body (GB106039023860)- Increased risk of deterioration from Minor, to Major, associated with the severe nature of the impacts predicted to effect the community in</td></tr>
</table>

		Reach 3 and 4. **Fish community** Reach 1 - Significance of impact likely to increase from Moderate to **Major** - The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the fish community being significantly impacted. Re-colonisation may be possible from the nearby River Thames downstream, however, habitat is unlikely to be suitable to support a self-sustaining fishery. Reach 1 and 2 – Potential impacts on the **WFD status/potential** of the Fish classification of the Ampney and Poulton Brooks (Source to Thames) (GB106039030300) - Increased risk of deterioration from Moderate, to **Major**, associated with the severe nature of the impacts predicted to effect the community in Reach 1 and 2. Reach 3 and 4 – Potential impacts on the **WFD status/potential** of the Fish classification of the Marston Meysey Brook water body (GB106039023860)- Increased risk of deterioration from Moderate, to **Major**, associated with the severe nature of the impacts predicted to effect the community in Reach 3 and 4. **Notable Macroinvertebrate Species** Fine lined pea mussel - Significance of impact likely to increase from Negligible to **Moderate** - The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the mussel population being significantly impacted. **NERC Species – Fish** Reach 1-4 – Brown trout *Salmo trutta* - Significance of impact likely to increase from Moderate to **Major** - The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the brown trout population being significantly impacted. Re-colonisation following cessation of the drought permit is likely to be limited due to the lack of an unimpacted source population located upstream or downstream (in the River Thames). Reach 1-4 – Brook lamprey *Lampetra planeri* - Significance of impact likely to increase from Moderate to **Major** - The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the brook lamprey population being significantly impacted. Re-colonisation following cessation of the drought permit is likely to be limited due to the lack of an unimpacted source population located upstream or downstream (in the River Thames). **NERC Act – Habitats** Reach 1-5 - Coastal and floodplain grazing marsh (Impact significance not assessed in the EAR) – Significance of impact likely to be **Moderate-Major** (Uncertain) (further investigation required) – The key physical environment risks are likely to result in the functioning of this habitat being impacted. **Ecologically Sensitive species – Macroinvertebrates** Reach 1-4 - *Stenelmis canaliculata* and *Riolus subviolaceus* - Significance of impact likely to increase from Minor to **Moderate** - The Major hydrological and geomorphological risks are likely to result in the ecological integrity of both species being significantly impacted. Re-colonisation following cessation of the drought permit is likely to be limited due to the impacted nature of the surrounding watercourses in the drought permit catchment.

Table A.6 Pangbourne Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Temporarily remove licence flow condition in the River Pang gauged at Pangbourne which prevents groundwater abstraction and allow the full amount of the Pangbourne licence to be abstracted from all licenced boreholes.
Continue groundwater abstraction at peak rate of 38.6Ml/d at all river flows (licence has conditions at Pangbourne gauging station relating to 7Ml/d of the licensed abstraction rate).</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Environmental Assessment of Pangbourne Drought Permit.
Stated, and assessed, as most likely in period May and December, with assessment including a delay to recovery of river levels of up to a few days during hydrological winter.
Two reaches assessed (Figure 4.1) – in the River Pang and Sulham Brook. Significance of impacts as stated in Table 5.6 and Table 6.21 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as November (earliest) to May, following continuously from first application period.
Study area reviewed and additional risk upstream in Reach 2 added. There is also uncertainty over risk to the River Bourne, a tributary of the River Pang in Reach 1
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low river flows also reduced significantly in the preceding spring/summer by the first application. Hydrological reference conditions (i.e. without a re-application) would be low autumn/winter flows but without significant legacy effects on river flows following expiry of first application.</td></tr>
<tr><td rowspan="3">Assessment of re-application</td><td>Key physical environment effects</td><td>It is considered likely that in an environmental drought worse than on record there would be changes to the flow regime in the River Pang and likely the River Bourne beyond those changes associated with previously recorded droughts. The source of continuous flow in the River Pang is likely to move downstream to Blue Pool and potentially further downstream if the perennial spring source there dries. Further, although some of the lower River Pang is known to be perched in recorded low groundwater conditions, it includes losing reaches and there is risk of significant flow reduction from reduced upstream flow and loses to groundwater and potential drying. However, the extent of contribution of the drought permit re-application on these watercourses and hydrological effects is difficult to describe. The lower reach of the River Bourne flows over the Chalk aquifer and is at risk of flow reduction associated with a drought, albeit the upper and middle reaches flow over clay and are likely to be dry as a result of loss of upstream baseflow.
Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Pang (Blue Pool to River Thames confluence)</td><td>Uncertain, up to Major; potential for dry reaches or significant flow reduction and reduction in wetted habitat and velocities as baseflow from contributing catchment reduces and influence of losing reaches increases with environmental drought.</td><td>Up to Major risks to geomorphology (from channel drying in atypical locations; extended period of fine sediment deposition in reaches with continuous flow) and water quality deterioration.</td></tr>
<tr><td>2: Sulham Brook (source to River Thames confluence)</td><td>Major; related to the significant extension of the period the reach is dry including seasons where this would not normally be the case.
Full flow recovery unlikely until late in the following winter.</td><td>Up to Major risks to geomorphology (duration of dry channel will have long-term effects on the bed and banks). Water quality effects from likely first flush of pollution during re-wetting.</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 6.3 in the EAR remain unchanged. The physical environment effects on Reach 1 were assessed as Negligible in the EAR, therefore no assessment of the baseline conditions has been undertaken. However, it is likely the potentially Major hydrological, geomorphological and water quality risks will result in Moderate-Major impacts on the environmental features, especially those closely associated with the ecology of the notable chalkstream habitat of the River Pang.

Designated Sites and associated Notable Habitats
Reach 2 and Groundwater Zone of Influence - Sulham and Tidmarsh Woods & Meadows SSSI and Coastal and floodplain grazing marsh – Significance of impact likely to increase from Negligible to Major (Uncertain) – the lack of surface water inundation over multiple winters, combined with groundwater abstraction pressures is likely to impact severely on the ecological integrity of the site.

Macroinvertebrate community
Reach 2 - Significance of impact likely to increase from Negligible to Moderate - The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the macroinvertebrate community being significantly impacted</td></tr>
</table>

		Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the Sulham Brook (GB106039023280) - Increased risk of deterioration from Negligible, to **Major**, associated with the significant impacts predicted to affect the community in Reach 2. **Macrophyte community and Ranunculus sp.** Reach 2 - Significance of impact likely to increase from Negligible to **Moderate -** The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the macrophyte community being significantly impacted. Re-colonisation following cessation of the drought permit is likely to be limited due to the lack of an unimpacted source population located upstream. **Fish community** Reach 2 - Significance of impact likely to be of **Moderate** significance (Not assessed in EAR) - The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the fish community being significantly impacted. Re-colonisation may be possible from the nearby River Thames downstream; however, habitat is unlikely to be suitable to support a self-sustaining fishery. **NERC Act Species – Fish** Reach 2 – Brown trout *Salmo trutta* and bullhead *Cottus gobio*– Significance of impact likely to increase from Minor to **Moderate -** The Major hydrological and geomorphological risks are likely to result in the ecological integrity of the brown trout and bullhead populations being significantly impacted. Re-colonisation of both species following cessation of the drought permit is likely to be limited due to the lack of an unimpacted source population located upstream. Reach 2 – European eel *Anguilla anguilla* – Significance of impact likely to increase from Negligible to **Moderate -** The Major hydrological and geomorphological risks are likely to result in the potential for Reach 2 to sustain an eel population in the future being severely impacted (eel are not currently recorded in the Reach 2). **Other Notable Habitats** Groundwater zone of influence - Coastal and floodplain grazing marsh - Significance of impact likely to increase from Moderate to **Moderate/Major** (uncertain) - The Major hydrological risks are likely to result in the ecological integrity of the habitat being significantly impacted. Reach 1 - Lowland fens - Significance of impact likely to increase from Moderate to **Moderate/Major** (uncertain) (dependent on groundwater connectivity) - The Major hydrological risks are likely to result in the ecological integrity of the habitat being significantly impacted. Reach 1 and 2 - Chalkstream - Significance of impact likely to increase from Moderate to **Major -** The key physical environment effects associated with Reach 1 and 2 are likely to severely impact the ecology closely associated with the chalkstream habitat, resulting in the degradation of this notable habitat.

Table A.7 Sundridge 2 Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Relax the annual average licence rate and increase the peak licence rate to 12Ml/d could be abstracted each day (sequential to Sundridge 1).</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in London Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options.
Stated, and assessed, as at any time of year, and sequential to a Sundridge 1 Drought Permit period. Assessment indicated that a delay to the recovery of river flows will depend upon the rate of groundwater recharge which could extend to the following summer/ autumn (up to 12 months).
Three reaches assessed (Figure 5.1) – Reach 1 to 3 in the River Darent. Significance of impacts as stated in Table 5.10, Table 5.35, Table 5.36 and Table 5.37 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as any time, following continuously from first Sundridge 2 application period, which itself would follow continuously from a Sundridge 1 period.
Study area reviewed and considered there are uncertainties in extent. There is risk of impact further upstream on the River Darent (Reach 1).
Hydrological conditions would be an extended multi-season drought longer than those on record. The antecedent period would be very prolonged low river flows also reduced significantly in the preceding applications. Hydrological reference conditions (i.e. without a re-application) would be low flows and legacy effects on river flows following expiry of first Sundridge 2 application.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Darent (source to confluence with Honeypot Stream)</td><td>Major; continuation of flow reduction and reduction in wetted habitat and velocities. Although the low flow investigation did suggest that a reduction of flow from the Lower Greensand aquifer is somewhat dampened compared to the Chalk. Full flow recovery unlikely until late in the following winter.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration</td></tr>
<tr><td>2: River Darent (confluence with Honeypot Stream to South Darenth)</td><td>Minor; continuation of flow reduction and reduction in wetted habitat and velocities. Full flow recovery unlikely until late in the following winter.</td><td>Up to Minor risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration</td></tr>
<tr><td>3: River Darent (South Darenth to tidal limit)</td><td>Minor; continuation of flow reduction and reduction in wetted habitat and velocities. Full flow recovery unlikely until late in the following winter.</td><td>Up to Moderate risks to water quality deterioration from reduced dilution</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 5.6 in the EAR remain unchanged.

Macroinvertebrate community, including non-designated macroinvertebrate species[90]
Reach 2 - Significance of impact likely to increase from Minor to Moderate – The Minor hydrological, geomorphological and water quality risks are likely to result in changes to the assemblage of the community, characterised by a reduction in rheophilic, sensitive taxa, and a proliferation of limnophilic, tolerant taxa. Re-colonisation post drought is likely to be impacted by the impacted reach upstream (Reach 1).

Reach 3 - Significance of impact likely to increase from Minor to Moderate – The Minor hydrological and Moderate geomorphological risks are likely to result in changes to the assemblage of the community, characterised by a reduction in rheophilic, sensitive taxa, and a proliferation of limnophilic, tolerant taxa. Re-colonisation post drought is likely to be impacted by the impacted reaches upstream (Reach 1 and 2).

Reach 2 and 3 - Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Middle and Lower Darent (GB106040024222) – Increased risk of short term deterioration from Minor, to Moderate/Major (uncertain)[91]. The key physical environment risks are likely to result in significant impacts which effect the ecological integrity of the macroinvertebrate community.</td></tr>
</table>

[90] The "Nationally Scarce" *Riolus subviolaceus* a riffle beetle, *Oulimnius rivularis* a riffle beetle, and *Ceraclea senilis* a cased caddisfly

[91] Holmes N.T.H. (2005) Environment Agency, Kent Area. Draft River Darent Restoration Strategy: Volume 1: Environmental Quality Appraisal, March 2005 – the report states the community had not recovered (2005) since the drought of 1976, therefore a future multi-season drought event may result in a Major impact.

Macrophyte community
Reach 1 - Potential impacts on the **WFD status/potential** of the Macrophyte classification of the Upper Darent (GB106040024221) – Increased risk of short term deterioration from Moderate, to **Major** (uncertain), due to the Major hydrological and Moderate geomorphological and water quality risks associated with the reach.

Reach 2 and 3 – Potential impacts on the **WFD status/potential** of the Macrophyte classification of the Middle and Lower Darent water body (GB106040024222) – Increased risk of short term deterioration from Moderate, to **Major** (uncertain).

Fish community
Reach 1 - Potential impacts on the **WFD status/potential** of the Fish classification of the Upper Darent (GB106040024221) – Increased risk of short term deterioration from Moderate, to **Major**, due to the Major hydrological and Moderate geomorphological and water quality risks associated with the reach.

Reach 2 and 3 – Potential impacts on the **WFD status/potential** of the Fish classification of the Middle and Lower Darent (GB106040024222) – Increased risk of short term deterioration from Minor, to **Major**, due to the Minor hydrological and Minor/Moderate geomorphological and water quality risks associated with the reaches.

NERC Act Species - Fish
Reach 1-3 - Brown trout *Salmo trutta* - Significance of impact likely to increase from Moderate and Major (depending on the time of year) to **Major** (all year round) – The key physical environment effects are likely to result in significant impacts to the ecological integrity of the population. Re-colonisation post drought is likely to be limited due to the already impacted nature of the population recorded in the Darent.

Reach 1-3 European eel *Anguilla anguilla* - Significance of impact likely to increase from Moderate to **Major** (all year round) – The key physical environment effects are likely to result in significant impacts to the ecological integrity of the population. Re-colonisation post drought is likely to be limited due to the already impacted nature of the population recorded in the Darent.

NERC Act Species – Macrophytes
Water crowfoot *Ranunculus* sp. - Significance of impact likely to increase from Minor to **Moderate** (all year round) – The key physical environment effects are likely to result in significant impacts to the ecological integrity of the community.

NERC Act - Habitats
The significance of the key physical environment effects on NERC Act 41 Habitats has not been assessed in the EAR.

Reach 1 – Reed beds – Significance of impact likely be **Major** (all year round) (uncertain) - The Major hydrological and Moderate geomorphological and water quality risks associated with the reach may impact upon the supply of water to this wetted habitat type.

Reach 2 and 3 - Coastal and floodplain grazing marsh - Significance of impact likely be **Moderate** (all year round) (uncertain) - The key physical environment effects are likely to impact upon the supply of water to this wetted habitat type.

Reach 3 – Mudflats - Significance of impact likely be **Moderate** (all year round) (uncertain) - The Minor hydrological and Moderate water quality risks associated with the reach may impact upon the supply of water to this wetted habitat type.

Reach 3 – Coastal saltmarsh – Significance of impact likely be **Minor/Moderate** (uncertain) - The Minor hydrological risks associated with the reach may impact upon the saline balance[92] and terrestrialisation of the plant community[93].

Other Notable Habitats – Chalkstream
Reach 1-3 - Significance of impact likely to be **Moderate/major** (uncertain) – The key physical environment effects associated with Reach 1-3 are likely to severely impact the ecology closely associated with the chalkstream habitat, resulting in the degradation of this notable habitat.

Other Environmentally Sensitive Fauna and Flora
Reach 1-3 - Bullhead *Cottus gobio*- Significance of impact likely to increase from Minor to **Moderate** (all year round) – The key physical environment effects are likely impact population abundance. Re-colonisation post drought may be limited by in-channel barriers preventing effective re-colonisation.

Invasive Macroinvertebrates
Reach 3 - The significance of the impact is likely to increase from Minor to **Moderate** (uncertain) as a result of changes in the distribution of the invasive macroinvertebrates – The Minor Hydrological risks

[92] Hughes, A.L.H. et al. (2012) Hydrologic variability in a salt marsh: Assessing the links between drought and acute marsh dieback. Estuarine, Coastal and Shelf Science, 111, 95-106
[93] Natural England. Climate Change Adaptation Manual – Ch. 27 Coastal saltmarsh

		may result in invasive macroinvertebrates increasing in abundance (e.g. zebra mussel *Dreissena polymorpha* and Chinese mitten crab *Eriocheir sinensis*), therefore potentially posing an increased risk to native biota. **Landscape, Navigation, Recreation, Heritage and Industry** Reach 1-3 - Darent Valley Path – Public Right of Way - Significance of impact likely to increase from Minor to **Moderate** (all year round) – The key physical environment effects are likely impact the general amenity value of this public right of way. Reach 1-3 - Angling - Significance of impact likely to increase from Negligible to **Moderate** – The key physical environment effects associated with Reach 1-3 are likely to impact the angling amenity.

Table A.8 Waddon Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Increase of 7Ml/d beyond existing licence limit (average rate per year of 7.6Ml/d).</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Environmental Assessment of Waddon Drought Permit.
Stated, and assessed, as most likely in period April – September, with assessment including a delay to recovery of river levels of up to one month.
Two reaches assessed (Figure 4.1) - Reach 1 the Waddon Ponds and Reach 2 in the River Wandle. Significance of impacts as stated in Table 5.3, Table 6.24 and Table 6.25 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period.
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low pond levels and river flows also reduced significantly in the preceding spring/summer by the first application. Hydrological reference conditions (i.e. without a re-application) would be low autumn/winter flows with one month of legacy effects on pond levels and river flows following expiry of first application.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: Waddon Ponds</td><td>Major; ponds at risk of drying or remaining dry and risk of several months before full recovery of pond levels post drought permit (duration uncertain)</td><td>Up to Major risks to dissolved oxygen and temperature while ponds drying/recovering</td></tr>
<tr><td>2: River Wandle (west of Waddon Ponds to Beddington STW effluent ditch)</td><td>Major; continuation of moderate flow reduction and reduction in wetted depths and velocities; however likely extension of delay to full flow recovery</td><td>Up to Moderate risks to geomorphological from duration of low flow period (e.g. sedimentation); and to water quality from poorer passed forward water quality from Waddon Ponds.</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 6.3 in the EAR remain unchanged.

Macroinvertebrate community
Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Wandle - Croydon and Wandsworth (GB106039023460) waterbody - Increased risk of short term deterioration from Minor, to short/long term (uncertain) Moderate, due to the anticipated reduction in species richness in Reach 2.

Macrophyte community
Potential impacts on the WFD status/potential of the Macrophyte classification of the Wandle - Croydon and Wandsworth (GB106039023460) waterbody - Increased risk of short term deterioration from Minor, to short/long term (uncertain) Moderate, due to the anticipated reduction species richness in Reach 2.

Fish community
Reach 1 - Whilst the Fish community is assessed as Local ecological value, the anticipated drying of the Waddon Ponds is likely to result in significant fish mortalities and the loss of the fish population, therefore the significance of this impact is assessed as Major.

Notable Species – Fish
Reach 2 (European eel Anguilla anguilla and bullhead Cottus gobio) – Significance of impact likely to increase from Minor to Moderate – The Major hydrological and Moderate geomorphological water quality risks are likely to impact both species.

Invasive Flora
Reach 2 - The significance of the impact may increase from Moderate to Major (uncertain) as a result of changes in the distribution of the invasive flora – The Major hydrological and Moderate geomorphological impacts associated with Reach 2 may result in invasive flora increasing in abundance, therefore potentially posing an increased risk to native biota.

Recreation
Reach 1 – Drying of the ponds for an extended period is likely to increase the significance of the impact on the recreational/visual amenity of the ponds from Moderate to Major.
Reach 2 – Angling was not assessed in the EAR. The key physical environment effects associated with Reach 1 and 2 are likely to severely impact the angling amenity – Moderate significance.</td></tr>
</table>

Table A.9 Ogbourne 1 Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Abstract 3.5 Ml/d from the existing Ogbourne boreholes.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Swindon and Oxfordshire Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options.
Stated, and assessed, as most likely in period April – September, with assessment including a delay to recovery of river levels of up to 21 days with full recovery not anticipated until 6 months.
Two reaches assessed (Figure 6.1) – Reach 1 in River Og and Reach 2 in River Kennet.
Significance of impacts as stated in Table 6.6, Table 6.20 and Table 6.21 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged dry channel (Reach 1) and prolonged low river flows (Reach 2).
Hydrological reference conditions (i.e. without a re-application) would likely be dry river (Reach 1) and very low flows in Reach 2, with significant legacy effects on groundwater levels and river flows following expiry of first application.</td></tr>
<tr><td rowspan="3">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Og (Ogbourne St George to River Kennet confluence)</td><td>Major; impacts related to the significant extension of the period the reach is dry including seasons where this would not normally be the case.
Full flow recovery unlikely until late in the following winter.</td><td>Up to Major risks to geomorphology (duration of dry channel will have long-term and potentially irreversible effects on the bed and banks). Water quality effects from likely first flush of pollution during re-wetting.</td></tr>
<tr><td>2: River Kennet (River Og confluence to River Aldbourne confluence)</td><td>Moderate; assessed as major as a result of the continuation of zero or reduced flow contribution from River Og leading to flow reduction in the River Kennet persisting following the cessation of the drought permit as a result of delayed groundwater recover, including into the following winter. Flow reductions in the River Kennet would lead to reduction in wetted habitat and velocities.</td><td>Up to Major risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration. Water quality risks include from reduced dilution of continuous and intermittent discharge and elevated temperature together with likely first flush of pollution from Reach 1 during re-wetting.</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in ecological features assessed in Section 6.6 in the EAR.

Designated Sites - River Kennet SSSI
Reach 2 - Significance of impact likely to increase from Minor and Moderate (depending on different conservation objectives) to Major (all year round) - The key physical environment effects are likely to result in the SSSI failing to meet the Conservation Objectives relating to: Indicators of local distinctiveness and habitat functioning (water flow).

Macroinvertebrate community, including Notable Species
Reach 1 - Significance of impact likely to increase from Minor to Moderate – The Major hydrological, geomorphological and water quality risks are likely to result in the ecological integrity of the macroinvertebrate community being significantly impacted.

Reach 1 - Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the River Og (GB106039023180) - Increased risk of deterioration from Minor, to Major, due to the Major hydrological and geomorphological and water quality risks.

Fish, including NERC Act and Notable Species
Reach 1 - Significance of impact likely to increase from Moderate to Major – The Major hydrological, geomorphological and water quality risks are likely to result in the ecological integrity of the fish community being significantly impacted. In-channel structures located towards the downstream end of the Og, close to the confluence with the Kennet are likely to limit any potential re-colonisation by fish.

Reach 2 – NERC Act fish – European eel (Anguilla anguilla) and sea trout (Salmo trutta) - Significance of impact likely to increase from Minor and Moderate to Major (all year round) – The Moderate hydrological and major geomorphology risks are likely to severely impact the ecological integrity of the European eel and seas trout population.</td></tr>
</table>

		Reach 2 - Potential impacts on the **WFD status/potential** of the Fish classification of the Middle Kennet (GB106039023173) - Increased risk of deterioration from Moderate, to **Major**, due to the Moderate hydrological and geomorphological/water quality risks associated with over half of the spatial reach encompassing the waterbody. **Other Notable Habitats – Chalkstream** Reach 1 and 2 - Significance of impact likely to be **Major –** The key physical environment effects associated with Reach 1 and 2 are likely to severely impact the ecology closely associated with the chalkstream habitat, resulting in the degradation of this notable habitat. **Landscape, Navigation, Recreation, Heritage and Industry** Reach 1 and 2 - North Wessex Downs AONB - Significance of impact likely to increase from Minor to **Moderate-Major** (uncertain) – visual amenity of the AONB in this area severely impacted by the loss/degradation of Reach 1 River Og and Reach 2 River Kennet chalkstream features respectively. Reach 1 and 2 - Angling - Significance of impact likely to be **Major** – The key physical environment effects associated with Reach 1 and 2 are likely to severely impact the angling amenity.

Table A.10 Ogbourne Emergency Boreholes Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Abstract 4.0 Ml/d from existing Ogbourne emergency boreholes.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Swindon and Oxfordshire Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options.
Stated, and assessed, as most likely in period April – September, with assessment including a delay to recovery of river levels of up to 31 days with full recovery not anticipated until 6 months.
Two reaches assessed (Figure 7.1) - Reach 1 in River Og and Reach 2 in River Kennet.
Significance of impacts as stated in Table 7.6, Table 7.20 and Table 7.21 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged dry channel (Reach 1) and prolonged low river flows (Reach 2).
Hydrological reference conditions (i.e. without a re-application) would likely be dry river (Reach 1) and very low flows in Reach 2, with significant legacy effects on groundwater levels and river flows following expiry of first application.</td></tr>
<tr><td rowspan="3">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Og (Ogbourne St George to River Kennet confluence)</td><td>Major; impacts are related to the to the significant extension of the period the reach is dry.
Full flow recovery unlikely until late in the following winter.</td><td>Up to Major risks to geomorphology (duration of dry channel will have long-term and potentially irreversible effects on the bed and banks). Water quality effects from likely first flush of pollution during re-wetting.</td></tr>
<tr><td>2: River Kennet (River Og confluence to River Aldbourne confluence)</td><td>Moderate; continuation of zero or reduced flow contribution from River Og leading to flow reduction in the River Kennet persisting following the cessation of the drought permit as a result of delayed groundwater recover, including into the following winter. Flow reductions in the River Kennet would lead to reduction in wetted habitat and velocities.</td><td>Up to Major risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration. Water quality risks include from reduced dilution of continuous and intermittent discharge and elevated temperature together with likely first flush of pollution from Reach 1 during re-wetting.</td></tr>
</table></td></tr>
<tr><td>Features</td><td colspan="2">Unless described below, the significance of the impacts on all features stated and assessed in ecological features assessed in Section 7.6 in the EAR.

Designated Sites - River Kennet SSSI
Reach 2 - Significance of impact likely to increase from Minor and Moderate (depending on different conservation objectives) to Major (all year round) - The key physical environment effects are likely to result in the SSSI failing to meet the Conservation Objectives relating to: Indicators of local distinctiveness and habitat functioning (water flow).

Macroinvertebrate community, including Notable Species
Reach 1 - Significance of impact likely to increase from Minor to Moderate – The Major hydrological, geomorphological and water quality risks are likely to result in the ecological integrity of the macroinvertebrate community being significantly impacted.

Reach 1 - Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the River Og (GB106039023180) - Increased risk of deterioration from Minor, to Major, due to the Major hydrological and geomorphological and water quality risks.

Fish, including NERC Act and Notable Species
Reach 1 - Significance of impact likely to increase from Moderate to Major – The Major hydrological, geomorphological and water quality risks are likely to result in the ecological integrity of the fish community being significantly impacted. In-channel structures located towards the downstream end of the Og, close to the confluence with the Kennet are likely to limit any potential re-colonisation by fish.

Reach 2 – NERC Act fish – European eel (Anguilla anguilla) and sea trout (Salmo trutta) - Significance of impact likely to increase from Minor and Moderate to Major (all year round) – The Moderate hydrological and major geomorphology risks are likely to severely impact the ecological integrity of the European eel and seas trout population.

Reach 2 - Potential impacts on the WFD status/potential of the Fish classification of the Middle</td></tr>
</table>

		Kennet (GB106039023173) - Increased risk of deterioration from Moderate, to **Major**, due to the Moderate hydrological and geomorphological/water quality risks associated with over half of the spatial reach encompassing the waterbody. **Other Notable Habitats – Chalkstream** Reach 1 and 2 - Significance of impact likely to be **Major –** The key physical environment effects associated with Reach 1 and 2 are likely to severely impact the ecology closely associated with the chalkstream habitat, resulting in the degradation of this notable habitat. **Landscape, Navigation, Recreation, Heritage and Industry** Reach 1 and 2 - North Wessex Downs AONB - Significance of impact likely to increase from Minor to **Moderate-Major** (uncertain) – visual amenity of the AONB in this area severely impacted by the loss/degradation of Reach 1 River Og and Reach 2 River Kennet chalkstream features respectively. Reach 1 and 2 - Angling - Significance of impact likely to be **Major** – The key physical environment effects associated with Reach 1 and 2 are likely to severely impact the angling amenity.

Table A.11 Axford 2 Summary of Severe Drought High Level Assessment

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Increase groundwater abstraction from 6Ml/d to 20Ml/d peak and average at all river flows (licence has conditions at Knighton gauging station).</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Swindon and Oxfordshire Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options.
Stated, and assessed, as most likely in period May – December, with assessment including a delay to recovery of river levels until March.
Four reaches assessed (Figure 9.1) in the River Kennet. Significance of impacts as stated in Table 9.6 and Table 9.25 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as November (earliest) to May, following continuously from first application period.
Study area reviewed and considered to extend to the River Lambourn confluence, some 3.1km downstream of the current study area.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low river flows. Hydrological reference conditions (i.e. without a re-application) would likely be very low flows, with significant legacy effects on groundwater levels and river flows following expiry of first application. The duration of the period without significant aquifer recovery would result in baseflow from the contributing catchment (not impacted by the drought permit) reducing progressively.</td></tr>
<tr><td rowspan="3">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Kennet (0.7km upstream of Axford village to River Aldbourne confluence)</td><td>Major; continuation of flow reduction and reduction in wetted habitat and velocities. Full flow recovery unlikely until late in the following winter.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration</td></tr>
<tr><td>2: River Kennet (River Aldbourne confluence to River Dun confluence)</td><td>Major; continuation of flow reduction and reduction in wetted habitat and velocities. Full flow recovery unlikely until late in the following winter.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration</td></tr>
<tr><td>3: River Kennet (downstream River Dun confluence)</td><td>Up to Major; exacerbation of flow reduction and reduction in wetted habitat and velocities as baseflow from contributing catchment reduces with environmental drought. Full flow recovery unlikely until late in the following winter.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration</td></tr>
<tr><td>4: River Kennet (upstream River Lambourn)</td><td>Up to Moderate; exacerbation of flow reduction and reduction in wetted habitat and velocities as baseflow from contributing catchment reduces with environmental drought. Full flow recovery unlikely until late in the following winter.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 8.6 in the EAR remain unchanged.

The physical environment effects on Reach 4 were assessed as Negligible in the EAR, therefore no assessment of the baseline conditions was undertaken. It is assumed that the features, effects and significance of impact in Reach 4 are similar to those in the upstream adjoining Reach 3, as outlined in the EAR and assessment of the re-application below.

Designated Sites - Kennet and Lambourn Floodplain SAC
Reach 1-4 - Kennet and Lambourn Floodplain SAC (including River Kennet SSSI, Chilton Foliat SSSI and NERC Act Section 41 Habitats – Coastal and floodplain grazing marsh) – Significance of impact likely to increase from Negligible to Major (all year round) – The key physical environment effects are likely to result in the SAC failing to meet the Conservation Objectives relating to: habitat extent, distribution, structure/form, supporting processes, and the population and distribution of the qualifying features. The impact on the SSSI's and associated NERC Act Section 41 habitats encompassed by the SAC are likely to be of Major significance.

Macroinvertebrate community, including Other Environmentally Sensitive macroinvertebrates
Reach 1, 2 and 3 - Significance of impact likely to increase from Minor (Reach 3) and Moderate (Reach 1 & 2) to Major (all three reaches, all year round) – The Major hydrological and Moderate geomorphological risks are likely to result in the ecological integrity of the macroinvertebrate community being significantly impacted.</td></tr>
</table>

		Reach 1 and 2 - Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the Middle Kennet (Marlborough to Hungerford) (GB106039023173) - Increased risk of deterioration from Moderate, to **Major**, due to the cumulative impacts on the community associated with Reaches 1, 2 and 3. Reach 3 and 4 - Potential impacts on the **WFD status/potential** of the Macroinvertebrate classification of the Middle Kennet (Hungerford to Newbury) (GB106039023174) - Increased risk of deterioration from Moderate, to **Major**, due to the cumulative impacts on the community associated with Reaches 1, 2 and 3. **Macrophyte community, including Other Environmentally Sensitive macrophytes** Reach 1, 2 and 3 - Significance of impact likely to increase from Minor (Reach 3) and Moderate (Reach 1 & 2) to **Major** (all three reaches, all year round) – the Major hydrological and Moderate geomorphological risks are likely to result in the ecological integrity of the macrophyte community being significantly impacted. Reach 1 and 2 - Potential impacts on the **WFD status/potential** of the Macrophyte and Phytobenthos combined classification of the Middle Kennet (Marlborough to Hungerford) (GB106039023173) - Increased risk of deterioration from Minor, to **Major**, due to the cumulative impacts on the community associated with Reaches 1 to 4. Reach 3 and 4 - Potential impacts on the **WFD status/potential** of the Macrophyte and Phytobenthos combined classification of the Middle Kennet (Hungerford to Newbury) (GB106039023174) - Increased risk of deterioration from Moderate, to **Major**, due to the cumulative impacts on the community associated with Reaches 1, 2 and 3. **Fish community, including NERC Act Species and Other Environmentally Sensitive fish** Reach 1, 2 and 3 - Significance of impact likely to increase from Moderate (Reach 1, 2 & 3) to **Major** (all three reaches, all year round) – the Major hydrological and Moderate geomorphological risks are likely to result in the ecological integrity of the fish community being significantly impacted. Reach 1 and 2 - Potential impacts on the **WFD status/potential** of the Fish classification of the Middle Kennet (Marlborough to Hungerford) (GB106039023173) - Increased risk of deterioration from Moderate, to **Major**, due to the cumulative impacts on the community associated with Reaches 1,2 and 3. Reach 3 and 4 - Potential impacts on the **WFD status/potential** of the Fish classification of the Middle Kennet (Hungerford to Newbury) (GB106039023174) - Increased risk of deterioration from Moderate, to **Major**, due to the cumulative impacts on the community associated with Reaches 1, 2 and 3. **Other Notable Habitats – Chalkstream** Reaches 1-4 - Significance of impact likely to be **Major –** The key physical environment effects associated with Reach 1-4 are likely to severely impact the ecology closely associated with the chalkstream habitat, resulting in the degradation of this notable habitat. **Invasive Flora** Reaches 1-4 – The significance of the impact is likely to increase from Negligible to **Moderate** as a result of changes in the distribution of invasive flora – A reduction in flow velocity may result in invasive species of flora increasing in abundance (species such as *Lemna minuta* favour lentic flow conditions), therefore potentially posing an increased risk to the health of native biota. **Landscape, Navigation, Recreation, Heritage and Industry** Reaches 1-4 - North Wessex Downs AONB - Significance of impact likely to increase from Negligible to **Moderate** – Visual amenity of the AONB severely impacted by the degradation of the River Kennet and associated habitats. Reach 1, 2 and 3 - Angling - Significance of impact likely to increase from Minor to **Major** – The key physical environment effects associated with Reach 1, 2 and 3 are likely to impact the angling amenity.

Table A.12 M2 Annual Licence Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Increase the calendar year annual maximum abstraction permitted under the M2 licence by up to 33,186Ml (5%).</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in London Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options.
Assumed as November and December.
No reaches assessed (Figure 7.1, M2 Annual Licence EAR). No adverse hydrological impacts identified therefore no impacts on the physical environment or ecological features anticipated.</td></tr>
<tr><td>Re-application</td><td>Assumed as November and December in the year following the first permit application, noting the annual total resets on 1 January.
Study area reviewed and considered to remain the same.
Antecedent hydrological conditions would be an extended multi-season drought, but with a significant period of normal or higher flows prior to the first application. Without a period of higher flows the amount of abstraction is lower and there is no risk to the M2 licence annual total. Full recovery from extremely low reservoir storage volumes requires significant abstraction and that in turn requires normal or higher flows, and only after a period of high rate abstraction under higher flows is there risk to the M2 licence annual total. Hydrological reference conditions (i.e. without a re-application) would be normal or higher river flows.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>At times of normal or higher river flows (the reference conditions) abstraction, as constrained by the LTOA (the 800Ml/d target flow would likely be the value in place) would not result in adverse hydrological effects in the freshwater River Thames or into the upper Thames Tideway.
Summary of high level assessment of key physical environment effects:
<table>
<tr><td>Reaches</td><td>Hydrology</td><td>Other significant physical environment considerations</td></tr>
<tr><td>1: River Thames (Datchet to Teddington)</td><td>Negligible</td><td>No risks</td></tr>
</table></td></tr>
<tr><td>Features</td><td>The first application and re-application assessment of the physical environment is assessed as Negligible. Screening in Section 4.6 of the EAR has not identified any environment features for which assessment is required, therefore a re-application assessment is not required.</td></tr>
</table>

Table A.13 Eynsford Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Increase in the aggregate licence between Eynsford and Horton Kirby such that abstraction at Horton Kirby would be maintained at a maximum daily peak of 11.36Ml/d and effective abstraction at Eynsford increased from 0Ml/d to maximum daily peak of 4.26Ml/d.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in London Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options.
Stated as most likely in period April to September but assessed as at any time of year, with the assessment indicating no delay to river level recovery following cessation of the drought permit.
One reach assessed (Figure 6.1) in the River Darent. Significance of impacts as stated in Table 6.6 and Table 6.25 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as any time of year, following continuously from first application period.
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low river flows likely with drying in the preceding seasons in part as result of the first application. Hydrological reference conditions (i.e. without a re-application) would likely be dry river or very low flows but without legacy effects on river flows following expiry of first application.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Darent (Lullingstone Weir to tidal limit)</td><td>Major; risk of drying or continuation of dry river, particularly in upper and middle reaches. Otherwise, continuation of significant flow reduction and reduction in wetted habitat and velocities. Potential Minor delay to flow recovery on cessation of drought permit.</td><td>Up to Major risks to geomorphology (extended period of fine sediment deposition and impacts associated with drying/return to flow) and water quality deterioration. Water quality risks (including from reduced buffering capacity for diluting continuous and intermittent discharges) and elevated temperature together with likely first flush of pollution during re-wetting.</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 6.3 in the EAR remain unchanged.

Macroinvertebrate community
Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Middle and Lower Darent (GB106040024222) – Increased risk of short term deterioration from Moderate and Major, to short/long term (uncertain) Major.

Macrophyte community
Potential impacts on the WFD status/potential of the Macrophyte and Phytobenthos combined classification of the Middle and Lower Darent (GB106040024222) – Increased risk of short term deterioration from Moderate, to short/long term (uncertain) Major.

Fish community, including NERC Act and Other Notable fish
Significance of impact likely to increase from Moderate and Major (select periods depending on impact/species) to Major (all year round) – The Major hydrological and geomorphological risks are likely to result in significant impacts which effect the ecological integrity of the fish community.

Potential impacts on the WFD status/potential of the Fish classification of the Middle and Lower Darent (GB106040024222) – Increased risk of short term deterioration from Moderate to Major, to short/long term (uncertain) Major.

Other Notable Species
Macrophytes (Water crowfoot Ranunculus sp.) - Significance of impact likely to increase from Minor (all year round) to Moderate (all year round). The Major hydrological and geomorphological risks are likely to result in significant impacts which effect the ecological integrity of Ranunculus sp.

Macroinvertebrates (Oulimnius rivularis, Riolus subviolaceus, Ceraclea senilis) - Significance of impact likely to increase from Minor (all year round) to Moderate (all year round) - The Major hydrological and geomorphological risks are likely to result in significant impacts which effect the ecological integrity of the population of all three species.

Landscape and Recreation
Significance of impact likely to increase from Minor to Major – Drying of the river bed and anticipated deterioration to the natural environment likely to be of great concern to the public.</td></tr>
</table>

Table A.14 Horton Kirby Summary of High Level Assessment of Drought Permit Re-application

Key Area		**Assessment**
Drought Permit conditions		Abstraction of up to 2.6Ml/d from the Lower Greensand aquifer.
Background	First application	Assessed in London Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options. No specific likely period stated or assessed, period of implementation could be at any time of year. No reaches assessed (**Figure 7.1**, Horton Kirby EAR). No adverse hydrological impacts identified therefore no impacts on the physical environment or ecological features anticipated.
	Re-application	Assumed as any time, following continuously from first application period however dependant on Thames Water receiving a licence to recharge the aquifer. Similar to the first implementation of the permit, no adverse hydrological impacts identified therefore, no impacts on the physical environment or ecological features anticipated.
Assessment of re-application	Key physical environment effects	Re-application dependant on Thames Water receiving a recharge licence will involve the abstraction of injected water into the Lower Greensand aquifer. Therefore, no further physical environmental effects are anticipated.
	Features	Assessment of environmental features were not assessed in the EAR due to Negligible risks associated with the physical environment. As no adverse hydrological impacts are associated with the re-application, impact on environmental features are considered Negligible

Table A.15 Fobney Direct Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Manipulation of the Arrowhead control structure at extreme low flows (<173Ml/d gauged at Theale) to allow abstraction from River Kennet at expense of flows to Holy Brook.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Kennet Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options.
Stated, and assessed, as most likely in period April – September, with the assessment indicating no delay to river flow recovery following cessation of the drought permit and the re-opening of the Arrowhead structure.
Two reaches assessed (Figure 6.1) – Reach 1 in the Holy Brook and Reach 2 in the River Kennet. Significance of impacts as stated in Table 6.5, Table 6.20 and Table 6.21 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period.
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low river flows, albeit the severity part-mitigated by augmentation form the West Berkshire Groundwater Scheme, also reduced significantly in the preceding spring/summer by the first application. Hydrological reference conditions (i.e. without a re-application) would be low autumn/winter flows but without legacy effects on river flows following expiry of first application and assumption of continued flow augmentation.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: Holy Brook (Arrowhead control structure to confluence with River Kennet)</td><td>Major; continuation of flow reduction and reduction in wetted habitat and velocities.</td><td>Up to Major risks to water quality (including from reduced buffering capacity for diluting continuous and intermittent discharges) and elevated temperature; also to prolonged fine sediment deposition period.</td></tr>
<tr><td>2: River Kennet (Arrowhead control structure to the Fobney WTW intake)</td><td>Beneficial impact with flows continuing to be increased while drought permit is implemented.</td><td>Not considered.</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 6.3 in the EAR remain unchanged. Note: Reach 2 remains benefitted by the augmentation form the West Berkshire Groundwater Scheme, therefore features assessment has been undertaken for Reach 1 only.

Macrophyte community
Significance of impact likely to increase from Minor (October to December) to Moderate (all year round) – Impacts most likely to result in changes to the assemblage of the community, including a reduction in rheophilic, sensitive taxa and a proliferation of tolerant limnophilic and marginal species. Re-colonisation post drought anticipated to occur from various upstream sources in the Kennet catchment.

NERC Act Macroinvertebrates
Depressed river mussel Pseudanodonta complanate - Significance of impact likely to increase from Minor (May to September) to Moderate (all year round) – the increased risk of deterioration to water quality may result in mortality/recruitment failure, whilst flow reductions may result in a reduction in population abundance due to habitat loss.

NERC Act Habitats
Flood plain and grazing marshes - Significance of impact likely to increase from Minor (May to December) to Moderate (all year round) – Biota associated with the habitat likely to be impacted by the Major hydrological and water quality risks.

Other Notable Species
Macrophytes (Water crowfoot Ranunculus sp.) - Significance of impact likely to increase from Minor (October to December) and Moderate (May to September), to Moderate (all year round) – A reduction in the abundance of the rheophilic species due to the Major hydrological and water quality risks.

Macroinvertebrates (Riffle beetle Macronychus quadrituberculatus and Snipe fly Atrichops crassipes) - Significance of impact likely to increase from Minor to Moderate – Reduction in population abundance due to Major hydrological and water quality risks.

Invasive Species
Flora (Floating pennywort Hydrocotyle ranunculoides and least duckweed Lemna minuta) - Significance of impact likely to increase from Minor (May to August) to Moderate (all year round) – A reduction in flow velocity may result in invasive species of flora increasing in abundance, therefore potentially posing an increased risk to the health of native biota.

Recreation – Angling</td></tr>
</table>

		Significance of impact likely to increase from Minor (May to December) to **Moderate** (all year round) – The Major hydrological and water quality risks are likely to severely impact the angling amenity.

Table A.16 Harpsden and Sheeplands Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Relax 22.33 Ml/d aggregate daily maximum licence condition between Sheeplands and Harpsden groundwater abstractions, increasing daily total take (in combination) to 27.9 Ml/d.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Henley, Slough/Wycombe/Aylesbury (SWA) and Guildford Water Resource Zone Drought Options Environmental Assessment Report Tier 2 Drought Options.
Stated, and assessed, as most likely in period April - September.
One reach assessed (Figure 4.2) in River Thames. No adverse hydrological impacts identified therefore no impacts on the physical environment or ecological features anticipated.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low river flows. Hydrological reference conditions (i.e. without a re-application) would be low autumn/winter flows but without legacy effects on river flows following expiry of first application. Note in this context that low flows in the River Thames, the impacted watercourse, are likely two orders of magnitude higher than the drought permit, even with a conservative estimate.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Thames (Reading gauging station to Newtown)</td><td>Negligible</td><td>Negligible risks</td></tr>
</table></td></tr>
<tr><td>Features</td><td>The first application and re-application assessment of the physical environment is assessed as Negligible. Screening in Section 4.5 of the EAR has not identified any environment features for which assessment is required, therefore a re-application assessment is not required.</td></tr>
</table>

Table A.17 New Ground Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Resume historical abstraction (6.5 Ml/d) from boreholes currently operating through emergency licence.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Henley, Slough/Wycombe/Aylesbury (SWA) and Guildford Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options.
Stated, and assessed, as most likely in period April – September, with assessment including a delay to recovery of river levels of up to 3 to 7 months in the December to April period.
Four reaches assessed (Figure 5.1) – three in the River Bulbourne and one in the Grand Union Canal. Significance of impacts as stated in Table 5.5 and Table 5.18 in the EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low river flows and poor Canal turnover. Hydrological reference conditions (i.e. without a re-application) would be a delayed recovery to flows lasting several months, concurrent with the re-application period.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Bulbourne (source to the 1st confluence with the Canal)</td><td>Major; impacts relate to the significant extension of the period the reach is dry including seasons where this would not normally be the case.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition and impacts associated with drying/return to flow) and water quality deterioration. Water quality risks (including from reduced buffering capacity for diluting continuous and intermittent discharges) and elevated temperature together with likely first flush of pollution during re-wetting.</td></tr>
<tr><td>2: Grand Union Canal (downstream of its 1st confluence with the River Bulbourne until downstream of the 2nd outflow of the River Bulbourne from the Canal)</td><td>Minor; prolonging of the period of poor turnover of water within the canal and extending the low velocity periods to seasons where this would not normally be the case.</td><td>Up to Moderate risks to water quality (including from reduced dispersion of continuous and intermittent discharges) and elevated temperature together with likely first flush of pollution from Reach 1 during re-wetting.</td></tr>
<tr><td>3: River Bulbourne (1st outflow from the Canal to its 2nd confluence with the Canal)</td><td>Minor; prolonging of the period of poor throughflow within the river and extending the low velocity periods to seasons where this would not normally be the case.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition and impacts associated with reduced throughflow) and water quality deterioration. Water quality risks passed forward from Reach 2.</td></tr>
<tr><td>4: River Bulbourne (2nd outflow from canal to confluence with River Gade)</td><td>Minor; prolonging of the period of poor throughflow within the river and extending the low velocity periods to seasons where this would not normally be the case.</td><td>Up to Moderate risks to geomorphology (extended period of fine sediment deposition and impacts associated with reduced throughflow) and water quality deterioration. Water quality risks passed forward from Canal</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in Section 5.6 in the EAR remain unchanged.

Macroinvertebrate community
Reach 1 - Significance of impact likely to increase from Minor to Moderate – The Major hydrological and moderate geomorphological/water quality risks are likely to result in significant impacts which effect the ecological integrity of macroinvertebrate community. Limited re-colonisation post drought from upstream source populations (Reach 1 represents the upper most reach of the Bulbourne watercourse).

Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Bulbourne (GB106039029890) - Increased risk of short term deterioration from Minor, to short/long term (uncertain) Moderate, due to the loss of the population in Reach 1 and a reduction in rheophilic, sensitive taxa in Reach 3 and 4.

Macrophyte community
Reach 1 - Significance of impact likely to increase from Negligible to Minor (based on expert judgement</td></tr>
</table>

		that the macrophyte community is of Local Ecological Value[94]) - The Major hydrological and moderate geomorphological/water quality risks are likely to result in significant impacts which effect the ecological integrity of macrophyte community. Limited re-colonisation post drought from upstream source populations (Reach 1 represents the upper most reach of the Bulbourne watercourse). **Fish community** Reach 2 - No previous assessment made in EAR. Due to the lack of data for the fish population of the Grand Union Canal in Reach 2, Environment Agency fish population survey data[95] from the adjacent Bulbourne has been used to assess the impact re-application. Species composition most likely to be indicative of the lentic canal habitat, including species less susceptible to the hydrological risks. A deterioration in water quality may result in a reduction in the abundance of the population. The overall significance of the impact has been assessed as **Minor** (based on the fish community classified as Local Ecological Value, medium magnitude, short term (uncertain), reversible, reach scale change to the fish community). Reach 3 and Reach 4 – No previous assessment made in EAR. Assessment of Environment Agency fish population survey data for this reach of the Bulbourne has been used to assess the impact re-application. Impact is likely to be of **Minor** significance (based on the fish community classified as Local Ecological Value, High magnitude, long term (uncertain), catchment scale change to the fish community. Minor hydrological and moderate geomorphological/water quality impacts likely to result in a reduction in rheophilic, sensitive species, and a proliferation of tolerant, limnophilic/eurytopic species. Re-colonisation post drought is not anticipated to occur from upstream source populations, due to the lack of a viable source population located upstream (Reach 1). As the Bulbourne (GB106039029890) has not been classified under the WFD for fish, an assessment to the risk of deterioration or prevention of achievement of GEP is not applicable (see **Section 5.6.2** of the EAR). In the event of a fish classification status being assigned in the future, the impact of a multi-season drought permit implementation would likely present a **Major** risk to deterioration of the fish classification status. **Notable Species - Fish** Reach 3 and Reach 4 (Bullhead *Cottus gobio*)– No assessment made in EAR. Significance of impact assessed as **Moderate** – the Major-Minor hydrological and Moderate geomorphological/water quality risks may result in a reduction in population abundance. **Invasive Macroinvertebrates** Reach 2-4 - Signal crayfish *Pacifastacus leniusculus* - The significance of the impact is likely to increase from Negligible to **Moderate** as a result of changes in the distribution of the invasive macroinvertebrates – As a result of the Major hydrological risks associated with Reach 1, any crayfish in this reach of the Bulbourne are likely to seek more appropriate (wetted habitat) in Reach 1-4, therefore potentially posing an increased risk to native biota. **Invasive Flora** Reach 2-4 – The significance of the impact is likely to increase from Negligible to **Moderate** as a result of changes to the distribution of the invasive flora – The Minor hydrological risks may result in invasive flora increasing in abundance (species such as floating pennywort *Hydrocotyle ranunculoides* favour lentic flow conditions), therefore potentially posing an increased risk to native biota. **Other Notable Habitats - Chalkstreams** Reach 1, 3 and 4 (Bulbourne only) - Significance of impact likely to increase from Minor to **Moderate** – The key physical environment effects associated with Reach 1, 3 and 4 are likely to severely impact the ecology closely associated with the chalkstream habitat, resulting in the degradation of this notable habitat.

[94] Note – Survey data is absent from the Bulbourne

[95] Environment Agency Freshwater Fish Counts for all Species, all Areas and Years (Online source) https://ea.sharefile.com/share/view/s5301a91e00c428a8

Table A.18 Shalford Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Suspension of the aggregate abstraction conditions with Tillingbourne, such that more water (up to 5Ml/d) can be abstracted from the River Wey.</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Henley, Slough/Wycombe/Aylesbury (SWA) and Guildford Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options
Stated, and assessed, as most likely in period April – September, with the assessment indicating no delay to river level recovery following cessation of the drought permit.
One reach assessed (Figure 6.1) in the River Wey. No adverse hydrological impacts identified therefore no impacts on the physical environment or ecological features anticipated.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period
Study area reviewed and considered to remain the same.
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low river flows also reduced ~4% in the preceding spring/summer by the first application. Hydrological reference conditions (i.e. without a re-application) would be low autumn/winter flows but without legacy effects on river flows following expiry of first application.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>Although the re-application is considered for drought reference conditions worse than those on record, review of gauged flow records indicate that the flow (prior to abstraction) locally in the River Wey in these months would need to reduce by ~30% (from ~160Ml/d to ~110Ml/d) before the drought permit would reduce flows by >10%. Such reduction in flow, from multi-season drought baseflow and throughflow reductions, is considered too extreme a reference condition and the hydrological assessment of the drought permit re-application is therefore Negligible.
Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Wey (Shalford WTW to the River Tillingbourne confluence)</td><td>Negligible</td><td>Negligible risks</td></tr>
</table></td></tr>
<tr><td>Features</td><td>The first application and re-application assessment of the physical environment is assessed as Negligible. Screening in Section 4.5 of the EAR has not identified any environment features for which assessment is required, therefore a re-application assessment is not required.</td></tr>
</table>

Table A.19 Albury Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Continuation of groundwater abstraction at times Law Brook flows at Albury below the normal licence condition ceasing abstraction (2.27Ml/d)</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Henley, Slough/Wycombe/Aylesbury (SWA) and Guildford Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options
Stated, and assessed, as most likely in period April – September, with assessment including a delay to recovery of river levels of up to one month.
Two reaches assessed (Figure 7.1) – Reach 1 and 2 in Law Brook. Significance of impacts as stated in Table 7.5, Table 7.14 and Table 7.15 in the Albury EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as October– March, following continuously from first application period
Study area reviewed and considered to remain the same.
Hydrological conditions would be worse than those on record. The antecedent period would include drying of Reach 1 and, in Reach 2, prolonged low river flows (multi-season) reduced significantly in the preceding spring/summer by the first application. Hydrological reference conditions (i.e. without a re-application) would be a dry river or low autumn/winter flows with one month of legacy effects on flow recovery following expiry of first application.</td></tr>
<tr><td rowspan="3">Assessment of re-application</td><td>Key physical environment effects</td><td>Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: Law Brook (Pursers Farm to Ford Cress Beds)</td><td>Major; dry reach remaining dry during the autumn and winter period until aquifer levels recover.</td><td>Up to Major risks to water quality; other risks up to Minor.</td></tr>
<tr><td>2: Law Brook (Ford Cress Beds to confluence with River Tillingbourne)</td><td>Uncertain, potentially Major. Effect of Albury abstraction on baseflow (including artesian boreholes at Ford Cress Beds) in extreme drought not known. Risk of flow reduction and reduction in wetted habitat and velocities.</td><td>Up to Major risks to water quality; other risks up to Minor.</td></tr>
</table></td></tr>
<tr><td>Features</td><td colspan="2">Unless described below, the significance of the impacts on all features stated and assessed in Section 7.6 in the EAR remain unchanged.

Macroinvertebrate community
Potential impacts on the WFD status/potential of the Macroinvertebrate classification of the Tillingbourne (GB106039017840) – Increased risk of short term deterioration from Minor to Moderate (uncertain).

Fish community, including Notable Species
Reach 1 – Significance of impact likely to increase from Minor (October to March) to Moderate – The Major hydrological and water quality risks are likely to result in the loss of the fish community in the upper reaches of the Law Brook. Re-establishment of the population significantly impacted due to a lack of a viable source population upstream, and the diminutive size of the species (i.e. bullhead Cottus gobio and stickleback sp.) limiting their ability to recolonise from Reach 2 downstream.

Invasive Macroinvertebrates
Reach 2 - The significance of the impact is likely to increase from Negligible to Moderate as a result of changes in the distribution of the invasive macroinvertebrates – The (potentially) Major Hydrological and major water quality risks may result in invasive macroinvertebrates increasing in abundance (e.g. New Zealand mud snail Potamopyrgus antipodarum and European physa Cheliocorophium curvispinum), therefore potentially posing an increased risk to native biota.

Invasive Flora
Reach 2 - The significance of the impact is likely to increase from Negligible to Moderate as a result of changes in the distribution of the invasive flora – A reduction in flow velocity may result in invasive flora increasing in abundance (e.g. Water fern Azolla sp., least duckweed Lemna minuta and pondweed Elodea sp.), therefore potentially posing an increased risk to native biota.</td></tr>
</table>

Table A.20 Pann Mill Summary of High Level Assessment of Drought Permit Re-application

<table>
<tr><th colspan="2">Key Area</th><th>Assessment</th></tr>
<tr><td colspan="2">Drought Permit conditions</td><td>Increase from revised licence peak and average of 9.5 Ml/d to 16.8 Ml/d</td></tr>
<tr><td rowspan="2">Background</td><td>First application</td><td>Assessed in Henley, Slough/Wycombe/Aylesbury (SWA) and Guildford Water Resource Zone Drought Options Environmental Assessment Report, Tier 2 Drought Options
Stated, and assessed, as most likely in period April – September, with the assessment indicating no delay to river level recovery following cessation of the drought permit.
Three reaches assessed (Figure 8.1) – Reach 1 and Reach 2 in River Wye and Reach 3 in the Wycombe Marsh Brook. Significance of impacts as stated in Table 8.4, Table 8.20 and Table 8.21 in the Pann Mill EAR.</td></tr>
<tr><td>Re-application</td><td>Assumed as October – March, following continuously from first application period
Study area reviewed and additional at risk downstream reach added (Reach 4).
Hydrological conditions would be an extended multi-season drought. The antecedent period would be prolonged low river flows also reduced significantly in the preceding spring/summer by the first application. Hydrological reference conditions (i.e. without a re-application) would be low autumn/winter flows but without legacy effects on river flows following expiry of first application.</td></tr>
<tr><td rowspan="2">Assessment of re-application</td><td>Key physical environment effects</td><td>As no flow from Reach 1 into Reach 2, and without perennial spring marking the upstream boundary of Reach 2, there is risk of the dry reach extending into upper Reach 2. Also risk that baseflow contribution in Reach 2 insufficient to buffer and dilute Little Marlow STW leading to water quality deterioration in the River Wye d/s Reach 2 to the River Thames confluence (added Reach 4).
Summary of high level assessment of key physical environment effects:
<table>
<tr><th>Reaches</th><th>Hydrology</th><th>Other significant physical environment considerations</th></tr>
<tr><td>1: River Wye (High Wycombe to Pann Mill PS)</td><td>Negligible; reach not in connectivity with Chalk aquifer</td><td>Negligible risks</td></tr>
<tr><td>2: River Wye (Pann Mill PS to Little Marlow STW discharge)</td><td>Major; risk of drying in upper reaches. Otherwise, continuation of significant flow reduction and reduction in wetted habitat and velocities. Potential Minor delay to flow recovery on cessation of drought permit.</td><td>Moderate risks to geomorphology (extended period of fine sediment deposition) and water quality deterioration</td></tr>
<tr><td>3: Wycombe Marsh Brook (1 km downstream of Pann Mill PS to its confluence with the River Wye)</td><td>Moderate; continuation of flow reduction and reduction in wetted depths and velocities</td><td>Up to Minor risks</td></tr>
<tr><td>4: River Wye (Little Marlow STW discharges to River Thames)</td><td>Unknown; Reach 2 flow contribution reduced and STW flow reduced. Probably Minor</td><td>Non-quantified risks to water quality and fine sediment deposition.</td></tr>
</table></td></tr>
<tr><td>Features</td><td>Unless described below, the significance of the impacts on all features stated and assessed in ecological features assessed in Section 8.6 in the EAR. Note: Features assessment of Reach 4 (added as part of re-application assessment) has not been undertaken due to insufficient data.

Invasive flora
Reach 2-4 – The significance of the impact of a multi-season drought permit implementation may increase from Minor to Moderate (uncertain) as a result of changes in the distribution of the invasive flora – The key physical environment effects associated with Reach 2-4 may result in invasive flora increasing in abundance (species such as Elodea candensis and Lemna minuta favour lentic flow conditions), therefore potentially posing an increased risk to native biota.

Invasive macroinvertebrates
Reach 2-4 - Signal crayfish Pacifastacus leniusculus - The significance of the impact is likely to increase from Negligible to Moderate (uncertain) - The key physical environment effects associated with Reach 2-4 may result in the spatial distribution of invasive crayfish increasing (as crayfish seek out more suitable wetted habitat in Reach 1 and 4), therefore potentially posing an increased risk to native biota.</td></tr>
</table>