Appendix C
Ecological Assessment Methodologies

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Southern Water

Contents

C.1 WFD STATUS AND ECOLOGICAL COMMUNITY ASSESSMENT

The following provides Water Framework Directive (WFD) status and ecological community assessment methodology for:

- Fish (freshwater and estuarine),
- Macroinvertebrates (freshwater and estuarine)
- Macrophytes
- Macroalgae and phytoplankton

Potential Effects

All major ecological communities, irrespective of Water Framework Directive (WFD) status being High, Good, Moderate or Poor, will be subject to a potential impact assessment to determine the likely impacts on these communities that lie within the zone of influence of the drought option. The likelihood of deterioration in status/potential based on the impact characteristics identified and the baseline ecological status/potential will be assessed as specified by the Environment Agency's Water Company Drought Plan Guideline December 2020.

Definition of Impacts

In order to define the potential WFD status impacts for fish, macroinvertebrates and macrophytes in a readily understandable manner, a series of criteria have been defined. The assessment will use the following criteria, based on the potential severity of the drought option impacts during an ongoing drought.

Likely Impact Category	Description
Major	A major level impact is one that results in deterioration in the WFD status classification of the waterbody, or specifically the fish/ macroinvertebrate/macrophyte biological element of the status classification.
Moderate	A moderate impact on fish/macroinvertebrate status occurs when the fish/macroinvertebrate population is assessed to be materially influenced, including effects on density, abundance or community composition, but where no deterioration in WFD status classification is assessed. Consideration should be given to the scale of the impact and the potential for recovery of the populations. A moderate impact on macroinvertebrate status occurs when the macroinvertebrate community is assessed to be materially influenced, including reduction in the LIFE score, or in community density +/- or abundance, but where no deterioration in WFD status is anticipated. Consideration should be given to the scale of the impact and the potential for recovery of the community.
Minor	A minor impact occurs when there is an assessed impact on fish/macroinvertebrate/macrophyte abundance, density or community composition that is within the usual variability for the site and which will recover within a short timescale.
Uncertain	Impacts are uncertain where there is lack of baseline information.

Data Requirements

Macrophytes

Baseline data for macrophytes will be collated from existing data (Environment Agency data and in some cases new data collected by Southern Water). The analysis will provide an assessment of the community type and its sensitivity.

Macrophyte status baseline assessment requires data from standard Environment Agency (or water company) monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Macrophyte data should include species presence, abundance and density.

The plant community is then analysed by Mean Trophic Rank (MTR), Mean Flow Rank (MFR) and LEAFPACS2.

The LEAFPACS2 is the combined metrics from:

1. River Macrophyte Nutrient Index (RMNI) derived from the RMNI scores of the taxa from surveys.
2. Number of macrophyte taxa (NTAXA) the number of truly aquatic scoring taxa recorded during surveys.
3. Number of functional groups (NFG) fully aquatic taxa are allocated to 24 functional groups.
4. Cover of green filamentous algae (ALG) percentage cover over the whole of the survey section of river.

Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area) as follows:

- Relevant study area (as identified in the hydrological assessment)
- Hydrology at or close to the monitoring sites to link to macrophyte data, including full flow hydrograph, wetted area and velocity profile. This will include daily gauged flow and spot flow surveys for all available relevant records, or otherwise use of rainfall data where flow data are insufficient from available rain gauge records
- Habitat data for the monitoring sites, which may include recent RHS data
- Routine Environment Agency water quality monitoring data (alkalinity, altitude of source, distance from source and slope) representative of the study area.

Macroinvertebrates

The baseline for macroinvertebrates will be established from existing data (Environment Agency data and in some cases new data collected by Southern Water) together with a comparison of species flow preference and taxon abundance. The analysis will provide an assessment of the community type and its sensitivity.

Macroinvertebrate status baseline assessment requires data from standard Environment Agency (or water company) monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Macroinvertebrate data should include the LIFE scores and WHPT scores ($WHPT_{NTAXA}$ and $WHPT_{ASPT}$ together with abundance and density data where available. Alternatively, in the absence of WHPT data, the Biological Monitoring Party (BMWP) score, Average Score Per Taxon (ASPT) and Number of Scoring Taxa (NTAXA) biotic indices (which are derived from BMWP) will be used to assess the risk of deterioration to WFD classification. Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area) and other environmental variables as follows:

- Relevant study area (as identified by the hydrological impact assessment)

- Hydrology at or close to the monitoring sites to link to macroinvertebrate data, including full flow hydrograph, wetted area and velocity profile. This will include daily gauged flow and spot flow surveys from all available relevant records. Otherwise, rainfall data can be reviewed where flow data are insufficient using available rain gauge records
- Habitat data for the monitoring sites where available (e.g. from RHS or Habscore surveys) to calculate HQA / HMS.
- Routine Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area from 01/01/2005 to present.

Fish

Fish status baseline assessment requires data from standard Environment Agency monitoring programmes (and in some cases new data collected by Southern Water) in the potentially impacted zone, and preferably in a control site outside of the zone of influence.

Fish data should include species presence, abundance and density. Fish counts should be used from depletion sampling or semi-quantitative catch per area sampling and be collected using electro –fishing methods.

Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area) as follows:

- Relevant study area (as identified in the hydrological assessment)
- Hydrology at or close to the monitoring sites to link to fish data, including full flow hydrograph, wetted area and velocity profile. This will include daily gauged flow and spot flow surveys for all available relevant records, or otherwise use of rainfall data where flow data are insufficient from available rain gauge records
- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys where available
- Routine Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.

Assessment Methodology and Uncertainty

Macrophytes and macroalgae

Baseline conditions for sites within the zone of influence of the drought permit/order will be established through existing data. These will include consideration of the hydrology, water quality, habitat and macrophyte variation over the monitored period.

The analysis will consider the relationship between macrophyte status and the supporting environmental variables over the period, with an emphasis on changes to macrophyte assemblage and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether macrophyte status responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, weather conditions, water quality (soluble reactive phosphorus (SRP and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought permit/order conditions (care will be taken to avoid using periods in the baseline analysis within which a drought permit/order may have been in operation), assessment will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from implementation of the drought permit/order. This will be undertaken for the hydrological data by overlaying the drought permit/order flows over the baseline flow hydrograph. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in flow.

Where data are not available, the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments if applicable. This is applicable for the macroalgae assemblage for estuarine water bodies.

The assessment of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or surveillance data are used for impact assessment purposes. Lastly, the environmental envelopes within which macrophyte species can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. The Environment Agency will be consulted on the envelopes of flow and habitat requirements that will be used to assess the risk to species. The assessment must therefore be undertaken in recognition that the assessment will be subject to potential variability. The assessment will therefore adopt a precautionary approach, with potential impacts highlighted where doubt exists. Monitoring and mitigation proposals for the drought permit/order can then be specified where required so that, should it be implemented, the actual impact can be recorded and any required adaptive mitigation/management undertaken to safeguard where possible macrophyte assemblages.

Macroinvertebrates

Having established the baseline, the relative changes expected as a result of the drought permit/order (in relation to natural drought conditions) in river hydrology, geomorphology and water quality will be identified. An assessment will then be made of the habitat requirements of the key riverine and estuarine macroinvertebrate communities present, using existing knowledge of their range of preferences. Depending on the resolution of baseline data available, detailed quantitative analysis of the datasets may be possible. However, in some cases, where relatively limited spatial and/or temporal datasets are available, the impact assessment of the drought permit/order will be based on qualified expert judgement of the potential effects of the assessed changes in the environmental variables on the macroinvertebrate communities. The analysis is supplemented by consideration of the implications of environmental change on the key macroinvertebrate metrics, including LIFE scores and WHPT scores ($WHPT_{NTAXA}$ and $WHPT_{ASPT}$).

The WFD macroinvertebrate classification for the water body will be identified and the reasons for the status/potential classification established from the Environment Agency. The data used to support the assessment will be analysed to ensure that the classification is accurate. Furthermore, for all available macroinvertebrate data where variables are available, EQRs should be calculated using RICT for $WHPT_{NTAXA}$ and $WHPT_{ASPT}$ indices which will directly relate to the macroinvertebrate community to WFD status over the monitoring period.

Baseline conditions for sites within the zone of influence of the drought permit/order will be established through existing data. These will include consideration of the hydrology, water quality, habitat and macroinvertebrate (LIFE scores and WHPT EQRs) variation temporally over the monitored period.

The analysis will consider the relationship between macroinvertebrate status and the supporting environmental variables over the period, with an emphasis on changes to status and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether status responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, weather conditions, water quality (dissolved oxygen and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought permit/order conditions (care will be taken to avoid using periods in the baseline analysis within which a drought permit/order may have been in operation), assessment will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from implementation of the drought permit/order. This will be undertaken for the hydrological data by overlaying the drought permit/order flows over the baseline flow hydrograph. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water flow.

Once the flow, habitat and water quality drought permit/order predictions have been established, their implications for the existing macroinvertebrate community will be assessed. The linkage between the flow and habitat environmental envelope for macroinvertebrate communities is subject to continuing debate but has been shown to be linked[1]. The assessed changes in supporting environmental variables (flow, habitat quality) due to the drought permit/order should be assessed against the macroinvertebrate community LIFE scores. Consideration will be given to the relationships between flow, habitat and LIFE scores including as set out in the DRIED-UP research papers[2]. Implications for $WHPT_{NTAXA}$ and $WHPT_{ASPT}$ indices will also be considered in relation to flow, habitat and water quality pressure changes resulting from implementation of the drought permit. Use of LIFE scores in conjunction with WHPT scores (WHPTNTAXA and WHPTASPT) will inform the sensitivity of the community and in turn the assessment to determine risk of deterioration to macroinvertebrate status.

The assessment will consider the scale and longevity of any macroinvertebrate community impacts. The WFD macroinvertebrate classification is calculated on a 3-year rolling basis. A deterioration in status classification would require a long term and significant effect on macroinvertebrate community structure to establish any deterioration between a WFD status class.

Where data are not available, the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments if applicable. This is relevant to benthic macroinvertebrates, where WFD status is rarely available for transitional water bodies.

The assessment of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or surveillance data are used for impact assessment purposes. Lastly the environmental envelopes within which the macroinvertebrate community can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. The Environment Agency will be consulted on the envelopes of flow and habitat requirements that will be used to assess the risk to species. For macroinvertebrates, the evidence base for the prediction of flows and changes to LIFE score remain subject to significant debate. The assessment must therefore be undertaken in recognition that the assessment will be subject to large potential variability. A precautionary approach will be adopted, with potential impact highlighted where doubt exists. Monitoring and mitigation proposals for the drought permit/order can then be specified so that, should the permit/order be implemented, the actual impact can be recorded and any required adaptive mitigation/management undertaken to safeguard where possible the macroinvertebrate community.

Fish

The WFD FCS2 classification for the waterbody will be identified and the reasons for classification established from the Environment Agency. The data used to support the assessment will be reviewed to ensure that the classification is accurate.

Baseline conditions for sites within the zone of influence of the drought permit/order will be established through existing data. These will include consideration of the hydrology, water quality, habitat and fish variation temporally over the monitored period.

The analysis will consider the relationship between fish status and the supporting environmental variables over the period, with an emphasis on changes to fish status and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether fish status responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, weather conditions, water quality (dissolved oxygen and temperature) and/or habitat quality and availability.

[1] Dunbar, M. J., Pedersen, M.L. , Cadman, D., Extence, C., Waddingham, J., Chadd, R. & Larsen, S. E. (2010) River discharge and local-scale physical habitat influenced macroinvertebrate LIFE scores. *Freshwater Biology* 55 (1) pp 226 - 242.
[2] Dunbar, M. J.; Young, A. R.; Keller, V.. 2006 *Distinguishing the Relative Importance of Environmental Data Underpinning flow Pressure assessment (DRIED-UP).* Bristol, Environment Agency, 55pp. (CEH Project Number: C02972) (Unpublished)

Having established the baseline conditions and variability outside the drought permit/order conditions (care will be taken to avoid using periods in the baseline analysis within which a drought permit/order may have been in operation), assessment will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from implementation of the drought permit/order. This will be undertaken for the hydrological data by overlaying the drought permit/order flows over the baseline flow hydrograph. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in flow.

Once the flow, habitat and water quality drought permit/order assessments have been established, their implications for existing fish species will be assessed. The flow and habitat environmental envelope of the key fish species is known. The assessed changes in supporting environmental variables (flow, depth, velocity, habitat quality, dissolved oxygen levels and temperature) due to the drought permit/order will be assessed against the fish population data. Where the supporting environmental variables for fish species are modified to take them outside of their preferred envelope, it can generally be assumed that there will be a moderate or major impact on that fish population. Consideration will be given to the potential for density dependent mortality where data show that the fish population has an existing good density, and where the drought permit/order reduces habitat availability significantly. The assessment will consider the scale and longevity of any fish status impacts. The WFD FCS2 classification is calculated on a 3-year rolling basis. A deterioration in classification would require a long term (2+ breeding seasons) and significant effect on fish population structure to lead to a deterioration in WFD classification status.

Where data are not available, the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments if applicable. This is applicable for the fish assemblage for estuarine water bodies.

The assessment of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or surveillance data are used for impact assessment purposes. Lastly, the environmental envelopes within which fish species can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. The Environment Agency will be consulted on the envelopes of flow and habitat requirements that will be used to assess the risk to species. The assessment must therefore be undertaken in recognition that the assessment will be subject to potential variability. The assessment will therefore adopt a precautionary approach, with potential impacts highlighted where doubt exists. Monitoring and mitigation proposals for the drought permit/order can then be specified where required so that, should it be implemented, the actual impact can be recorded and any required adaptive mitigation/management undertaken to safeguard where possible the fish populations.

C.2 DESIGNATED SITES, NERC S41 SPECIES OF PRINCIPAL IMPORTANCE AND HABITATS, NOTABLE SPECIES

The following provides assessment methodology for:

- Designated sites
- NERC S41 species of principal importance and habitats
- Notable species

Potential Effects
Where screening of the drought option has identified that a sensitive ecological feature is present within the zone of influence of the drought option and screening has indicated that it is sensitive to the impacts of the drought option, the potential impact is to be investigated. The investigation will consider the impacts of the variation in surface water flows and levels or changes to groundwater levels, and the consequent impacts on the habitats and species. Potential effects are associated either 1) directly to a reduction in river or groundwater levels and/or flows; or 2) a reduction in water quality; 3) secondary effects of reduced velocity, for example on sediment characteristics.
Definition of Impacts
In order to define the potential impacts on ecological communities in a readily understandable manner, a series of criteria have been defined. A combination of two guidelines has been used for the assessments; CIEEM guidance for valuing and characterising the impacts, and the EA Drought Plan guidance (2020) for assessing sensitivity and likely impact rating. For each feature of interest there is a need to state 'Sensitivity' (low, medium, high, not sensitive or uncertain), 'Summary of likely impact' (description including duration of impact), 'Category of impact' (minor, moderate, major or uncertain) and confidence level (low, medium or high). *Sensitivity of Receptor* The Environment Agency 'Environmental assessment for water company drought planning supplementary guidance' (July 2020) identifies that a key part of the environmental assessment should be understanding how sensitive each environmental feature / receptor of interest is to the likely changes in hydrology (or hydrogeology) (and associated habitat changes) caused by supply side actions. The sensitivity of the ecological receptor has been determined in the context of the likely impacts resulting from the drought option. Consideration has therefore been given to which ecological receptors are likely to be particularly sensitive to changes in groundwater levels, surface water flows and levels, water quality changes, changes to salinity regimes, changes in wetted area, increased siltation etc. As an initial guide, the UK Technical Advisory Group on the Water Framework Directive Guidance on the Identification of Natura Protected Areas (final) March 2003, has been used to identify water dependent features (although noting this covers habitats and species also reliant on coastal processes). Then professional judgement, informed by relevant literature review, has identified the sensitivity of the feature to the changes resulting from the drought option. This was used as a basis to screen features in and out of needing further assessment in the environmental assessment.

Value of the Ecological Receptor

When assigning a value, consideration was given to abundance, range and geographical distribution, and historic trends (e.g. if a species is rare and population is in decline). It is important to note that there is a difference between the legislative and conservation status of an ecological receptor i.e. although a species may be identified as an Annex II species, unless the population is contained within an SAC, it is unlikely to warrant an international value. The approach to valuing ecological receptors is detailed in **Table C.1.**

Table C.1 Value of Ecological Receptor

Ecological Value	Example
International	European Protected Species (EPS) identified in the Habitats Directive. Internationally important populations.
National	Nationally protected species and those identified as priority species in the UK NERC. Viable breeding populations of Red Data Book species (excluding scarce) or habitats providing critical habitat requirements for them.
Regional	Viable breeding populations of Nationally Scarce species or those included in Regional NERC, or habitats providing critical habitat requirements for them.
County	Viable breeding populations of species of county/metropolitan rarities, or habitat supplying critical habitat requirements for them.
District	Viable breeding populations of species listed as rare in the district or borough, or habitat supplying critical habitat requirements for them.
Parish (local)	Species whose presence is considered to appreciably enrich biodiversity within the context of the parish or local neighbourhood, including as a local recreational/educational resource.
Site (within zone of influence only)	Species which are so low grade or widespread so as to be considered as not contributing to biodiversity value outside the boundaries of the site.

Characterising the Impacts

The implementation of the drought option, and the resulting hydrological and hydrogeological changes, could affect habitat quality, population/community status, breeding or migration potential. The following characteristics have therefore been considered in determining the likely impact category (minor, moderate, major or uncertain):

- **Positive or Negative Impact** – all impacts are considered to be negative unless otherwise stated in the feature assessment.
- **Extent** – the extent of the impact is the spatial or geographical area over which the impact/effect may occur.
- **Magnitude** – the magnitude of the impact looks to define the potential change in WFD status/change in size, amount, volume of the ecological communities (quantified where possible e.g. % of habitat lost, % of population subject to decline).
- **Duration** – the duration of impact is considered to be for 6 months, which is the duration for which a drought permit/order is implemented, unless otherwise stated (e.g. it will be expected to be longer for groundwater impacts because of recovery times).
- **Reversibility** – all impacts are considered to be reversible unless they are identified to have a likely impact on the overall viability of the ecological receptor.
- **Timing and Frequency** – the drought permit/order could be implemented at any point in the year (unless otherwise statement in the assessment), however the different life stages of the ecological species are taken into account. The assessment is based on the operation of a single drought permit/order for a period of 6 months, with subsequent applications for a drought permit/order required to consider cumulative effects of multiple drought permits/orders.
- **Probability** – all impacts are considered to be probable, unless otherwise stated.

Data Requirements

Designated Sites

- Relevant citation documents.
- Conservation objectives (Special Areas of Conservation and Special Protection Areas) and Supplementary Advice (where available).
- Site Improvement Plans (Special Areas of Conservation and Special Protection Areas).
- Regulation 33 information for European Marine Sites.
- Review of Consents information available from the Environment Agency.
- Favourable condition tables for underlying Sites of Special Scientific Interest.
- Article 12 (Special Protection Areas) and Article 17 (Special Areas of Conservation) status reports.
- Sites of Special Scientific Interest condition assessments.
- Common Standards Monitoring Guidance (where specific targets have been set and agreed by Natural England and Environment Agency).
- Habitat preferences for the qualifying species (e.g. nesting, foraging, commuting) and food preferences.
- Physical characteristics of the habitats and environment influencing them.

NERC S41 Habitats of Principal Importance (water dependent/sensitive)

NERC habitat baseline review requires available data from the Environment Agency, Natural England and other relevant organisations. Data should include the condition of the habitat and species composition:

- Mapping of areas of priority habitats.
- Information on the sensitivity of habitats to surface water/groundwater flows and levels e.g. water level management plans.
- NVC surveys.

NERC S41 Species of Principal Importance and Notable Species (water dependent/sensitive)

NERC species baseline review requires data from standard Environment Agency monitoring programmes and other monitoring programmes that are available (e.g. Natural England) in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Data should include species presence, abundance and density. Environmental supporting data should include habitat availability, hydrology and water quality as follows:

- Relevant study area (as identified in the hydrological/hydrogeological assessment).
- Hydrology/hydrogeology at or close to the monitoring sites to link to species data, including full flow hydrograph, wetted area and velocity profile for rivers and water level information for wetland sites. This will include daily gauged flow/spot flow surveys or groundwater level data for all available records, or otherwise rainfall data where flow data are insufficient from available rain gauge records or groundwater levels.
- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys where available.

- Routine Environment Agency water quality monitoring data (e.g. dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity for river reaches) representative of the study area.
- Habitat preferences for the given NERC species will be described, against which habitat change can be assessed.

Assessment Methodology and Uncertainty

Baseline conditions for sites within the zone of influence of the drought permit/order will be established through existing data. These will include graphing the hydrology/hydrogeology, relevant water quality, habitat and species variation temporally and, if multiple sites, spatially over the monitored period.

The analysis will consider the relationship between the species lifestages (if appropriate), and the supporting environmental variables over the period, with an emphasis on changes to status and environmental conditions between low, average and high flow/water level years. The purpose of the analysis is to establish whether the species population responds to changes in flow/water level and associated environmental variables inter-annually relating to changes in flow/level, weather conditions, water quality (e.g. dissolved oxygen and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought permit/order conditions (care will be taken to avoid using periods in the baseline analysis within which a drought permit/order may have been in operation), assessment will be made of the changes in the supporting environmental variables (flow/level, habitat and water quality) resulting from application of the drought permit/order conditions. Ideally for rivers this will be undertaken for the hydrological data by overlaying the drought permit/order flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought permit/order. Similarly, assessment can be made of wetland sites in relation to water level data. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in flow/wetted area or water levels. In many cases these data are currently unlikely to exist and proxy measures such as RHS and/or aerial survey data will be used.

Once the flow/level, habitat and water quality drought permit/order assessments have been established, their implications for the species will be assessed. The flow and habitat environmental preferences of each species will be described. The assessed changes in supporting environmental variables (flow, depth, velocity, habitat quality, water quality (e.g. dissolved oxygen levels and/or temperature)) due to the drought permit/order should be assessed against the species population data.

Where data are not available the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments if applicable, and relevant literature.

The assessed impacts of hydrological and water quality changes on aquatic and estuarine ecology remains subject to significant uncertainty. This is exacerbated where few data or surveillance data are used for impact assessment purposes. Lastly, the environmental preferences within which species can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. The assessment must therefore be undertaken in recognition that the assessment will be subject to potential variability. The assessment will therefore adopt a precautionary approach, with potential impact highlighted where doubt exists. Monitoring and mitigation proposals for the drought permit/order can then be specified where required so that, should it be implemented, the actual impact can be recorded and any required adaptive mitigation/management undertaken to safeguard where possible the species populations.

Habitat Preferences of Key Aquatic Species			
Type/ Age Class	**Description**	**Unfavourable Habitat**	**Potential Impacts**
Atlantic salmon *Salmo salar and* Brown/Sea trout *Salmo trutta*			
Spawning	Clean and unconsolidated gravels typically in the transitional area between pools and riffles where the flow is accelerating and depth is decreasing	-	Deposition of silt
			Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
Nursery (fry and parr life stage)	Shallow areas with a low water velocity and pebble substrate, often at the margins of riffles	Deep and/or high velocity habitats.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	Deep habitats that provide shelter including one or more of the following: submerged structures undercut banks overhanging vegetation <50cm above the water surface water surface turbulence causing a broken surface Deep pools downstream of obstacles and sufficient water quantity through structures to enable passage across obstacles.	Open and shallow habitats but will use these during migration to reach spawning gravels. Habitats upstream of significant obstructions.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Increased significance of barriers to impede migration as a result of decreased flows
			Deterioration in water quality
Brook lamprey *Lampetra planeri*			
Spawning	Clean, unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth

	Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.		Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	Cover (stones and vegetation) in the vicinity of spawning gravels.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
River lamprey *Lampetra fluviatilis*			
Spawning	Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	Suitable estuarine conditions, that is free from pollution and with suitable prey species available. Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.	Areas with significant pollution or limited prey availability. Habitats upstream of significant obstructions.	Increased significance of barriers to impede migration as a result of decreased flows
			Increased risk of entrainment into water intake
			Deterioration in water quality
Sea lamprey, *Petromyzon marinus*			
Spawning	Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed

	estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.		Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	Suitable estuarine conditions, that is free from pollution and with suitable prey species available. Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.	Areas with significant pollution or limited prey availability. Habitats upstream of significant obstructions.	Increased significance of barriers to impede migration as a result of decreased flows
			Increased risk of entrainment into water intake
			Deterioration in water quality
Bullhead, *Cottus gobio*			
Spawning	Coarse, hard substrate of gravel and stones.	Deep, silty watercourses with high flow velocities and little or no cover.	Deposition of silt
			Reduction in velocity, depth and/or wetted width
			Increased water velocity and depth
Nursery	Shallow, stony riffles		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adult	Sheltered sections created by woody debris, tree roots, leaf litter, macrophyte cover or larger stones.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
European eel, *Anguilla anguilla*			
Juvenile (<30cm)	Wetland habitats within 30km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.	Low productivity watercourses with dominance of coarse substrates and low macrophyte cover and diversity. Habitats upstream of significant obstructions.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake

			Deterioration in water quality
Adult (>30cm, female >45cm)	Deep, slow flowing watercourses and wetland habitats within 80km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased significance of barriers to impede migration as a result of decreased flows
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Barbel *Barbus barbus*			
Spawning	Run/glide flow Less than 50cm deep Velocities greater than 0.5m/s Substrate composed of clean and uncompacted gravel	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	Marginal shallow bays set back from or within margins of main channel Depths between 1cm and 30cm No discernible to minimal flow Substrate composed of >30% gravel and sand with low silt content Lack of or very little riparian shading		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	Commonly associated with stretches of clean gravel and macrophyte beds, showing a preference to relatively fast-flowing stretches in the middle reaches of large rivers. The species also occupies deep water habitats at the foot of weirs, in the lee of large woody debris, rock ledges or other obstructions on the river bed.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Impedance to movement upstream
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
			Increased water velocity and depth

Depressed river mussel *Pseudanodonta complanata*			
All life stages	Fine sediments of lowland rivers and canals,	High velocity watercourses with coarse substrates.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
White-clawed crayfish *Austropotamobius pallipes*			
All life stages	Slow-flowing sections of stony rivers Boulder riffles in chalk or clay streams Submerged tree roots Debris dams Crevices in old or damaged submerged brickwork, stonework, cracked concrete or rotten wooden structures Un-mortared stone revetting which protects banks from erosion Stands of submerged and emergent aquatic plants Old gravel workings and chalk pits Good water quality	Uniform clay channels Areas of deep or soft silt Dense filamentous algae Narrow fast-flowing channels Areas of sand and gravel, or bedrock, which are lacking in cobble or boulder (though they may feed in or commute through these areas) Pebble or cobble shingle regularly exposed by changing river levels Areas of armoured bed where the substrate is compacted by the river flow Acidic streams or ochreous drainage Poor water quality or salinity	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Transfer of non-native species or disease
			Deterioration in water quality