Dŵr Cymru Welsh Water

Environmental Assessment of Crai Reservoir Drought Order (8201-1)

Final

March 2019

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NON-TECHNICAL SUMMARY

INTRODUCTION AND PURPOSE OF THIS REPORT

Welsh Water's Drought Plan provides a comprehensive statement of the actions Welsh Water will consider implementing during drought conditions to safeguard essential water supplies to customers and minimise environmental impact. It encompasses a number of drought management options that will only be implemented if and when required and includes drought permit / order options.

A drought permit or order is a management action that, if granted, can allow more flexibility to manage water resources and the effects of drought on public water supply and the environment.

The objective of this report is to provide an independent and robust assessment of the potential environmental effects of implementing a drought order at Crai Reservoir, over and above those arising due to natural effects of drought and those which would occur under "normal" abstraction licence conditions.

Crai Reservoir is located in the Tywi WRZ. The Tywi WRZ extends from the Vale of Glamorgan in the east, to the west of Camarthenshire, and northwards past Llanwytrd Wells.

Water from Crai reservoir discharges into the Afon Crai, a tributary of the River Usk. Both rivers are components of the River Usk Tributaries SSSI and SAC therefore consideration has been given to the potential impacts of drought order implementation on the features and species of these designated sites.

The assessment also considers how the proposed drought order may affect the environment in combination with the effects of other existing abstraction licences, environmental permits and other drought management plans.

This report is a 'shelf-copy' report which would be updated to support an application to the Welsh Ministers for a drought order at Crai Reservoir, which may be required by Welsh Water in the future.

PROPOSED DROUGHT ORDER DETAILS

In order to protect public water supplies within Welsh Water's Tywi WRZ in the event of a future severe drought, Welsh Water would make an application to Welsh Ministers for a drought order to vary the conditions of abstraction Crai reservoir.

If granted, the drought order involves a proposed reduction in the statuatory compensation release flow from Crai Reservoir to the Afon Crai from 6.82Ml/d to

3.4Ml/d. This flow reduction will conserve the longevity of reservoir storage for direct supply to Welsh Water's customers during an environmental drought and also improve the probability of winter refill of the reservoir. The drought order will influence the Afon Crai and may influence the upper River Usk.

The drought order is most likely to occur during the summer to winter period, and is considered not to extend outside the period August to November. This has been confirmed by Welsh Water's water resources modelling.

The revised abstraction arrangements would legally be authorised for four months but would be removed sooner if water resources have returned to adequate levels to safeguard future water supplies, as agreed with the Welsh Ministers / Natural Resources Wales (NRW).

NEED FOR THE DROUGHT ORDER

Application for a drought order is a precautionary approach. Due to the time needed to determine a drought order application, Welsh Water will potentially apply for a drought order more frequently than it will be used.

The justification for the drought order sought will be set out in a "Needs Statement". This will be produced by Welsh Water at the time of a potential future application and will form part of the full drought order application.

ALTERNATIVE SOURCES CONSIDERED

Details of alternative sources considered by Welsh Water will be completed at the time of application for the drought order at Crai Reservoir. This will demonstrate justification for the proposed drought option details applied for.

POTENTIAL IMPACTS OF DROUGHT ORDER IMPLEMENTATION

The scope of the assessment has been defined by a screening and scoping exercise.

Summary of the Hydrological Assessment

The assessment has concluded that there is a **major** impact on flows in the Afon Crai as a result of implementing the drought order. Impacts on the River Usk have been assessed as **minor** during August to September, and **negligible** during October to November. These hydrological impacts are assessed as leading to **moderate** impacts on the physical environment of the river, including water quality.

Summary of the Environmental Features Screening

Environmental assessment is required and included for features where screening has

identified a major or moderate impact.

Screening identified designated sites, WFD status and Community Assessment / Environment (Wales) Act Section 7 Species, landscape, archaeology and recreation as environmental features for which an environmental assessment was required.

The assessment has concluded that during periods when there is a reduction in total flow release from Crai Reservoir to the Afon Crai there are **major** to **moderate** impacts on the River Usk (Upper Usk) SSSI, fish, **moderate** to **minor** impacts on macroinvertebrates and phytobenthos and **moderate** to **negligible** impacts on macrophyte.

The HRA Screening could not conclude that implementation of a drought order would not result in likely significant effects on the brook and river lamprey, Atlantic salmon and bullhead populations within the River Usk SAC

Cumulative Impacts

No cumulative effects of implementing the drought order with other existing licences, consents and plans are currently anticipated. However, this should be reviewed at the time of any future application for a drought order at Crai Reservoir.

MITIGATION AND MONITORING

The environmental assessment has identified significant impacts of implementation of a drought order at Crai Reservoir. Consequently, in line with the DPG, an Environmental Monitoring Plan has been proposed. Potential mitigation measures have also been proposed and further discussion with NRW is required in order to develop suitable mitigation measures.

CONCLUSIONS

In summary, it has been concluded that the environmental effects on river flows, water quality and ecology of implementing a drought order at Crai Reservoir during August to November inclusive, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **major.**

Contents

1 INTRODUCTION

1.1 PURPOSE OF THE ENVIRONMENTAL ASSESSMENT

The objective of this Environmental Assessment Report (EAR) is to provide an independent and robust assessment of the potential environmental effects of the implementation of a drought order by Dŵr Cymru Welsh Water (Welsh Water) to reduce the total flow release from Crai Reservoir to the Afon Crai by 3.4Ml/d. Water stored at Crai Reservoir is used to provide public water supplies to Welsh Water's Tywi Water Resource Zone (WRZ) (see Section 2.1).

This EAR is a 'shelf-copy' report which would be updated in the event that Welsh Water needs to make an application during any future drought to Natural Resources Wales (NRW) for a drought order at Crai Reservoir. A drought order is a management action that, if granted, can help ensure essential water supplies are maintained to homes and businesses. The circumstances under which a drought order may be required is set out in the Welsh Water Drought Plan.

The assessment presented in this EAR considers the effects of implementation of the drought order over the months of August to November inclusive, the period for which Welsh Water has determined it might require a drought order for this water source. The purpose of the assessment is to determine the environmental impacts of the drought order over and above any effects arising from natural drought conditions.

The study area and focus of this environmental assessment of the Crai drought order, covers the following waterbodies:

- Afon Crai (GB109056033080) - source to River Usk confluence
- River Usk (GB109056039980) - confluence Afon Hydfer to confluence Afon Senni
- River Usk (GB109056040081) - Usk –Afon Senni confluence to Afon Crawnon confluence

This EAR includes discussion of the following:

- an assessment of the likely changes in river flow / water level regime due to implementing the proposed drought order (**for a summary, see Section 4 of this report**)
- identification of the environmental features that are sensitive to these changes and an assessment of the likely impacts on these features (**see Section 5 of this report**)
- identification of mitigation measures that may be required to prevent or reduce impacts on sensitive features (**see Section 6 of this report**)

- recommendations for baseline, in-drought and post-drought order monitoring requirements (**see Section 10 of this report**).

The environmental assessment has been conducted in accordance with Government regulations and using the Welsh Government / Natural Resources Wales Drought Plan Guideline[1] (DPG); specifically Section 5 and Appendices I and J, and Welsh Government / Defra / NRW / Environment Agency guidance on drought permits and drought orders[2].

Consideration has been given to the potential impacts of drought order implementation on statutory designated sites, including those designated under international law (Habitats Directive, Birds Directive and the Ramsar Convention) and national legislation (notably Sites of Special Scientific Interest (SSSIs).

In accordance with the DPG, the assessment also considers how the proposed drought order may affect the environment in combination with the effects of existing abstraction licences, environmental permits and other relevant activities and plans. This is discussed further in Sections 3 and 7.

1.2 SUPPORTING STUDIES

The DPG identifies in Section 5.4 that EARs are required as supporting documents to any drought permit or drought order application. The circumstances for which an environmental assessment is required are set out in **Box 1** below.

Box 1: Drought Plan Guidance - requirement for environmental assessment

The DPG requires that all features that could be affected by implementation of a drought order /permit are listed in the EAR and that an assessment is made of how sensitive each feature is to the likely changes in hydrology, hydrogeology and geomorphology, due to implementing the drought order /permit.

The DPG requires a detailed environmental assessment for applications where sensitive features are likely to be subject to a major or moderate impact, or a minor impact where this applies to environmentally designated features. Further environmental assessment is **not** required for those drought orders / permits where there is certainty that there are no such impacted sensitive features.

This environmental assessment is based on data available at the time of writing and includes the environmental features and data types determined by Box 1 in Appendix I of the DPG (except where these are considered not to be relevant to this drought

[1] Natural Resources Wales (2017) *Water Company Drought Plan Technical Guideline*. Available at https://cdn.naturalresources.wales/media/684414/final-wc-drought-plan-guidance-2017.pdf?mode=pad&rnd=131656713580000000, Accessed 04 February 2019.
[2] Welsh Government / Defra / Natural Resources Wales / Environment Agency (2015) *Apply for a drought order or emergency drought order*, https://www.gov.uk/government/collections/apply-for-a-drought-permit-drought-order-or-emergency-drought-order Accessed 21 December 2018.

order). Data were requested from key consultees (including NRW).

Where appropriate, this report also identifies areas where there are deficiencies in data availability and makes recommendations for future data / information gathering and monitoring. Welsh Water will continue to engage closely with NRW to ensure that adequate and sufficient data / information are collated and kept up-to-date in subsequent years to inform future environmental assessments.

1.3 CONSULTATION

Consultation is identified as an essential exercise in the preparation of the EAR. In preparing this 'shelf-copy' EAR for a drought order at Crai Reservoir, consultation with regulators and wider stakeholders has been undertaken to gain feedback on potential adverse effects, gather data and discuss any required monitoring and / or mitigation measures.

Further consultation will be also be undertaken at the time of any future applications for the drought order.

1.4 STRUCTURE AND CONTENT OF THE REPORT

This EAR comprises the following sections:

Section 1: Introduction

Section 2: Background to the Drought Order

Section 3: Approach

Section 4: Hydrology and the Physical Environment

Section 5: Environmental Features Assessment

Section 6: Mitigation

Section 7: Cumulative Impacts

Section 8: Summary of Residual Impacts

Section 9: Impacts on Statutory Designated Sites

Section 10: Environmental Monitoring Plan (EMP)

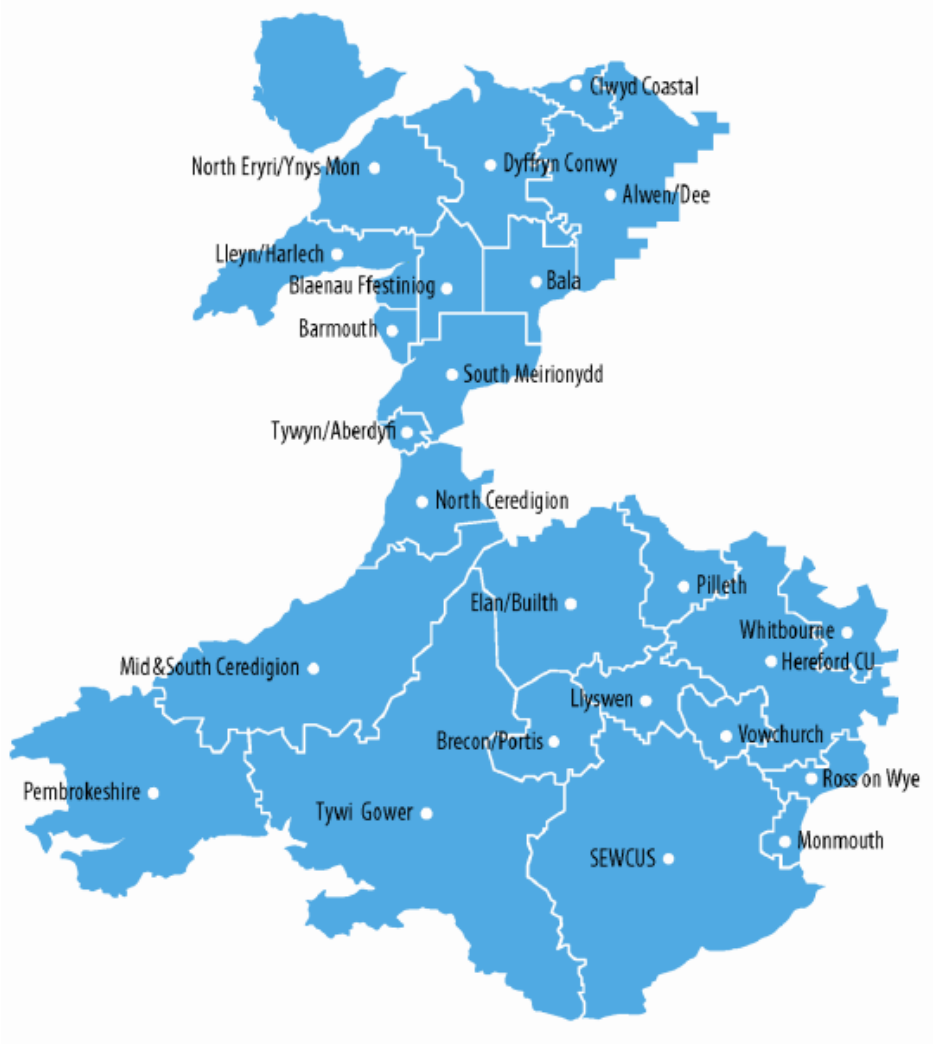
Section 11: Conclusions

2 BACKGROUND TO THE DROUGHT ORDER

2.1 WELSH WATER'S SUPPLY SYSTEM

Welsh Water supplies water to more than 3 million people. The Welsh Water supply area covers the majority of Wales and a small part of England. It is split into 24 WRZ's (see **Figure 2.1**).

Figure 2.1 Welsh Water Water Resource Zones

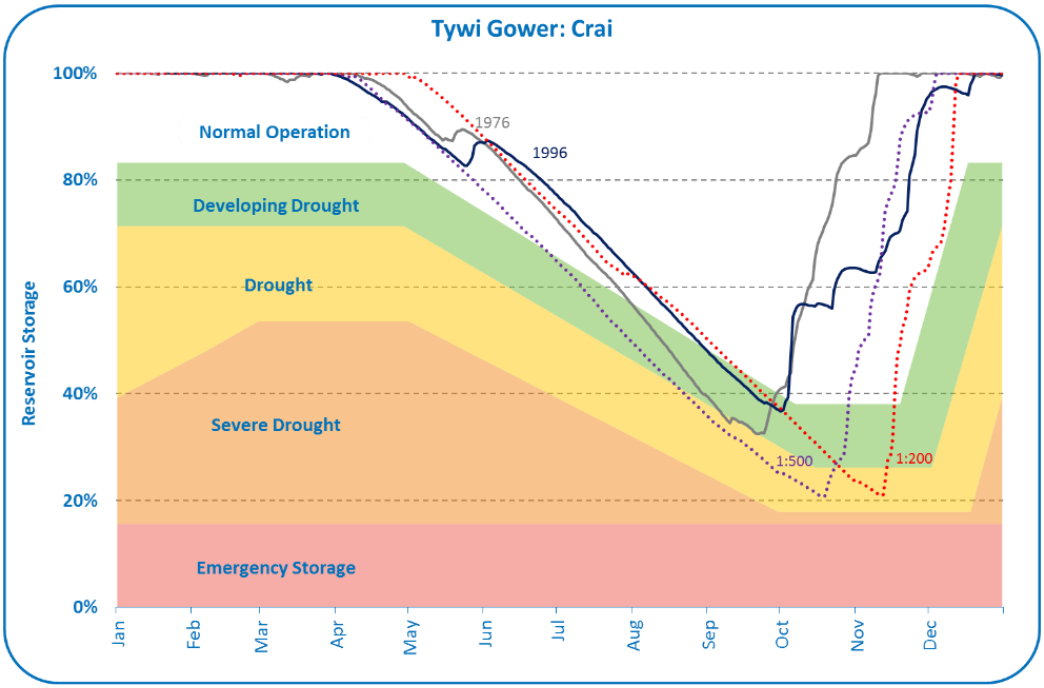


Crai Reservoir is located in the Tywi WRZ. The Tywi WRZ extends from the Vale of Glamorgan in the east, to the west of Camarthenshire, and northwards past Llanwytrd Wells.

The trigger levels for applying for a drought order at Crai are based on water levels in Crai Reservoir falling below a defined threshold level as shown in **Figure 2.2** (orange shading labelled 'severe drought'). Welsh Water's assessment in its draft Drought Plan 2020 indicates that drought conditions severe enough to require an application for this drought option are unlikely to occur more frequently than at a return period of around

once every 200 to 500 years. Fuller details of the work undertaken to assess this risk are provided in Annex 1 to the draft Drought Plan 2020

Figure 2.2 Tywi WRZ : Crai Reservoir Drought Action Zones and Historic Droughts



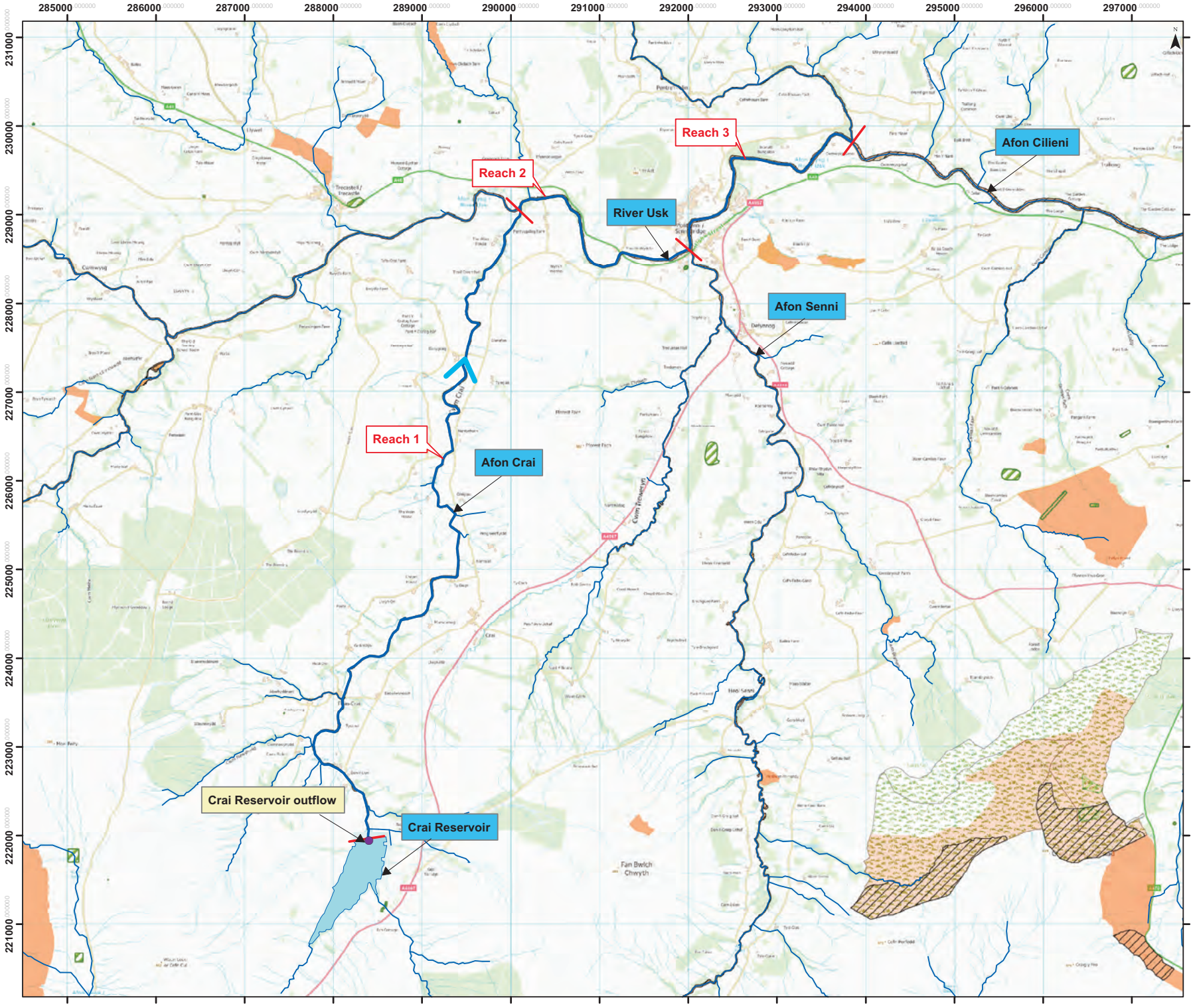
2.2 DESCRIPTION OF EXISTING ARRANGEMENTS AT CRAI RESERVOIR

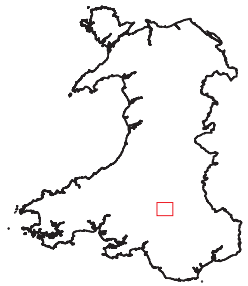
Welsh Water's licence (number 20/56/53/0002) to abstract water under the Water Resources Act at Crai Reservoir includes the following conditions:

- 15,774 million litres (Ml) authorised to be abstracted per annum.
- At an abstraction rate not exceeding 43.2Ml/d.
- Provision of a uniform statutory compensation water discharge of 6.82Ml/d at all times.

The abstraction for potable supply is made directly from the reservoir and piped by gravity to Crai Water Treatment Works (WTW) for treatment. Distribution is by mains to towns in the Tawe valley and north Swansea, with overlap into the Felindre zone.

The study area is illustrated on **Figure 2.3**.





Legend

- Abstraction
- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- Special Area of Conservation
- National Nature Reserve
- Scheduled Ancient Monuments
- Site of Special Scientific Interest

RICARDO

Dŵr Cymru Welsh Water

1:40,000

Note: All locations are approximate

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Study Area: 8201_1 Crai Reservoir

Figure Number: Figure 2.3

Date: February 2019

2.3 WELSH WATER'S DROUGHT PLANNING PROCESS

Water companies in England and Wales are required to prepare and maintain Statutory Drought Plans under Sections 39B and 39C of the Water Industry Act 1991, as amended by the Water Act 2003, which set out the management and operational steps a water company will take before, during and after a drought. The Water Industry Act 1991 defines a drought plan as '*a plan for how the water undertaker will continue, during a period of drought, to discharge its duties to supply adequate quantities of wholesome water,* with *as little recourse as reasonably possible to drought orders or drought permits*'.

The Drought Direction (Wales) 2017 states that revised Drought Plans should be submitted according to the following schedule:

> *4(b) for a revised drought plan –*
>
> *if section 39B(6)(a) of the Act applies, within 6 months after the date on which the material change of circumstances occurs; and*
>
> *if section 39B(6)(c) of the Act(c) applies, no later than 4 years after the date on which its drought plan, or its last revised drought plan, is published.*

2.4 STATEMENT OF THE NEED FOR DROUGHT ORDER

This section will be completed at the time of application for a drought order.

2.5 DROUGHT ORDER– REGULATORY ARRANGEMENTS

In periods of unusually low rainfall, when water resources become scarce, the Water Resources Act 1991, as amended by the Environment Act 1995 and the Water Act 2003, allows for three mechanisms for temporarily augmenting water supplies from rivers, lakes, reservoirs and groundwaters: drought permits; ordinary drought orders; emergency drought orders.

Drought permits are granted by NRW, and allow a water company powers to abstract from specified water sources, or to modify or suspend the conditions set out in existing abstraction licences. Drought orders are granted by the Welsh Ministers and give powers either to a water company or to NRW to abstract from specified water sources, or to modify or suspend the conditions set out in existing abstraction licences, but also to allow the discharge of water to specified places, modify or suspend conditions relating to a discharge or prohibit or limit particular non-essential uses of water as set out in the Drought Plan (Wales) Direction 2017. Emergency drought orders grant the same powers as a drought order, but in addition, confer powers to prohibit or limit water uses as specified by the water company and allow the set up and supply of water by means of standpipes and/or water tanks or rota cuts.

Drought permits and orders may be granted for a period of up to six months and they can be extended for up to a further six months.

As part of the drought order/permit application process, water companies are required to prepare an Environmental Report setting out anticipated effects of the proposal, including the effect on other abstractors and sufficient information to inform assessments, where applicable, in relation to the Habitats Directive, Countryside and Rights of Way Act (CRoW), and the Water Framework Directive (WFD).

Further information on the requirements for the environmental assessment and reporting according to legislation and national guidance are provided in Section 3.

2.6 REVIEW OF ALTERNATIVE OPTIONS

This section will be completed at the time of application for a drought order, setting out the alternative options to the drought order that Welsh Water has considered in addressing the risks to essential public water supplies due to drought.

2.7 PROPOSED DROUGHT ORDER DETAILS

In order to protect essential public water supplies within Welsh Water's Tywi WRZ in the event of a future severe drought, Welsh Water may need to make an application to NRW for a drought order to vary the conditions of its abstraction licence from Crai Reservoir.

If granted, the drought order involves a proposed reduction in the statutory compensation release from Crai Reservoir to the Afon Crai from 6.82Ml/d to 3.42Ml/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought, and improve the probability of reservoir winter refill. The drought order scheme will influence the downstream Afon Crai and may influence the upper River Usk.

The timing of the reduction in the compensation release is most likely to occur during the period from August to November inclusive. This is based on modelling of Crai Reservoir performance under normal operating conditions, together with Welsh Water's experience of operating the source.

Table 2.1 Crai Reservoir Existing and Proposed Drought Order Abstraction

Abstraction Water Source	NGR	Normal Abstraction	Proposed Drought Order Abstraction	Benefit Ml/d
Crai Reservoir	SN 88483 21358	Welsh Water's licence (number 20/56/53/0002) to abstract water under the Water Resources Act at Crai Reservoir (see Figure B1.1) includes the following conditions: • 15,774 million litres (Ml) authorised to be abstracted per annum. • At an abstraction rate not exceeding 43.2Ml/d. • Provision of a uniform statutory compensation water discharge of 6.82Ml/d at all times. The abstraction for potable supply is made directly from the reservoir and piped by gravity to Crai Water Treatment Works (WTW) for treatment. Distribution is by mains to towns in the Tawe valley and north Swansea, with overlap into the Felindre zone.	The drought order involves a proposed reduction in the statutory compensation release from Crai Reservoir to the Afon Crai from 6.82 Ml/d to 3.42 Ml/d.	3.4 Ml/d

[Note: it will probably be necessary to remove the NGR for any public domain version]

2.8 DROUGHT ORDER PROGRAMME

Drought orders may remain in force for a period of up to six months, and they can be extended for up to a further six months. However, the period of implementation for this drought order is restricted to August to November, as confirmed by water resources modelling carried out by Welsh Water.

Prevailing weather conditions and rainfall in the intervening period may delay the requirement for applications, or even result in no requirement to apply. An order may be granted but not actually implemented if weather conditions improve or, equally, the order may only be partially implemented.

2.9 DROUGHT ORDER BASELINE

It is important for the assessment to establish the environmental "baseline" conditions that would exist in drought conditions but in the absence of the drought order being implemented. For the purposes of this assessment, the "without drought order" baseline includes the continuation of abstraction from Crai Reservoir in accordance with the abstraction licence conditions, including the continuation of a daily compensation release of 6.82Ml/d from Crai Reservoir whenever regulation releases are not occurring. The assessed drought order involves a reduction of 3.4Ml/d in the total flow release (either compensation or regulation) from Crai Reservoir to the Afon Crai.

3 APPROACH

3.1 INTRODUCTION

The DPG states that the environmental report must include:

i. the likely changes in flow, level, channel/riparian form and sediment due to implementing the action;
ii. the features that are sensitive to these changes;
iii. potential impacts on sensitive features;
iv. a plan of baseline, in-drought and post-drought monitoring; and
v. mitigation or compensation measures that may be required

Items i and ii above were subject to an initial screening process as part of the scoping exercise. Section 3.2 below describes the approach taken. This has provided the relevant study area and a list of features scoped into the environmental assessment which are the subject of this EAR.

Section 3.3 describes how the environmental assessment has been undertaken, including discussion of the general approach, guidance used, provision of data, assessment methodologies and consideration of mitigation and monitoring. Limitations to the environmental assessment are described in Section 3.4, 4 and 5.

To set the context of the studies, it should be noted that EAR considers the environmental impacts of implementing a drought order during the worst environmental conditions (natural drought) that the order could be implemented in.

In accordance with the DPG and the Habitats Regulations, the assessment considers how the proposed drought order may affect the environment in combination with the effects of other existing abstraction licences, environment permits and other plans. This includes assessment of the potential cumulative effects of the following:

- Welsh Water's existing abstraction licences that operate within the hydrological zone of influence of the drought option, as well as other abstraction and discharge consents
- Assessment of cumulative impacts of the drought order with other Welsh Water supply side and drought permit / order options within the hydrological zone of influence (including both intra- and inter- zone options)
- Other plans and projects of relevance, including:
    - Welsh Water's WRMP schemes which are scheduled to be implemented and become operational within the time period of the revised Drought Plan (i.e. before 2025)

- Drought options from other neighbouring water company Drought Plans, Natural Resource Wales Drought Plans
- National Policy Statements for Wastewater and Renewable Energy Infrastructure.

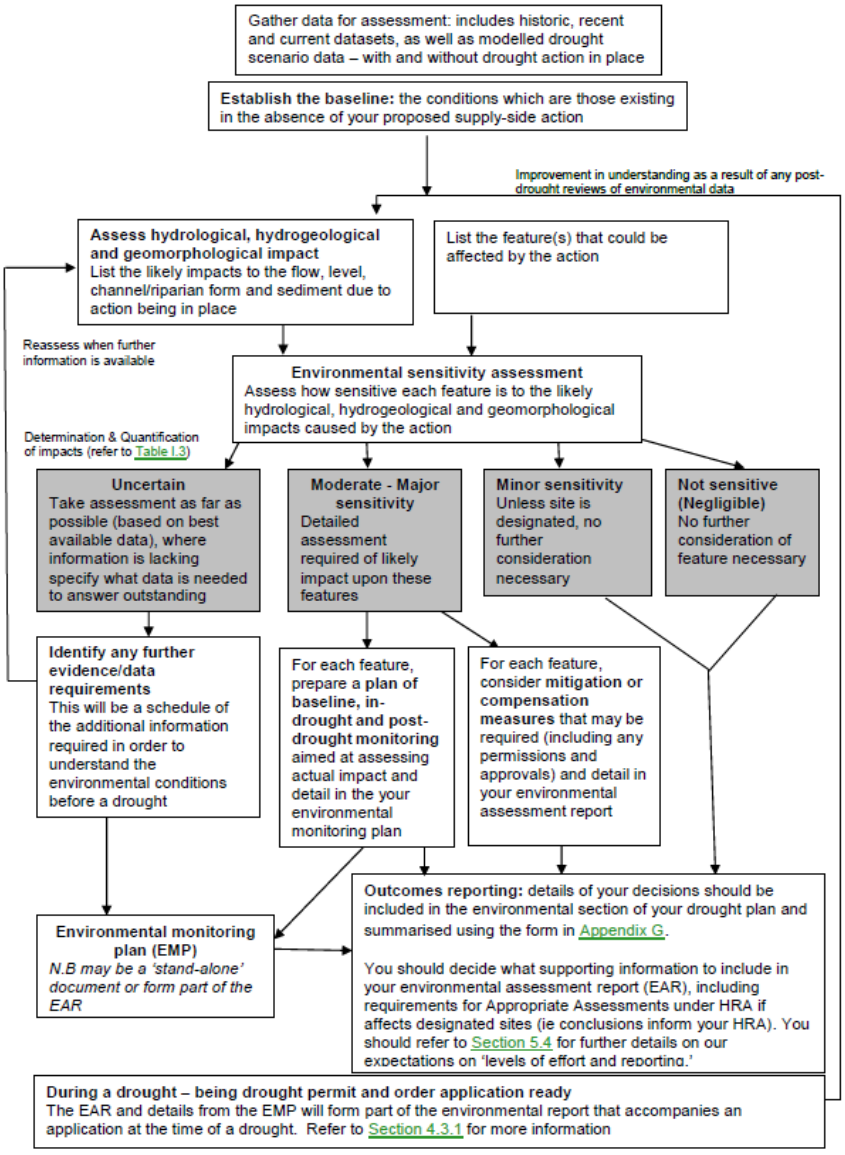
This is discussed further in Section 7.

3.2 APPROACH TO SCREENING AND SCOPING

3.2.1 Screening

Screening was undertaken using the DPG; specifically Section 5 and Appendix I. Figure 2 of the DPG (replicated in **Figure 3.1** below) identifies the environmental impact activities required.

Figure 3.1 Environmental Impact Activities Identified in the Drought Plan Guideline



The screening fulfils the requirement to "Assess how sensitive each feature is to the likely hydrological, hydrogeological and geomorphological impacts caused by the action". Stage 1 (hydrological impact) fulfils the requirement to "List the likely impacts to the flow, level, channel/riparian form and sediment due to action being in place". Stage 2 (environmental sensitivity) fulfils the requirement to "list the feature(s) that could be affected by the action" and to "Assess how sensitive each feature is to the likely hydrological, hydrogeological and geomorphological impacts caused by the action"

It is important to acknowledge the basis of the assessment; i.e. impacts of drought order implementation should be considered in the context of what would occur without drought order implementation (see Sections 2.2, 2.7 and 2.9).

The approach to undertaking Stages 1 and 2 is described below.

Stage 1 – Hydrological and Hydrogeological Impact

Consideration is required (by the DPG) of the likely impacts on the hydrology, hydrogeology and geomorphology of every river reach, wetland or lake area influenced by the proposed drought management action, specifically:

- identify the drought conditions which trigger the proposed action;
- identify any changes that the action is likely to bring about, specifying their length, severity and location in relation to existing natural and artificial features;
- describe the likely conditions in the absence of the proposed action;
- describe how the likely conditions would differ with the action in place compared to the same (or analogous) watercourse under natural conditions; and
- identify the extent of the area affected by the planned actions.

The hydrogeological and hydrological information is used together with information on the other environmental features in the study area from Stage 2 - Environmental Sensitivity (see below) to identify the environmental risk of implementing the drought order.

Although the DPG informs the hydrometric data to be used as part of environmental features for consideration within the environmental assessment (see Box 1 Appendix I of the DPG), it does not provide a methodology for identifying the hydrological impact. A bespoke assessment has therefore been undertaken.

The full hydrological assessment approach is set out in **Appendix A**.

The output from these studies provides an understanding of the scale of change in the

hydrological characteristics as a result of implementing the drought order. Where changes have been identified, the potential significance of adverse or beneficial impacts has been assessed.

Quantitative and qualitative measures have been used to grade the impacts on surface waters. The assessment has identified the potential severity of impact based on the following criteria:

- **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 covered as part of the magnitude consideration.
- **Magnitude** – the magnitude of the impact is identified as**:**
  - *High*: There is a long-term large-scale (i.e. catchment) change in the physical environment.
  - *Medium*: There is a short-term large-scale change or long-term short-scale (i.e. reach) change in the physical environment, however, no changes in the overall integrity of the physical environment.
  - *Low*: There is a short-term small-scale change in the physical environment, but its overall integrity is not impacted.
  - *Negligible*: No perceptible change in the physical environment.
- **Duration** – the duration of impact is considered to be for 6 months, which is the duration for which a drought option is implemented, unless otherwise stated.
- **Reversibility** – all hydrological impacts are considered to be reversible**.**
- **Timing and Frequency** – the drought option could be implemented at any point in the year, unless otherwise stated. The assessment is based upon the operation of a single drought order, with subsequent applications for a drought order required to consider cumulative effects of multiple drought order.
- **Probability** – all impacts are considered to be probable, unless otherwise stated.

The hydrological impact assessment is described fully in **Appendix B**.

Section 4 provides a summary of the hydrology and physical environment assessment as a result of implementing a drought order at Crai Reservoir.

Stage 2 - Environmental Sensitivity

With the extent and level of flow impact mapped, using GIS and other data sources, potentially sensitive receptors (sites / features) located within the extents of impact have been identified. Potentially sensitive features investigated in the screening have been drawn from Box 1 in Appendix I of the DPG. These include:

- designated biodiversity sites (Local Nature Reserve (LNR), National Nature Reserve (NNR), Marine Protected Areas, National Parks, Areas of Outstanding Natural Beauty (AONB), SSSI, Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar) and Environment (Wales) Act Section 7 species / habitats which are located on or within 500m of the impacted reaches;
- protected species;
- ecological communities (fish, bryophytes & lichen, macro-invertebrates, macrophytes, algae) and, where identified, Water Framework Directive (WFD) status of designated waterbodies which contain the impacted reaches;
- invasive non-native species;
- sensitive ecological features as advised by NRW;
- wider features which should be taken into account in determining the potential impacts of drought option implementation – specifically socio-economic & health, amenity & aesthetics, recreation, navigation, architectural & archaeological heritage.

Each of the identified sensitive receptors within the extent of impact have been listed, alongside a brief summary of their potential susceptibility to flow impacts. For designated sites, this has included an indication as to whether the sites have water dependent qualifying interests.

The environmental sensitivity of each site has been identified according to the ecological and nature conservation interests of the area and, in particular, the proximity of and / or connectivity with the designated protected area. Each site has been assessed according to whether the extent of hydrological influence includes or is considered to affect a designated or protected site. Designated or protected sites outside the extent of hydrological influence are considered not to be influenced by the drought order.

The outcome of Stage 1 and Stage 2 of the screening exercise are presented in Sections 4 and 5 respectively.

3.2.2 Scope

The screening exercise establishes the study area for the Crai Reservoir drought order together with identification of relevant, sensitive environmental features within those study areas (based on the risk of them being impacted by the drought order during the period of its operation).

As set out in **Figure 3.1**, the environmental sensitivity screening identifies the outcome for each listed feature. Four outcomes are possible from the screening: uncertain; moderate-major sensitivity; minor sensitivity; not sensitive (negligible);

and identifies appropriate next steps. Sections 4.2 and 5.2 present the findings which show that a number of features were identified as either: 1) uncertain; 2) moderate-major sensitivity; or 3) minor sensitivity in a designated site and in accordance with the DPG are features for which further assessment work will be required. These features alone form the scope of monitoring, environmental assessment, and consideration of mitigation actions.

The DPG states that environmental assessment, mitigation and / or monitoring is not required for features where screening has identified a minor (unless a site is designated) or negligible impact. However, the requirement for assessment, monitoring and / or mitigation has been reviewed on a case-by-case basis. In some cases, mitigation and / or monitoring has been recommended where minor impacts are identified, where considered appropriate on a precautionary basis.

3.3 APPROACH TO ASSESSING IMPACTS, MITIGATION AND MONITORING

3.3.1 General Approach

The assessment approach is in accordance with legislation, national regulations and guidance, including:

- NRW (2017) Water Company Drought Plan Technical Guideline (DPG)
- Welsh Ministers (2017) The Drought Plan (Wales) Direction
- Institute of Environmental Management and Assessment (2004) Guidelines for Environmental Assessment
- Chartered Institute of Ecology and Environmental Management (CIEEM) (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland[3]
- UKWIR (2007, updated 2012) Strategic Environmental Assessment – Guidance for Water Resources Management Plans and Drought Plans. Prepared by Cascade Consulting
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)
- Council Directive 2009/147/EC of 30 November 2009 on the conservation of wild birds
- The Convention on Wetlands of International Importance especially as Waterfowl Habitat , December 1975
- Conservation of Habitats and Species Regulations 2017

[3] CIEEM, Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial. Freshwater and Coastal. September 2018.

- The Countryside and Rights of Way Act 2000.

All aspects of the drought order of potential environmental significance are considered in the environmental assessment.

The DPG states that a water company should clearly show what evidence and data have been used in decision making, that uncertainties should be identified, and which additional data requirements are provided for through the environmental monitoring plan.

In accordance with the DPG the approach to the assessment addresses the following: i) potential effects on each sensitive receptor; ii) definitions for impacts (adverse / beneficial); iii) the data requirements; iv) assessment methodology (including the treatment of uncertainty where the complete data requirements are not available).

This EAR presents the environmental baseline, i.e. habitats and environmental pressures (including flow and water quality) in the study identified zone of hydrological influence without the drought order in place, utilising a description of the catchment, geomorphology, anthropogenic features and water quality. Key changes to the physical environment as a result of implementing the drought order have been identified and described and, where appropriate, this information is used to frame and support the assessments of features which have been scoped in further to the screening and scoping exercise (see Section 3.2).

3.3.2 Assessment Methodologies

The aim of the Environmental Assessment is to provide:

- A clear summary of the outcome of each assessment (per feature) from which NRW can readily identify the significance of the impact when determining the drought order application
- Identification of those predicted impacts which are to be taken forward to consider additional monitoring and mitigation actions.

The assessment considers the environmental impacts of implementing the drought order against baseline operating conditions of Welsh Water's abstraction licence in advance of drought order implementation. Environmental sensitivity has been assessed considering the context of the timing of drought order implementation. **It is important to acknowledge the basis of the assessment; i.e. impacts of drought order implementation are assessed against what would occur without drought order implementation**.

The impact assessment for sensitive features is feature specific and is dependent on the availability and resolution of available data. Where possible, quantitative assessments have been undertaken. However, for many features, it is acknowledged

that the assessments are qualitative and based on professional judgement, and using, where relevant, experience of local knowledge and reference to literature. This introduces uncertainty into the impact assessment. A precautionary approach has been used to assigning impact significance where data are absent or found not to be robust.

The assessment of impacts on designated sites has been undertaken using professional judgement with reference to conservation objectives and condition status of habitats and species, for which a site has been designated. The ecological assessment has been undertaken recognising the IEMA[4,5] and the CIEEM study guidelines[6]. The assessment of impacts on other environmental receptors e.g. recreation and landscape has been carried out largely by qualitative expert judgement.

Assessment of impacts on specific features has then been undertaken. Specific assessment methodologies have been developed for key environmental features. These are set out in **Appendix C** (assessment methodologies for the ecological assessment of Environment (Wales) Act Section 7 species, designated sites and other flora and fauna).

Other abstractors, including other water company abstractions, are features that have been reviewed within the assessment. This has been undertaken to determine whether other abstractors could potentially be affected by changes to surface water flows and levels as a result of implementation of the drought order.

3.3.3 Mitigation and Monitoring

Section 5.3 of the DPG identifies the specific requirements for mitigation of serious impacts on the environment as a result of implementing a drought management measure. The assessments undertaken in this EAR confirm the features requiring consideration of mitigation and appropriate monitoring triggering mitigation. Appropriate mitigation actions identified are both available and practicable.

The DPG also identifies the specific requirements for monitoring. The assessments undertaken in this EAR inform the features requiring consideration for monitoring prior to, during, or after implementation of the drought order.

The mitigation and monitoring proposals (see Sections 6 and 10) will act as a safeguard that responds and is responsive to both predicted and unpredicted drought impacts. Future data collection and monitoring can then be focused to identify the aquatic ecosystem interaction to better quantify the potential impacts where gaps in the evidence base are identified and ensure the appropriate targeting of monitoring and

[4] IEMA (2004) Guidelines for Environmental Impact Assessment.
[5] IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK
[6] CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland.

mitigation response. The EMP will need to be finalised in agreement with NRW.

3.4 LIMITATIONS OF THE ASSESSMENT AND UNCERTAINTIES

The DPG states that a water company should clearly show what evidence and data have been used in decision making, that uncertainties should be identified, and which additional data requirements are provided for through the environmental monitoring plan.

The assessment presented in this document draws on available information from surveys and investigations undertaken by Welsh Water, NRW, as well as other bodies over a number of years. Reference has also been made to wider studies from published and grey literature, i.e. academic literature that is not formally published, where appropriate.

Specific details are provided on the quality of the data collected and used in the assessment. Where uncertainties remain with respect to the quantification and prediction of impacts, the limitations and any assumptions made are included in the relevant technical sections (Sections 4 and 5).

Overall, it is considered that the conclusions are based on information that is robust and valid at the time of writing. However, it should be noted that this EAR would be updated to support any future actual application, including a review of data.

4 CRAI RESERVOIR DROUGHT ORDER - HYDROLOGY AND THE PHYSICAL ENVIRONMENT

4.1 INTRODUCTION

Consideration of hydrology and the water physical environment sets the context for the potential range of environmental effects of the drought order. **Appendix B** sets out an assessment of the potential impacts on the physical environment of Crai Reservoir during the period of implementation of the drought order. The "without drought order" baseline is set out in Section 2.9.

The water physical environment assessment includes consideration of hydrology and hydrodynamics; geomorphology; and water quality. The assessment has three key objectives:

1. It is used to "list likely changes in flow, level, channel/riparian form and sediment due to implementing the action' as required by the DPG and set out in Figure 2 of the DPG

2. It is used to support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Section 5 of this report

3. Where sensitive features are the physical environment itself, it provides supporting technical information for their screening and assessment.

Each of these are summarised below.

4.2 SUMMARY OF STAGE 1 SCREENING

This fulfils the DPG requirements of Stage 1 of the screening of potential drought order impacts, identifying the likely changes in flow/ level regime due to implementing the drought order. The specific requirements of the DPG are summarised as:

- identify any changes that the drought order is likely to bring about, specifying their length, severity and location in relation to existing natural and artificial features (e.g. flow, water level, channel dynamics and sediment changes);
- describe the likely conditions in the absence of the drought order;
- describe how the likely conditions would differ with the drought order in place compared to the same (or analogous) watercourse under natural conditions; and
- identify the extent of the area affected by your planned actions.

These requirements are addressed in the following sections.

1. The perceived extent of potential impact:

The study area (see **Figure 2.3**) is identified as the Crai Reservoir and the downstream Afon Crai and River Usk catchments.

2. The nature and duration of the potential impact:

A description of the likely conditions with the drought order in place, in comparison to the baseline conditions (absence of the proposed action) is provided in **Appendix B**. Given the conditions of the proposed drought order, the key areas for the assessment of the physical environment have been identified as:

- Change in river flows downstream of Crai Reservoir.

The **Appendix B** assessment has been summarised in **Table 4.1** in terms of the magnitude and duration of each of these potential physical environment impacts.

3. The length of the potential impact:

The **Appendix B** assessment has been summarised in **Table 4.1** in terms of the timing of each of the potential physical environment impacts. The drought order is most likely to occur during the summer and autumn period, considered to not extend outside the period August to November.

4.3 SUMMARY OF POTENTIAL EFFECTS ON THE PHYSICAL ENVIRONMENT

The potential changes to the physical environment (water quality and geomorphology) due to implementation of the drought order are summarised in **Table 4.1.** These impacts are presented in detail in **Appendix B**.

Table 4.1 Summary of Potential Hydrodynamic and Water Quality Impacts of the Drought Order

Afon Crai (Reach 1)	
Flows in the Afon Crai *Major impacts during the period August to November inclusive*	• Up to 50% reduction in low flows at any time of year.
Geomorphology in the Afon Crai *Minor to negligible impacts during the period August to November inclusive*	• Minor impacts on wetted width and bedload transport. • Negligible impacts on suspended sediment.
Water quality in the Afon Crai *Low to Medium during the period August to November inclusive*	• Low risk of water quality deterioration with respect to total ammonia and dissolved oxygen • Moderate risk of water quality deterioration for soluble reactive phosphorus due to history of good standard failure
River Usk (Reach 2)	
Flows in the River Usk *Minor impacts during the period from August to September inclusive; negligible impacts during the period from October to November inclusive*	• Up to 11.6% reduction in summer low flows, with moderate reductions in wetted width / wetted depth, and up to 8.1% reduction in year round low flows
Geomorphology in the River Usk *Negligible impacts during the summer/autumn period*	• Negligible impacts on wetted width and sediment.
Water quality in the River Usk *Low to Medium impacts during the summer/autumn period*	• Low risk of water quality deterioration with respect to total ammonia and dissolved oxygen • Moderate risk of water quality deterioration for soluble reactive phosphorus due to history of good standard failure
River Usk (Reach 3)	
Flows in the River Usk *Minor impacts during the period from August to September inclusive; negligible impacts during the period from October to November inclusive*	• Up to 12.3% reduction in summer low flows, with minor reductions in wetted width / wetted depth and up to 6.3% reduction in year round low flows
Geomorphology in the River Usk *Negligible impacts*	• Negligible impacts on wetted width and sediment.
Water quality in the River Usk *Unquantified risk, assumed medium during the summer/autumn period*	• No water quality data was available at the monitoring sites in this reach • The water quality deterioration risk is assumed moderate due to the influence of Sennybridge STW

4.3.1 Support to the Screening and Assessment of Sensitive Features

The assessment included in **Appendix B** has provided information to support the screening and assessment of sensitive features in Section 5. This includes information on short and long term (acute and chronic) direct and indirect, cumulative, and permanent and temporary effects. The assessment is also specific on the difference between the drought order impacts and the baseline condition without a drought order in place.

4.3.2 Supporting Technical Information for Assessment of any Physical Environment Sensitive Features

As described in Section 5, several sensitive features relate to the physical environment, rather than ecology or human interaction (e.g. landscape, recreation). The assessment included in **Appendix B** has provided supporting technical information for their screening and assessment in Section 5.

5 CRAI RESERVOIR DROUGHT ORDER ENVIRONMENTAL FEATURES ASSESSMENT

5.1 INTRODUCTION

As set out in **Box 1** above, environmental sensitivity screening of the drought order was undertaken in line with the approach recommended by the DPG, and scoping undertaken in line with the methodology described in Section 3.2. The screening and scoping has subsequently been reviewed and refined further to discussions and consultation with NRW (see Sections 1.2 and 1.3). The outcome of this process is described in Section 5.2 which shows that a number of features were identified as either: 1) uncertain; 2) moderate-major sensitivity; or 3) minor sensitivity in a designated site. These features form the scope of environmental assessment, which is further described in Section 5.3.

The features assessment is informed by the assessment of the physical environment presented in Section 4 (which includes hydrology, geomorphology and water quality) and identifies the significance of any potential impacts. Consideration of mitigation actions and monitoring is described in Sections 6 and 10 respectively.

Points of interest referred to throughout the text in Section 5 are indicated on **Figure 2.3**.

5.2 SUMMARY OF STAGE 2 SCREENING AND SCOPING

5.2.1 Designated Sites and Other Sensitive Fauna and Flora

In accordance with the DPG, **Table 5.1** identifies designated biodiversity sites (including LNR, NNR, SSSI, SAC, SPA), Environment (Wales) Act Section 7 species / habitats and other sensitive receptors that could be affected by the drought order. Susceptibility to the flow / level impacts resulting from the drought order (see Section 4) is identified according to whether interest features of the site or the species are water dependent. Sensitivity is then determined according to professional judgment based on susceptibility and the level of hydrological impact at the location.

Table 5.1 Designated Sites and Other Sensitive Receptors Within the Zone of Influence of the Crai Reservoir Drought Order

Site/Feature and designation	Hydrological Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
River Usk (Tributaries) SSSI	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	Designated due to the presence of a number of nationally important species and features. The drought order may impact on mobile species that access the tributary rivers.	Major	Yes
River Usk (Upper Usk) SSSI	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	Designated due to the presence of a number of nationally important species and features.	Major	Yes
River Usk SAC	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	Designated due to the presence of a number of species and features of European importance.	Major	Yes
Notable Species – Fish Atlantic salmon *Salmo salar* Twaite shad *Alosa fallax* Allis shad *Alosa alosa* River lamprey *Lampetra fluviatilis* Brook lamprey *Lampetra planeri* Sea lamprey *Petromyzon marinus* Bullhead *Cottus gobio* Brown and sea trout *Salmo trutta*	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	A number of notable species are noted in the reach. Changes to velocity, depth, wetted width may restrict the access of migratory fish to spawning tributaries or to dry spawning gravels. There is a risk of increased mortality due to habitat loss and reduced water quality.	Major	Yes
Notable Species – Mammals Otter *Lutra lutra* Water vole *Arvicola terrestris*	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	Otter and water vole have been recorded in the area. Otter are water-dependent, foraging in, over or adjacent to water for fish and aquatic invertebrates. However, these species are not expected to be significantly impacted by the drought order implementation, as habitat availability and quality for otter is not anticipated to be significantly altered. Water vole are associated with bankside tree cover, but are considered not to be detrimentally affected.	Negligible	No
Notable Species – Macrophytes *Rannuculion fluitantis* *Callitricho-Batrachion*	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	A number of nationally rare species can be found in this section of the river. A reduction in growth as a result of major impacts on water levels and flows will likely lead to changes to community composition and habitat loss resulting from a reduction in wetted width and depth.	Moderate/Minor	Yes
Notable Species – Mammals Otter *Lutra lutra*	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	The upper Usk and Usk tributaries are known to support one of the strongest otter populations in England and Wales.	Negligible	No

Site/Feature and designation	Hydrological Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
Notable species – Invertebrates White-clawed crayfish *Austropotamobius pallipes* *Freshwater pearl mussel Margaretifera margaretifera*	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	White-clawed crayfish has previously been found in the River Usk between Brecon Weir and Llansantffraed on a few occasions between 1982 and 2001. The drought order is thought unlikely to impact this feature given the location of the species relative to the spatial extent of the hydrological impact. There are historical records of freshwater pearl mussel within the River Usk catchment although the current status and distribution is uncertain. Freshwater pearl mussels are highly susceptible to reductions in flow, wetted width and depth.	Uncertain	Yes
Benthic macroinvertebrate communities	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	A reduction in growth as a result of major impacts on water levels and flows will likely lead to changes to community composition and habitat loss resulting from a reduction in wetted width and depth.	Moderate	Yes
Invasive flora and fauna	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	No invasive riparian plants have been recorded in the impacted reaches.	Negligible	No
Landscape and visual amenity	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	The study area falls within Brecon Beacons National Park and is largely rural and sparsely populated. There were six cultural landscape areas identified within 500m of the study site; Powys rural hinterland, Sennybridge, Upper Usk River Valley, The Beacons, Brecon Beacons National Park and Reservoirs. Water width/depth may affect the landscape and visual amenity value of the site.	Uncertain	Yes
Recreation	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	Recreation activities include canoeing, fishing, walking, cycling, picnicking and bird watching. Any reduction in wetted width and depth may influence the water-dependent activities such as fishing and canoeing.	Uncertain	Yes
Archaeology	Major – Reach 1 Moderate – Reach 2 Minor – Reach 3	There were three Ancient monument sites found within 500m of the study site; Castell-Du, Sennybride – a medieval defence site, Pont Gihirych – a post medieval transport site and Waunewydd standing stone – a prehistoric religious/ritual site. As these are not water dependant the operation of the drought order is not anticipated to impact these features.	Negligible	No

5.2.2 WFD Waterbody Status

Table 5.2 identifies the WFD status classification of the WFD waterbodies that may be impacted by implementation of the drought order. Waterbodies classified as overall high / good status / potential, and / or high / good ecological status for fish or macroinvertebrates are likely to be more sensitive to flow impacts. **Table 5.2** summarises the risk to WFD status and indicates where further assessment has been carried out as reported in Section 5.3 below.

Table 5.2 WFD Status Classifications

Waterbody Name	**Afon Crai – source to confluence with River Usk (GB109056033080)**		**Usk – conf Afon Hydfer to conf Afon Senni (GB109056039980)**		**Usk – conf Afon Senni to conf Afon Crawnon (GB1090560400810)**	
Hydrological Impact at Location (Major, Moderate, Minor, Negligible)	Major		Minor (August to September) Negligible (October to November)		Minor (August to September) Negligible (October to November)	
Heavily Modified Waterbody (Y/N)	Yes		No		No	
RBMP Cycle	RBMP2 (2015)[7]	2018 C2 Interim[8]	RBMP2 (2015)	2018 C2 Interim	RBMP2 (2015)	2018 C2 Interim
Ecological	Good	Good	Moderate	Good	Good	Good
Fish	Moderate	Moderate	Good	Good	Not assessed	Not assessed
Macrophytes and Phytobenthos	High	High	High	High	Not assessed	Not assessed
Phytobenthos (Sub-Element)	High	High	High	Not assessed	Not assessed	Not assessed
Macrophyte (Sub-Element)	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Macro-invertebrates	High	High	Not assessed	Not assessed	High	High
Total P/ Phosphate	Good	High	Moderate	High	Good	Good
Ammonia	High	High	High	High	High	High
Dissolved Oxygen	High	High	High	High	High	High
pH	High	High	High	High	High	High
Sensitivity (Uncertain, Moderate/ Major, Minor, Not sensitive)	Major		Minor		Minor	
Further Consideration Required (Y/N)	Yes		Yes		Yes	

[7] NRW (2017) https://drive.google.com/file/d/0B2hsDbbdxz1tZHItRU9lNkg1YWs/view
[8] NRW (2018) https://drive.google.com/file/d/14w17jL05sNuToVELqMCK_yc6DdHU7STb/view

5.3 FEATURES ASSESSMENT

5.3.1 Basis of Features Assessment

This section describes and assesses the potential impacts on the sensitive features during the period of implementation of the drought order.

Based on the sensitive features identified in Section 5.2.2, the degree of impact has been assessed and analysed in Section 5.3. Desk-based assessments have been completed for each of the sensitive receptors, where applicable, in order to determine the magnitude of impact in the Crai Reservoir drought order hydrological zone of impact. Each feature assessment describes the analyses carried out and a statement of the assessed impact. All impacts are considered to be negative / adverse unless otherwise stated in the feature assessment. The approach is described in Section 3.3.

The hydrological assessment is summarised in Section 4 and is presented in full in **Appendix B**.

5.3.2 Summary of Features Assessment

Table 5.3 presents the overall summary of the significance of potential impacts of the drought order identified from the assessment of designated sites, and other ecologically significant receptors and their relevant reaches. Full details of the features assessment are provided in **Appendix D**. A brief summary of the features assessment is also provided below in Sections 5.3.3 – 5.3.8.

Table 5.3 Summary of Impacts of Drought Order Implementation Pre-Mitigation

Month		J	F	M	A	M	J	J	A	S	O	N	D
River Usk Tributaries SSSI and SAC		N/A	N/A	N/A	N/A	N/A	N/A	N/A					
Reach 1 – (Afon Crai)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody macrophyte status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Brook and river lamprey	Spawning and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Atlantic salmon	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Adult upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Brown / sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Juveniles (habitat loss)	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
European eel		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Other fish species- Minnow		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody fish status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Phytobenthos		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody phytobenthos status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A

Month		J	F	M	A	M	J	J	A	S	O	N	D
Landscape		N	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Recreation		N	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Archaeology		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Reach 2 - (River Usk, from Afon Crai confluence to Afon Senni confluence)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N/A
Notable macrophyte species - *Welsh thread-moss and E. adscendens*		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody macrophyte status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Notable macroinvertebrate species – *Margaritifera margaritifera*		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Brook and river lamprey	Spawning and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Atlantic salmon	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Adult upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Brown / sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Juveniles (habitat loss)	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
European eel		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Other fish species - Minnow		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody fish status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Phytobenthos		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody phytobenthos status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Landscape		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Recreation		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Archaeology		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Reach 3 – (River Usk, from Afon Senni confluence to Afon Cilieni confluence)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N/A
Notable macrophyte species - *Welsh thread-moss and E. adscendens*		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody macrophyte status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Notable macroinvertebrate species – *Margaritifera margaritifera*		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Brook and river lamprey	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Atlantic salmon	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Adult upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Brown / sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Juveniles (habitat loss)	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
European eel		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Other fish species - Minnow		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Risk to WFD waterbody fish status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Phytobenthos		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody phytobenthos status		N/A	N/A	N/A	N/A	N/A	N/A						N/A
Landscape		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Recreation		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Archaeology		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A

Key to Environmental Effects:

N	Negligible impacts are considered likely
N/A	Outside implementation period
	Minor adverse impacts are considered likely
	Moderate adverse impacts are considered likely
	Major adverse impacts are considered likely
	Potential minor beneficial impacts are considered likely
	Potential moderate beneficial impacts are considered likely

5.3.3 Designated Sites

Table 5.4 presents a summary of the potential impacts of the drought order identified from the assessment of designated sites. The location of each of the designated sites discussed below is set out in **Figure 2.3**.

Table 5.4 Summary of Impacts of Drought Order Implementation on Designated Sites

Feature	Impact	Significance of Impact
Reaches 1, 2, 3 and 4		
River Usk SAC	• Impacts on Atlantic salmon, river lamprey, brook lamprey, and bullhead (Annex II species for which the SAC has been designated) have been assessed as major to minor during drought order implementation.	**Major**
Upper Usk SSSI	• Impacts on Atlantic salmon, river lamprey, brook lamprey, bullhead, and freshwater pearl mussel have been assessed as major to minor during drought order implementation.	**Major**

5.3.4 WFD and Community Assessment

This section considers the potential impact on the feature community within each reach as well as identifying the risk of deterioration in status / potential under the WFD.

WFD Definitions

The following definitions are provided for the determination of status under the WFD.

High ecological status - the values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions and show no, or only very minor, evidence of distortion.

Good ecological status - the values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.

Moderate ecological status - the values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.

Poor ecological status - waters showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor.

Bad ecological status - waters showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type are absent, shall be classified as bad.

Good ecological potential - there are slight changes in the values of the relevant biological quality elements as compared to the values found at high ecological potential.

Moderate ecological potential - there are moderate changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential.

The Environment Agency[9] identify that a number of different factors need be considered when making an assessment of the ecological potential of HMWBs. Of primary importance is the need to put a specified range of mitigation measures in place to address the effects of the anthropogenic impact. Selected ecological quality elements may also be required to be at GES for the waterbody to be classified as GEP. Where the designated use includes for impacts on flow and flow-related mitigation measures the measured status of the fish and macroinvertebrate communities do not affect the classification of GEP.

Assessment

A summary of the potential impacts of the drought order on macrophyte, macroinvertebrate, phytobenthos and fish communities and WFD status is presented below. Full details, including detailed baseline information, can be found in **Appendix D**.

[9] Environment Agency (2011) Method statement for the classification of surface water bodies v2.0 (external release) Monitoring Strategy v2.0 July 2011

Macrophytes

Table 5.5 presents a summary of the potential impacts of the drought order identified from the assessment of macrophytes.

Table 5.5 Summary of Impacts of Drought Order Implementation on Macrophytes

WFD Status/ Community	Impact	Significance of Impact
GB109056033080 (Crai - source to River Usk confluence) Current Status: Not assessed	• Not assessed	**N/A**
GB109056039980 (Usk, confluence Afon Hydfer to confluence Afon Senni) Current Status: Not assessed	• Not assessed	**N/A**
GB109056040081 (Usk –Afon Senni confluence to Afon Crawnon confluence) Current Status: Not assessed	• Not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Crai, from the Crai Reservoir outflow to the River Usk confluence		
Macrophytes	• Reduction in growth as a result of major impacts on water levels and flows. • Changes to community composition due to changes to flow velocities and habitat loss due to reduction in wetted width and depth. • Increase in filamentous algae levels due to moderate increase in nutrients, increases in water temperature and decreased velocity.	**Moderate** (August to September) **Minor** (October and November)
Reach 2 - River Usk, from the Afon Crai confluence to the Afon Senni confluence		
Macrophytes	• Reduction in growth as a result of moderate - minor impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Increase in filamentous algae levels due to minor increase in nutrients or water temperature and decreased velocity.	**Minor** (August to September) **Negligible** (October and November)
Reach 3 - River Usk, from the Afon Senni to the Afon Cilieni confluence		
Macrophytes	• Reduction in growth as a result of moderate - minor impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Increase in filamentous algae levels due to minor increase in nutrients or water temperature and decreased velocity.	**Minor** (August to September) **Negligible** (October and November)

Macroinvertebrates

Table 5.6 presents a summary of the potential impacts of the drought order identified from the assessment of macroinvertebrates.

Table 5.6 Summary of Impacts of Drought Order Implementation on Macroinvertebrates

WFD Status/ Community	Impact	Significance of Impact
GB109056033080 (Crai - source to River Usk confluence) Current Status: High	There is a risk of short-term deterioration in status of the macroinvertebrate component due to the drought order.	**Moderate**
GB109056039980 (Usk, confluence Afon Hydfer to confluence Afon Senni) Current Status: Not assessed	• Not assessed	**N/A**
GB109056040081 (Usk –Afon Senni confluence to Afon Crawnon confluence) Current Status: High	• There is a risk of short-term deterioration in status of the macroinvertebrate component due to the drought order.	**Minor**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Crai, from the Crai Reservoir outflow to the River Usk confluence		
Macroinvertebrates	• Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats • Reduction in species diversity as a result of deterioration to water quality	**Moderate**
Reach 2 - River Usk, from the Afon Crai confluence to the Afon Senni confluence		
Macroinvertebrates	• Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats • Reduction in species diversity as a result of deterioration to water quality	**Minor**
Freshwater pearl mussel	• Reduction in habitat area and suitability • Potential for mortality due to reduced flows and wetted width.	**Moderate**
Reach 3 - River Usk, from the Afon Senni to the Afon Cilieni confluence		
Macroinvertebrates	• Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats	**Minor**
Freshwater pearl mussel	• Reduction in habitat area and suitability • Potential for mortality due to reduced flows and wetted width.	**Moderate**

Fish

Table 5.7 presents a summary of the potential impacts of the drought order identified from the assessment of fish.

Table 5.7 Summary of Impacts of Drought Order Implementation on Fish

WFD Status/ Community	Impact	Significance of Impact
GB109056033080 (Crai - source to River Usk confluence) Current Status: Moderate	• There is a risk of short-term deterioration in status of the fish component due to the drought order.	**Major to moderate**
GB109056039980 (Usk, confluence Afon Hydfer to confluence Afon Senni) Current Status: Good	• There is a risk of short-term deterioration in status of the fish component due to the drought order.	**Major to moderate**
GB109056040081 (Usk –Afon Senni confluence to Afon Crawnon confluence)	• Not assessed	**N/A**
Species	**Impact**	**Significance of Impact**
Reach 1 – Afon Crai, from the Crai Reservoir outflow to the River Usk confluence		
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Major**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
Brook and river lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Major**
	• Reduced water quality	**Minor**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Moderate**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Major**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Major**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Moderate**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Major**
Reach 2 - River Usk, from the Afon Crai confluence to the Afon Senni confluence		
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Moderate**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Moderate**

Brook and river lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Moderate**
	• Reduced water quality	**Minor**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Minor**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Moderate**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Moderate**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Moderate**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Minor**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Moderate**
Reach 3 - River Usk, from the Afon Senni to the Afon Cilieni confluence		
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Minor**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
Brook and river lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Minor**
	• Reduced water quality	**Minor**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Negligible**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Minor**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Negligible**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**

Phytobenthos

Table 5.8 presents a summary of the potential impacts of the drought order identified from the assessment of phytobenthos.

Table 5.8 Summary of Impacts of Drought Order Implementation on Phytobenthos

WFD Status/ Community	Impact	Significance of Impact
Afon GB109056033080 (Crai - source to River Usk confluence) Current status: High	• There is a risk of short-term deterioration in status of the fish component due to the drought order.	**Moderate**
GB109056039980 (Usk, confluence Afon Hydfer to confluence Afon Senni) Current status: High	• There is a risk of short-term deterioration in status of the fish component due to the drought order.	**Minor**
GB109056040081 (Usk – Afon Senni confluence to Afon Crawnon confluence) Current status: Not assessed	• Not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Crai, from the Crai Reservoir outflow to the River Usk confluence		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Moderate increase in SRP affecting phytobenthos community composition and TDI score	**Moderate**
Reach 2 - River Usk, from the Afon Crai confluence to the Afon Senni confluence		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition Moderate increase in SRP affecting phytobenthos community composition and TDI score	**Minor**
Reach 3 - River Usk, from the Afon Senni to the Afon Cilieni confluence		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Moderate increase in SRP affecting phytobenthos community composition and TDI score	**Minor**

5.3.5 Landscape, Recreation and Archaeology

Table 5.9 presents a summary of the potential impacts of the drought order identified from the assessment of landscape, recreation and archaeology.

Table 5.9 Summary of Impacts of Drought Order Implementation on Landscape, Recreation and Archaeology

Feature	Impact	Significance of Impact
Landscape	• Flows during a drought will be low such that further reduction in flows due to the drought order would not result in a further loss of aesthetic value	**Negligible**
Recreation	• Impacts on recreation activities (e.g. angling, canoeing, walking) are not anticipated over those from the natural drought conditions	**Negligible**
Archaeology	• No water dependant archaeological features are present within the zone of impact.	**Negligible**

6 CRAI RESERVOIR DROUGHT ORDER – MITIGATION

The environmental assessment has identified some significant impacts, including major to negligible hydrological impacts on flows, major impacts on designated sites, major to minor aquatic ecology impacts including major to moderate impacts on fish and moderate to minor impacts on macroinvertebrates.

For those receptors with a potential impact or risk identified as being significant as a result of implementation of the drought order, precautionary monitoring and mitigation measures have been identified, and will be further developed in consultation with NRW.

Mitigation measures are feature, location, species and community specific, and are targeted only to those impacts that arise specifically as a result of drought order implementation (as opposed to those arising due to environmental drought pressures). Similarly, monitoring and the targeting of mitigation measures to impacts that arise specifically as a result of drought order implementation will help identify the responsible party for the specific actions relating to the associated measure. Information attained through monitoring undertaken during future droughts and potential drought order implementation events will provide a tool for discussions regarding best working practices between Welsh Water, NRW and any other interested parties.

The range of mitigation measures that are possible for the features identified fall into three general activity types:

1) measures to reduce impacts at source

2) measures to modify environmental conditions in the river/lake

3) management of sensitive ecological species and communities.

The first activity type looks at mitigation measures that will reduce the pressure at source by reducing the hydrological impact. In the circumstances, the options are limited because the drought order is required to safeguard public water supply. The second activity focuses on mitigation measures that involve undertaking actions within the waterbodies to reduce the pressure at sensitive locations. The third activity type involves direct action to manage impact by movement or management of the receptor / feature itself.

The mitigation measures that could be considered at the on-set of drought, during implementation of the drought order and post-drought order implementation include:

Table 6.1 Potential Generic Mitigation Measures Considered to Address Adverse Effects of the Drought Order

Type of Mitigation	Typical Application
Temporary reduction or cessation of the terms of the Drought Order/Permit	Where continuous water quality monitoring (typically dissolved oxygen) and/or fish distress monitoring indicate a sharp deterioration in aquatic conditions, modifications to abstraction licence conditions under the terms of the order/permit may need to be reduced or cease altogether until conditions have improved. The precise trigger levels for considering such action would be set out in discussion with NRW at the time of application taking account of the time of year and prevailing environmental conditions. Temporary cessation of the implementation of the order/permit may be required as a means of mitigating ecological effect, balanced against the need to safeguard public water supplies.
Fish distress monitoring with triggers and response plan	Regular visual observations carried out on key stretches of rivers or lakes to detect signs of large scale fish distress and agree appropriate mitigation with NRW specific to the conditions identified. This might include temporary oxygenation measures.
Protection of 'spate flows'	Temporary increases in river flows following periods of rain can be important to flush sediment/pollutants from the system or promote fish passage. Where possible, the terms of the drought order/permit could be temporarily reduced/suspended so that these spate flows are preferentially allowed to pass through the system. This decision would need to be taken in dialogue with NRW to take account of the prevailing conditions and considering the merits of encouraging fish migration during a drought.
Reduce fish predation	Consider (where feasible) a limited and targeted reduction of predation risk on fish through either the provision of refugia, in the form of artificial or natural habitat provision or improvement, or the placement of piscivorous bird scarers (in areas remote from residential locations). The merits of each option and subsequent deployment would be subject to review on a case-by-case basis in consultation with NRW.
Physical works	In some cases, temporary physical in-river works such as channel narrowing or provision of refugia could be carried out to mitigate environmental risks. If any physical works are likely to impact fish passage, appropriate mitigation measures will need to be considered as part of the design of the works.
Compensation flows	In some cases, it may be possible to use other sources of water to provide compensation flows within surface water courses to temporarily mitigate the impact of the drought order/permit
Provision of alternative water supplies	If there is a risk of derogation of other abstractors from the drought order/permit, it may be possible for Welsh Water to provide alternative water supplies or lower pumps in boreholes. Provision is otherwise provided in legislation[10] for compensation to be agreed with the abstractor.

A suggested suite of mitigation measures for environmental features with potentially significant impacts relating to implementation of the Crai drought order are given in **Table 10.1**. For these features, a range of precautionary monitoring and triggers leading to enabling of appropriate mitigation measures are also described.

[10] Schedule 9 of the Water Resources Act (WRA) 1991

7 CUMULATIVE IMPACTS

In accordance with the DPG and the Habitats Regulations, consideration has been given to how the proposed drought order may affect the environment in combination with the effects of existing abstraction licences, environmental permits and other plans. This includes assessment of the potential cumulative effects of the following:

- Welsh Water's existing abstraction licences that operate within the hydrological zone of influence of the drought option, as well as other abstraction licences and discharge permits, as identified in NRW Review of Consents reports;
- Assessment of cumulative impacts of the drought order with other Welsh Water supply-side and drought order options within the hydrological zone of influence (including both intra- and inter- zone options);
- Other plans and projects of relevance, including;
    - Any Welsh Water WRMP schemes which are scheduled to be implemented and become operational within the time period of the Drought Plan (i.e. before 2025).
    - Drought supply-side and drought order / permit options from NRW Drought Plans.
    - National Policy Statements for Wastewater and Renewable Energy Infrastructure.
- Environmental monitoring before, during and after drought order implementation (see Section 10).

If a drought order application is progressed in the future, the potential for cumulative effects will be reviewed and revised to reflect any changes which are relevant to the timing of the drought order specified in the application.

Welsh Water's existing abstraction licences and other abstraction licences and discharge permits

The assessment of hydrological impacts presented in **Appendix B**, and summarised in Section 4, has considered how the proposed drought order may affect the environment in combination with the effects of existing licences and consents. Therefore no relevant licences or consents have been identified as relevant for assessment of cumulative effects.

Other relevant Welsh Water drought permit / orders

No cumulative effects of implementing the Crai drought order with other drought order / permit schemes have been identified. However, this should be reviewed at the

time of any future application for a drought order at Crai Reservoir.

Welsh Water WRMP schemes

No WRMP schemes identified with cumulative impacts.

NRW Drought Plans

No cumulative impacts of options in NRW Drought Plan with a drought order at Crai are anticipated. However, this should be reviewed at time of future application for a drought order.

National Policy Statements for Wastewater and Renewable Energy Infrastructure

No cumulative schemes have been identified for assessment.

Environmental Monitoring

Recommendations for environmental monitoring before, during and after drought order implementation have been made in the EMP which is presented in Section 10 of this EAR. The EMP has been developed in consultation with NRW.

It is assumed that all monitoring activities will be undertaken with the best interests of the site in mind, and in discussion and agreement with NRW. Where activities which require in-river working are proposed, a method statement for the survey will be prepared and agreed with NRW in advance of the survey.

Assuming rigorous implementation of the method statements, there will be no adverse impacts of the monitoring on hydrology, water quality or ecology, and no adverse impacts of environmental monitoring on the site are anticipated.

8 CRAI RESERVOIR DROUGHT ORDER - SUMMARY OF RESIDUAL IMPACTS

The residual impact on environmental features is dependent on the effects observed during environmental monitoring, and the mitigation measures that are taken forward and their timely and effective application once the trigger for their need has been identified. Consequently, at this stage it is not possible to provide an accurate indication as to the residual impacts on environmental features due to implementation of mitigation measures. However, should the mitigation measures be effectively applied in all situations in a timely manner, it is anticipated that the magnitude of impacts, and in some cases the significance of impacts, will be reduced from those summarised in **Table 5.3**.

Should the application of mitigation measures applicable during the drought order implementation period not reduce the impact magnitude or significance, compensatory measures such as restocking will be considered to help ensure pre-drought conditions return and reduce the significance of any post-drought order impacts.

9 HABITATS REGULATIONS ASSESSMENT: STAGE 1 SCREENING

9.1 INTRODUCTION

Under Regulations 63 and 105 of the Habitats Regulations, the competent authority (in the case of a drought order in Wales this would be the Welsh Ministers, advised by NRW) is required to undertake an Appropriate Assessment of any plan / project which is likely to have a significant effect on a European site, to determine the implications for the site in view of the site's conservation objectives. The Regulations state that a person applying for any such consent (in this case Welsh Water), must provide such information as the competent authority (Welsh Ministers, advised by NRW) may reasonably require for the purposes of the assessment or to enable them to determine whether an appropriate assessment is required.

9.1.1 HRA Stages

Stage 1 – Screening

The first stage in the Habitats Regulations Assessment (HRA) is screening to determine the likelihood of the drought order to have a significant effect (LSE) on any European site (either alone or in-combination with other plans and projects) and thus if a full 'Appropriate Assessment' of any of the drought order would be required.

An in-combination assessment is carried out to establish the possibility of cumulative or synergistic impacts.

The screening stage identifies if the drought order is likely to have significant effects on European designated site, and requires Appropriate Assessment.

Stage 2 – Appropriate Assessment

Drought orders that are identified during HRA Screening (Stage 1) as being likely to have a significant effect (either alone or in combination) will be taken forward to Appropriate Assessment. The Appropriate Assessment will consider the impacts of the drought order, against the conservation objectives of a European Site, in order to identify whether there are likely to be any adverse effects on site integrity and site features. The assessment will conclude whether or not the drought order, either alone or in combination with other plans and projects, would adversely affect the integrity of the European site in question. This is judged in terms of the implications of the plan for a site's conservation objectives, which relate to its 'qualifying features' (i.e. those Annex I habitats, Annex II species, and Annex I bird populations for which it has been designated). The responsibility for undertaking the Appropriate Assessment lies with the Welsh Ministers (advised by NRW).

Stage 3 – Alternative Options Stage

Where significant adverse effects are identified at the Appropriate Assessment stage, alternative options would be examined to avoid any potential damaging effects to the integrity of the European site.

Stage 4 – Assessment Where Adverse Impacts Remain

Stage 4 comprises an assessment of compensatory measures where, in the light of an assessment of Imperative Reasons of Overriding Public Interest, it is deemed that the project or plan should proceed. Imperative Reasons of Overriding Public Interest will only be progressed if no alternatives are identified as part of Stage 3.

9.2 STAGE 1 SCREENING OF CRAI RESERVOIR DROUGHT ORDER

The objective of this section is to bring together all relevant information to enable a HRA to be undertaken of the impacts of the Crai Reservoir drought order on relevant European designated sites

These assessments have been completed in accordance with the DPG (see Section 3.3).

This section considers each of the designated features of the designated sites and discusses the potential for the drought order at the Crai Reservoir to influence their status. For species, impacts on populations, range and supporting habitats and species have been considered.

9.2.1 Potential Impacts on River Usk SAC Qualifying Features

In carrying out the screening process, the assessment has considered the main possible sources of effects on the sites arising from the potential drought order, possible pathways to the designated sites and the effects on possible sensitive receptors in the sites. Only if there is an identifiable pathway between the impacted reaches and the designated sites, or individual receptors, is there likely to be an impact and where this is absent those sites have been screened out. The screening assessment has also considered the River Usk SAC conservation objectives. The development of conservation objectives is required by the 1992 'Habitats' Directive (92/43/EEC). In accordance with the Habitats Directive, the objectives aim to achieve the 'favourable conservation status' of habitats and species features for which SAC is designated (see **Figure 9.1**).

Site-specific conservation objectives provide a description of what is considered to be the favourable conservation status of the feature within the whole plan area. Conservation objectives for the site have been prepared by NRW.

Figure 9.1 Favourable conservation status as defined in Articles 1(e) and 1(i) of the Habitats Directive

"The conservation status of a natural habitat is the sum of the influences acting on it and its typical species that may affect its long-term natural distribution, structure and functions as well as the long term survival of its typical species. The conservation status of a natural habitat will be taken as favourable when:

- *Its natural range and areas it covers within that range are stable or increasing, and*
- *The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and*
- *The conservation status of its typical species is favourable.*

The conservation status of a species is the sum of the influences acting on the species that may affect the long-term distribution and abundance of its populations. The conservation status will be taken as 'favourable' when:

- *Population dynamics data on the species indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and*
- *The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and*
- *There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis."*

In addition to the conservation objectives, the Core Management Plan has been used to determine LSEs against each of the specific attributes and targets for each of the qualifying features. A summary of the overall screening conclusion for each feature is provided below, with **Table 9.1** providing the assessment against each attribute and target.

Allis and Twaite Shad

There are no records of Allis *Alosa alosa* or Twaite *Alosa fallax* Shad within or near to the hydrological zone of impact because of barriers to upstream migration (e.g. Crickhowell Bridge) further downstream in the River Usk Therefore it can be concluded that the drought order will have no likely significant effects on the feature..

Brook, River and Sea Lamprey

There are no records of sea lamprey within or near to the hydrological zone of impact (SAC Management Units 6 and 9), as set out in the SAC Core Management Plan. Therefore it can be concluded that the drought order will have no likely significant effects on the feature.

Brook lamprey *Lampetra planeri* and river lamprey *Lampetra fluviatilis* are known to be present in both Units 6 and 9, being key species in Unit 9. There is the potential for

reduced flow to result in a decrease in river levels and wetted width. This has particular significance for juvenile (ammocoetes and transformer) lamprey habitat which tends to consist of silt in shallow, marginal areas. There is therefore the potential for a loss or degradation of this habitat. Provided minimum low flows are available, juvenile lamprey are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would likely increase.

As a result, it can be concluded that implementation of a drought order has the potential to result in likely significant effects on the populations of lamprey in Reaches 1 to 3 within the River Usk SAC.

Bullhead

Bullhead are likely to be present throughout the hydrological zone of influence. The species is flow sensitive and spawning and egg incubation takes place from March to May and these life stages will no be affected by the drought order implementation. . Particularly susceptible juvenile lifestages are likely to be affected by reduced flows (and likely reduced water quality) associated with implementation of a drought order. In particular, the young-of-the-year individuals that depend on flows for distribution along the watercourse. The reductions in flow in all reaches (up to 50% in Reach 1) are likely to have a significant impact on bullhead.

As a result, it can be concluded that implementation of a drought order has the potential to result in likely significant effects on the populations of bullhead in Reaches 1 to 3 within the River Usk SAC.

Atlantic Salmon

The River Usk within the hydrological zone of influence is an important migratory corridor for Atlantic salmon with two return migratory runs: a modest spring run (April to June) of often very large Atlantic salmon, and a later run from mid-summer to December when the majority of migrating Atlantic salmon enter the river. A reduction in flow as a result of the drought order could affect the timing of this migration.

The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature. As such the drought order is unlikely to impact on smolt migration. The impact on Atlantic salmon migration should be considered in the context of extreme low flows and drought conditions as a baseline. Periods of increased flow are considered to be a primary cue in initiating Atlantic salmon migration and very low flows are likely to delay migration. . The drought order is unlikely to impact on migration cues in the early part of implementation (August to September). During the months of October and November, the drought order is also unlikely to impact on migration in the main River Usk as Q_{50} flows will only decrease by 2.4% and 1.5% within Reaches 2 and 3 respectively. There remains some uncertainty with regards to the potential impact on migration into the Afon Crai as limited

information regarding the impact of a 50% reduction in compensation flows on wetted width and depth was available at the time of this assessment.

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in habitat to increase stress and subsequent loss of condition. Atlantic salmon are susceptible to poor water quality and particularly dissolved oxygen and water temperature. The effects of reduced water quality are likely to impact particularly sensitive juvenile lifestages.

In addition to issues with flow and water quality, the drought order has the potential to degrade or reduce in extent habitat used by juveniles and gravel spawning habitat. Provided minimum low flows are available, juvenile Atlantic salmon are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. If gravels containing redds and/or eggs (likely to occur from December to January) become de-watered this is likely to have a more significant effect with the potential for significant mortality due to desiccation and increased predation.

As a result, it can be concluded that implementation of a drought order has the potential to result in likely significant effects on the populations of Atlantic Salmon in Reaches 1 - 3 within the River Usk SAC.

Otter

The screening assessment identified the potential for impacts on otter as a result of a reduction in the flow velocity, wetted width and depth of the river.

However, there are not anticipated to be any changes to habitat or prey availability for otter as a result of drought order implementation. Therefore it can be concluded that the drought order will have no likely significant effects on the feature

Water Courses of Plain to Montane Levels with the Ranunculion fluitantis and Callitricho-Batrachion Vegetation

All reaches impacted by this drought order are located within Management Units 6 and 9 of the River Usk SAC. The Core Management Plan identifies that Annex II habitat Rivers with *Ranunculion fluitantis and Callitricho-Batrachion* vegetation is "not present" within this management unit[11].

As a result, it can be concluded that implementation of a drought order will have no likely significant effects on the water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation feature in Reaches 1 - 3 within the River Usk SAC.

[11] Countryside Council for Wales (2008) Core Management Plan Including Conservation Objectives For River Usk Special Area Of Conservation.

Table 9.1 Summary of Likely Significant Effects of Drought Order Implementation Against Conservation Objective Performance Indicators for the River Usk SAC

Feature	Attribute (taken directly from NRW Conservation Objectives document)	Site Specific Target range and Measures	Impact of Drought Order and level of certainty	LSE?
Brook and River Lamprey	Age/size structure of ammocoete population	Samples < 50 ammocoetes ~ 2 size classes Samples > 50 ammocoetes ~ at least 3 size classes	Potential adverse impacts of drought order implementation on on the age / size structure of ammocoetes.	Yes
	Distribution of ammocoetes within catchment	Present at not less than 2/3 of sites surveyed within natural range No reduction in distribution of ammocoetes	Potential adverse impacts of drought order implementation on distribution of ammocoetes	Yes
	Ammocoete density	Optimal habitat: >10m-2 Overall catchment mean: >5m-2	Potential adverse impacts of drought order implementation on ammocoetes density	Yes
Atlantic Salmon	Adult run size	Conservation Limit complied with at least four years in five	Potential adverse impacts of drought order implementation on Atlantic salmon adult run size	Yes
	Juvenile densities	Density thresholds from elecrofishing results.	Potential adverse impacts of drought order implementation on juvenile Atlantic salmon densities	Yes
	Water quality – biological	Biological GQA class A	No risk to achievement of conservation objective;.	No
	Water quality – chemical	RE1	No risk to achievement of conservation objective;.	No
	Hydromorphology – flow	Targets are set in relation to river/reach type(s).	Potential adverse impacts of drought order implementation on hydromorphology of the river	Yes
Bullhead	Adult densities	No less than 0.2 m-2 in sampled reaches	Potential adverse impacts of drought order implementation on adult bullhead densities	Yes
	Distribution	Bullheads should be present in all suitable reaches. As a minimum, no decline in distribution from current.	Potential adverse impacts of drought order implementation on adult bullhead distribution	Yes
	Reproduction/age structure	Young of year fish should occur at densities at least equal to adults	Potential adverse impacts of drought order implementation on bullhead reproduction/age structure	Yes
	Alien/introduced species	No impact on native biota from alien or introduced species	No risk to achievement of conservation objective.	No

9.2.2 Summary

In summary, likely significant effects have been identified for the brook and river lamprey, Atlantic salmon and bullhead populations within the River Usk SAC as a result of the implementation of the drought order.

A Stage 2 Appropriate Assessment has therefore been carried out to identify whether the implementation of the drought order will result in adverse effects on the site's conservation objectives and therefore whether the overall site integrity would be compromised. This is reported separately.

9.2.3 Cumulative and In-combination Impacts

The Habitats Directive requires a consideration in the assessment of '*any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plan or projects*'.

Consideration of potential plans or projects with in-combination effects is presented in Section 7, and the Stage 2 Appropriate Assessment.

10 ENVIRONMENTAL MONITORING PLAN (EMP)

10.1 INTRODUCTION

The overall scope of the EMP for the Crai Reservoir drought order meets the requirements of Section 5.2 (Monitoring) and informs the requirements of Section 5.3 (Mitigation) of the DPG. As required by the DPG, the level of monitoring identified in the EMP is risk-based. The EMP is tailored to the characteristics of the study area and is informed by the knowledge and assessment of environmental sensitivity (presented in Sections 4 and 5 of this EAR). The EMP fulfils several requirements, including:

- Establishing required baseline environmental monitoring and data acquisition to maintain and update the understanding of the environmental baseline conditions and to reduce uncertainties in the assessment.
- Pre-drought order monitoring describes the prevailing environmental conditions prior to drought order implementation. This will inform the implementation and management of any mitigation actions during the drought.
- During-drought order monitoring describes the environmental conditions during the implementation of the drought permit. Surveillance monitoring of sensitive locations, informed by, for example, walkover surveys and pre-drought monitoring, will provide early warnings of any unpredicted environmental impacts and ensure that mitigation actions are operating as designed.
- Post-drought order monitoring describes the recovery of environmental conditions following the cessation of a drought order, and establishes whether the affected ecosystems have recovered to conditions prevailing in the pre-drought order period.

The basis of the development of the EMP is provided in Section 10.2.1. Monitoring recommendations are set out in Section 10.2.2.

10.2 BASIS OF THE EMP

Guidance on the objectives and content of the EMP is given in Section 5.2 and Appendix J of the DPG.

The guidance states that:

- Water companies are responsible for understanding the effects of a drought and its drought management actions on the environment and that companies can demonstrate this by assessing the impacts of drought management actions during and after a drought and completing the environment assessment.
- Companies should ensure that adequate arrangements for environmental

monitoring are detailed in an EMP within its drought plan.

- The level of monitoring needed should be risk-based. Not all sites will require in-drought and post-drought monitoring.
- Surveys may be needed to support/inform the decisions on environmental sensitivity and likely impact or to ascertain baseline conditions.
- In-drought order monitoring is required to assess the impacts from the implementation of the drought management action and for the management of mitigation actions during a drought.
- Post-drought order monitoring aims to assess a site's recovery.
- Sites with moderate to major environmental risk should focus monitoring on those feature(s) sensitive to the likely impacts from implementing drought management actions. For Habitats Directive sites, data collected will be sufficient to demonstrate there is no adverse effect on the interest features. For SSSIs, data collected will need to be sensitive enough to pick up the likelihood of damage at the site. For WFD sites data collected will be to assess any potential 'deterioration' to status and allow you to comply with the requirements of Articles 4.6 to 4.9.
- Control sites are important to provide a comparison between the 'natural' impacts of the drought and the impacts of the drought management action.
- The EMP should include details of any surveys to support the environmental assessment, in-drought and post-drought data needs, including:
    - the feature/s to be monitored and the methods used
    - the location of survey sites
    - the timing and frequency of monitoring
    - who will undertake the monitoring.
- Separating the 'natural' impacts of a drought from those resulting from the implementation of drought management actions can be complex and made more difficult where data problems and/or a lack of hydro-ecological understanding exists. Water companies must ensure that their EMP is adequate to assess the most significant environmental impacts of its proposed drought actions and associated mitigation measures.
- The EMP needs to be agreed with NRW. Consultation with NRW should be undertaken to ensure that the monitoring proposed within the EMP to assess the potential impacts at these sites is adequate.
- A water company must provide details in the Drought Plan of likely mitigation or compensation needed against serious impacts on the environment or other water users of any proposed drought action. The EMP should assist in identifying sites that may require mitigation. In some cases, mitigation actions may be necessary

to prevent derogation of other abstractions (for example, by providing alternative supplies or releasing compensation water into watercourses to limit the impact of reduced flows).

10.3 MONITORING RECOMMENDATIONS

The EMP describes the nature and extent of the baseline and drought year data that would be required in order to differentiate the impacts resulting solely from the implementation of a drought order with those resulting naturally as a result of the drought itself. The EMP is site specific and the scope is based on the current assessment of the drought order.

Recommendations for pre-drought, in drought and post-drought monitoring, based on the outcome of the current environmental assessment, are provided in **Table 10.1** and are illustrated on **Figure 10.1**.

Monitoring outside of drought conditions is also recommended to address the baseline data limitations to the environmental assessment identified in this report and ensure a robust baseline exists for all sensitive features.

Data and results from baseline monitoring will increase the robustness of the assessment, and will be incorporated at the time of EAR preparation to support any future application for drought powers. The impact assessment has adopted a precautionary approach where baseline data limitations have been identified.

Control sites are crucial in assessing the ecological impact of flow pressure resulting from water resource activities. They can help determine whether any ecological impact being observed is a result of the water resource activity being investigated, rather than wider environmental influences. Good control sites for hydroecological assessment should be chosen where there are no significant water quality problems or pressures which could undermine relationships between ecology and flow. They must not be affected by the water resource activity being investigated nor have additional water resource activity upstream that could affect the flow regime. It is imperative that they are as similar in nature to the baseline conditions of the impact sites as possible, most importantly stream size and channel gradient. Possible options could include reaches upstream of those impacted, or other watercourses where the watercourses are comparable and not subject to a drought permit/order application. Control sites will need to be identified at the time of application following a review of where drought permit/orders are required to be implemented. Consultation with NRW to determine suitable control sites will be undertaken at the time of application of this drought order.

The following monitoring programme is an initial draft and will be iterated and agreed with NRW prior to EMP implementation. Any updates to the EMP will consider:

- Any potential changes in the assessment of the hydrological, water quality and geomorphological impacts based on baseline conditions at the onset of drought;
- Any potential changes in the assessment of impacts on environmental features based on baseline conditions at the onset of drought; and
- Any changes in assessment and/or monitoring methodologies and biological indices.

Table 10.1 Recommended EMP - On-set of Natural Drought, During Drought and Post Drought Monitoring and Mitigation

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	**Monitoring and trigger setting**	**Trigger and monitoring to inform mitigation action**	**Mitigation actions triggered by monitoring**	**Monitoring and post-drought mitigation (where applicable)**	
N/A		Walkover survey during low flow conditions - Mapping of sensitive habitats, communities, species and any monitoring sites that are required in order to improve understanding of the baseline communities.	N/A				Welsh Water
		Hydrology of Sensitive Locations – Reaches 1 - Cross-sectional profile (depth and wetted width), flow and velocity. Location to be informed by walkover surveys.					Welsh Water
		Spot flow gauging surveys	One site per hydrological reach. Three occasions.	One site per hydrological reach. Three occasions.	N/A	One site per hydrological reach. Three occasions.	Welsh Water
		Biochemical water quality sampling.	One site per hydrological reach. Monthly. Consider continuous monitoring.	One site per hydrological reach. Weekly. Consider continuous monitoring.	N/A	One site per hydrological reach. Monthly, until recovery to pre-drought levels. Consider continuous monitoring.	Welsh Water
Macrophytes **Reach 1**	• Reduction in abundance and distribution of flow sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats • Increase in filamentous algae	Carry out walkover (where survey site identification is required) and river macrophyte survey at one site in each of the impacted freshwater reaches. Follow LEAFPACS2 standard methodology. To be carried out annually during June-September, to ideally provide a three-year baseline dataset. To complement any existing NRW monitoring, in discussion with NRW.	Survey to be undertaken and macrophytes identified (if drought order likely to be implemented in plant growing season r). Follow LEAFPACS2 standard methodology [12]. Walkover survey to identify any key sources of nutrient loading. Carry out water quality sampling at the baseline sites including samples for	Walkover of key sections known to be susceptible to lower flows, informed by pre-drought survey. If drought order implementation occurs in plant growing season, carry out macrophyte surveys at baseline sites. Follow LEAFPACS2 standard methodology for assessing macrophyte communities.	Mitigating impacts to the macrophyte community as a result of lowered flow and water level is not feasible during drought order implementation. Mitigating this impact should be triggered by post drought macrophyte community assessments to implement post drought mitigation measures. Consider measures to	In the two years following drought order implementation and in June to September monitoring period carry out LEAFPACS2 macrophyte surveys at the baseline monitoring sites. To be extended if recovery has not occurred in two years. Significant alteration to macrophyte community composition (as informed by expert judgement, based on baseline data and multivariate	Welsh Water

[12] Environment Agency (2011). Surveying freshwater macrophytes in rivers. Operational instruction 131_07. (Unpublished procedures manual)

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	levels due to increased nutrients or water temperature and decreased velocity		soluble reactive phosphorus.	Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.	address identified point sources of nutrient loading. Consider scope for addressing any identified sources of nutrient loading from walkover survey, if this would help address water quality risks. Consider possible in-stream measures or adjustments to improve habitat conditions.	statistical analyses) triggers post drought mitigation actions: If existing macrophyte community has significantly deteriorated, consider reseeding /replanting where possible to promote recovery. Replanting of macrophyte community composition to be informed by pre-drought community. Consider the removal of fine silt by manual raking of small areas to improve habitat quality.	
Macroinvertebrates **Reach 1** **Reaches 2 & 3 (Freshwater pearl mussels only)**	• Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction in species diversity as a result of the loss of flow-sensitive taxa. • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats.	The macroinvertebrate community in the impacted reach are not well understood as a result of limited monitoring carried out by NRW. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites should be informed by initial walkovers at sensitive sites. No Freshwater Pearl Mussels data is currently available. Targeted FWPM surveys required and habitat	Seasonal monitoring of macroinvertebrates at the baseline survey sites (spring and autumn). Targeted FWPM surveys required and habitat suitability assessments for Reaches 2 and 3. Samples to be collected and identified to species level. Carry out water quality surveys at same time. In severe drought conditions, no in stream monitoring is advised during environmental drought to prevent further harm to the invertebrate	Seasonal monitoring of macroinvertebrates at the baseline survey sites (spring and autumn). Targeted FWPM surveys required and habitat suitability assessments for Reaches 2 and 3. Samples to be collected and identified to species level. Carry out water quality surveys at same time. In severe drought conditions, no in stream monitoring is advised during environmental drought to prevent further harm to the invertebrate community through kick/ sweep sampling.	Mitigating impacts to the macroinvertebrate community as a result of lowered flow and water level is not feasible during drought order implementation. Mitigating this impact should be triggered by post drought macroinvertebrate community assessments to implement post drought mitigation measures. Consider possible in-stream measures or adjustments to improve habitat conditions.	In the two years following drought order implementation, 3-minute kick sampling and mixed taxon level analysis at the three routine monitoring sites. To be extended if recovery has not occurred in two years. Targeted FWPM surveys required and habitat suitability assessments for Reaches 2 and 3. Significant alteration to macroinvertebrate community composition (as informed by expert judgement and based on baseline data) triggers post drought mitigation actions: Targeted habitat alteration/improvements can enhance natural recovery.	Welsh Water

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
		suitability assessments for Reaches 2 and 3.	community through kick/ sweep sampling. .		Consider the removal of fine silt by manual raking of small areas.	Habitat restoration techniques can be utilised to improve habitat quality, and flush sediment from benthic substrate. If sedimentation is deemed to be a risk to the community, consider the removal of fine silt by manual raking of any accessible shallow marginal areas. If recovery of the community does not occur within two years, consider the installation of fly boards at unimpacted sites during egg laying season, before transferring the boards to the impacted reach for eggs to hatch and re-populate.	
Fish (including river, brook and sea lamprey, Atlantic salmon, bullhead, brown / sea trout, European eel and Other fish species) **Reach 1**	• Decreased growth, alteration to feeding and migration • Siltation of spawning gravels • Loss of important habitats (spawning gravels, nursery habitat, resting pools) • Stranding of individuals as a	The fish community in the impacted reach is reasonably well understood as a result of monitoring carried out by NRW Quantitative electric fishing surveys to be carried out at historic monitoring sites outlined in Section D3.3.1 and an appropriately located control site (to be identified during walkover survey outlined above). Surveys to be repeated every three years. Monitoring sites are located at:	Electric-fishing surveys to monitor fish populations at two sites in the impacted reach. Quantitative, lamprey-specific electric fishing surveys targeting known optimal and sub-optimal habitat. Two sites in the impacted reach. In severe drought conditions, no fish population surveys are advised during drought as	No fish population surveys are advised during drought as this may cause further stress. Additional walkovers, if situation is expected to deteriorate in stream sections known to contain to contain high fish densities, spawning, nursery and cover habitats. Record extent of exposed marginal habitats, spawning habitats, bed substrates and estimates of overlaying silt cover. Frequency of walkovers to be determined based on the on-set of environmental drought	Targeted installation of woody debris features to provide fish with the habitat required to support feeding and development (growth). If the results of the walkovers deem spawning gravels to be at risk to siltation, the following mitigation action/s may be undertaken: • Gravel washing of key spawning areas to be undertaken prior to salmonid spawning	Two years of annual post-drought fish population surveys at baseline monitoring sites (corresponding with a control and impact site/s) to determine any changes in population dynamics both temporally and spatially. Quantitative, lamprey-specific electric fishing surveys targeting known optimal and sub-optimal habitat. Two sites in the impacted reach. The results of the fish population surveys should help inform mitigation targeting habitat restoration where	Welsh Water

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	result of a reduction in velocity • Fragmentation of habitats and increased significance of obstacles/barriers • Changes in flows and water levels may delay or prevent passage over barriers to migration	• NRW site: U003a (Reach 1) • NRW site: U016a (Reach 1) • Lamprey specific monitoring at two sites in Reach 1 (NRW site U500L & U014L)	this may cause further stress. Walkover of key sections known to be susceptible to lower flows: • Identification of key habitats which are at risk of fragmentation. • Identification of key structures which may provide a barrier at lower flows. • Identification of key spawning locations recording the number of redds potentially affected, undertaken during the salmonid winter spawning period (depending on order being implemented during the salmonid winter spawning period). Record extent of exposed marginal habitats, spawning habitats, composition of the bed substrate and estimates of overlaying silt cover. Approximation of the number of each fish species (e.g. 10s, 100s) in each	walkover and expert judgement of the resolution required to monitor the impacts of the drought. Targeted fish passage assessment of barriers /obstructions to fish passage and any associated fish passes should be undertaken to ascertain if they pose an increased risk to the free movement of fish during key migration periods, i.e. during adult salmonid and downstream lamprey migration period (late summer/autumn). Frequency of fish passage assessments to be determined based on the on-set of environmental drought walkover and expert judgement of the resolution required to monitor the impacts of the drought. Measure dissolved oxygen, conductivity and temperature in the field using calibrated handheld equipment. Deployment of automated water quality equipment that continuously monitors for	period (winter)[13] • Targeted installation of woody debris features to increase localised flow velocity/scour at impacted spawning gravels (to aid sediment transport and increase water depth for spawning depth) If the results of the walkovers deem important habitats to be at risk to exposure/ reduction (in extent), the following mitigation action/s may be undertaken: • Targeted installation of woody debris features to increase flow heterogeneity/scour and marginal cover in shallow areas of the channel[14] • Deployment of aeration equipment in key reaches that have	deemed to be appropriate to support and enhance affected populations. Walkover of key spawning locations recording the number of redds potentially affected, undertaken during the winter spawning period. Record extent of exposed marginal habitats, spawning habitats, composition of the bed substrate and estimates of overlaying silt cover. If the results of the walkovers deem spawning gravels to have suffered from siltation, the following mitigation action/s may be undertaken: Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)[15] Targeted installation of woody debris features to: • increase flow heterogeneity/scour and marginal cover in shallow areas of the channel[16] • increase localised flow velocity/scour at impacted spawning gravels (to aide	

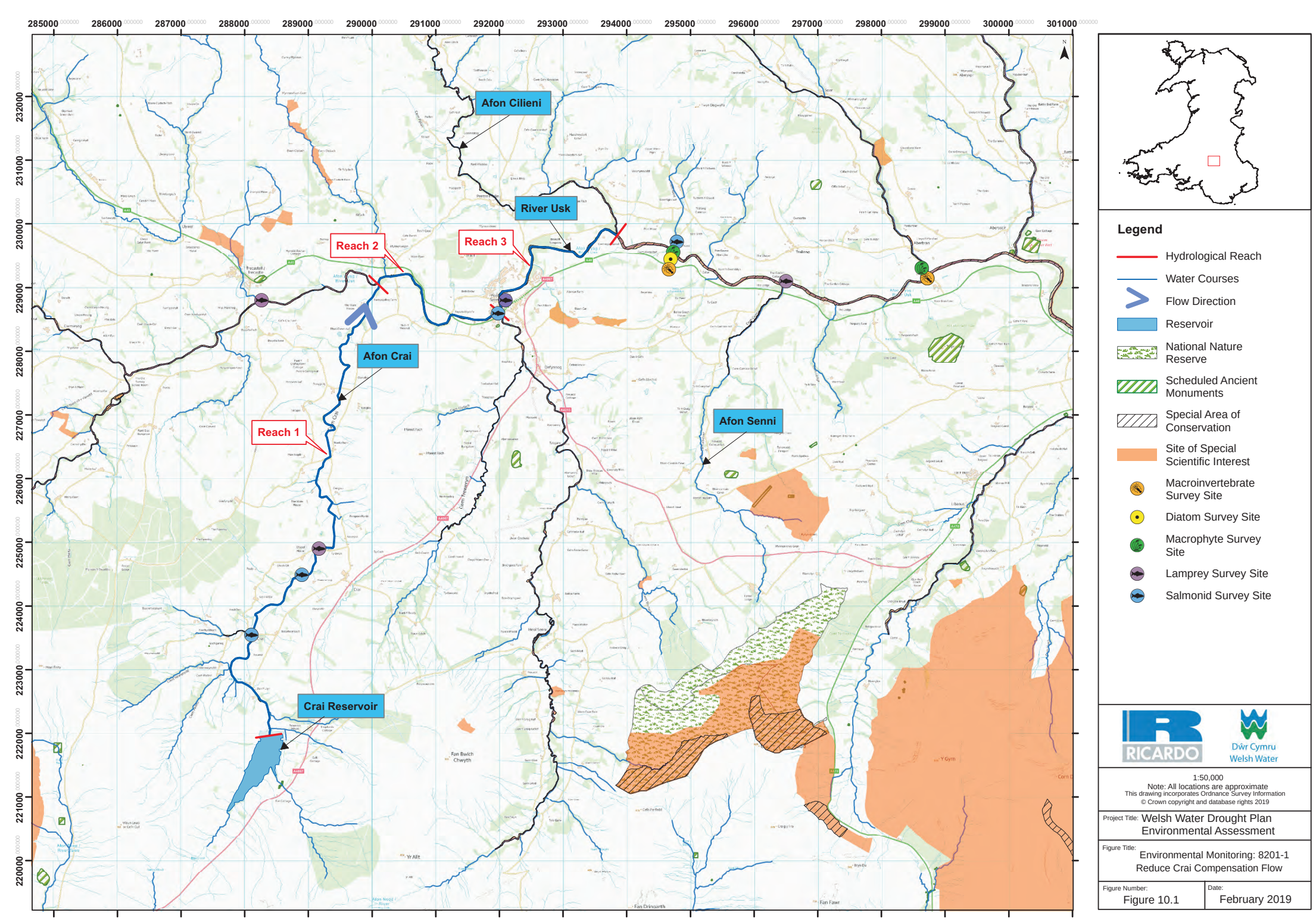
[13] Wild Trout Trust Habitat Management Sheet – Gravel Cleaning http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf
[14] Wild Trout Trust Chalkstream Habitat Manual – Use of Large Woody Debris http://www.wildtrout.org/sites/default/files/library/Large_Woody_Debris.pdf
[15] Wild Trout Trust Habitat Management Sheet – Gravel Cleaning http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf
[16] Wild Trout Trust Chalkstream Habitat Manual – Use of Large Woody Debris http://www.wildtrout.org/sites/default/files/library/Large_Woody_Debris.pdf

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
			ponded reach, where safe and practical to do so.	dissolved oxygen.	standing or slow flowing water with low oxygen levels. • Targeted installation of woody debris features to provide submerged and overhead cover from predation where significant abundances of fish have been identified by walkover surveys. Consider provision of physical deterrents to deter piscivorous birds at significant locations (e.g. scare crows) in consultation with NRW. In extreme cases (where environmental parameters such as dissolved oxygen and temperature allow), consider removal of concentrated abundances of fish deemed to be stranded/at risk, relocating fish to suitable locations outside of the impacted reach within more suitable catchment, but would need to be discussed with NRW to ensure compliance with the Keeping and Introduction of Fish	sediment transport and increase water depth for spawning depth) If the results of the walkovers deem important habitats to be at risk to exposure/ reduction (in extent), the following mitigation action/s may be undertaken: • Targeted fish passage assessment of barriers /obstructions to fish passage and any associated fish passes should be undertaken to ascertain if they pose an increased risk to the free movement of fish during key migration periods, i.e. during juvenile eel migration (spring/summer). • Modify any impacted fish passes (where possible) to ensure passage is achievable during key migration periods (e.g. agree to provide an appropriate proportion of flow into the pass to enable passage). Where fish passage is not currently provided at a barrier, investigate appropriate methods of improving passage (e.g. fish passage design and installation).	

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
					Regulations 2014. Modify any impacted fish passes (where possible) to ensure passage is maintained during key migration periods (e.g. agree to provide an appropriate proportion of flow into the pass to enable passage). Consider 'Trap & Transport' of concentrated abundances of migrating fish accumulated below impassable barrier/s to spawning grounds upstream of the impacted reach (where environmental parameters such as dissolved oxygen and temperature allow). Alternatively, mitigation should seek to protect any populations 'trapped' as a result of the barrier/s until flows increase for example by using aeration (if dissolved oxygen levels are low) or preventing predation (see Increased Mortality impact mitigation actions outlined above). Deployment of aeration equipment in key reaches that have standing or		

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	**Monitoring and trigger setting**	**Trigger and monitoring to inform mitigation action**	**Mitigation actions triggered by monitoring**	**Monitoring and post-drought mitigation (where applicable)**	
					slow flowing water with low oxygen levels.		
River Usk SAC	• Impacts on river lamprey, brook lamprey, Atlantic salmon and bullhead (Annex II species for which the SAC has been designated) have been assessed as major in Reach 1.	See fisheries surveys.	See fisheries surveys. At the onset of drought conditions and at least four-weeks prior to the implementation of the drought order, detailed survey to inform the mapping of the distribution of lamprey, Atlantic salmon and bullhead habitat will be required The mapping of lamprey habitat and the determination of the percentage distribution of optimal, sub-optimal and unsuitable lamprey habitat within the zone of influence. Semi quantitative and quantitative surveys to inform targets for attributes as indicated in the SAC Core Management Plan	See fisheries surveys. Semi quantitative and quantitative surveys to inform targets for attributes as indicated in the SAC Core Management Plan.	See fisheries surveys.	See fisheries surveys. Semi quantitative and quantitative surveys to inform targets for attributes as indicated in the SAC Core Management Plan.	Welsh Water
Phytobenthos **Reach 1**	• Decrease in flow affecting phytobenthos community composition.	The phytobenthos community in the impacted reach is not well understood. Surveys to ideally be carried out to provide a three-year	Sampling according to DARLEQ2 protocol, at baseline survey sites, in spring and autumn.	Sampling according to DARLEQ2 protocol, at baseline survey sites, in spring and autumn.	No additional measures specified.	Sampling according to DARLEQ2 protocol, at baseline survey sites, in spring and autumn.	Welsh Water

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	• Low risk of deterioration to SRP affecting phytobenthos community composition and TDI score. • Increases in filamentous algae smothering the substrate.	baseline dataset, then repeated every three years. Monitoring sites should be informed by initial walkovers at sensitive sites.					



Legend

- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- National Nature Reserve
- Scheduled Ancient Monuments
- Special Area of Conservation
- Site of Special Scientific Interest
- Macroinvertebrate Survey Site
- Diatom Survey Site
- Macrophyte Survey Site
- Lamprey Survey Site
- Salmonid Survey Site

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Note: All locations are approximate

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Environmental Monitoring: 8201-1 Reduce Crai Compensation Flow

Figure Number: Figure 10.1

Date: February 2019

11 CONCLUSIONS

This EAR provides an assessment of the potential environmental impacts relating to the implementation of the Crai Reservoir drought order. If granted and implemented, the drought order would enable Welsh Water to reduce the total flow release to the Afon Crai by 3.4Ml/d, conserving storage in the reservoir.

The scope of the assessment has been defined by an impact screening and scoping exercise. In accordance with the DPG, the screening exercise involved two stages, a hydrological impact assessment (Stage 1) and the identification of the environmental features that could be affected by the drought order (Stage 2).

The assessment has concluded that there is a **major** impact on flows in the Afon Crai as a result of implementing the drought order. Impacts on the River Usk have been assessed as **minor** during August to September, and **negligible** during October to November. These hydrological impacts are assessed as leading to **moderate** impacts on the physical environment of the river, including water quality.

An environmental assessment was therefore required and included for features where screening has identified a major or moderate impact. Screening identified designated sites, WFD status and Community Assessment / Environment (Wales) Act Section 7 Species, landscape, archaeology and recreation as environmental features for which an environmental assessment was required. The assessment has concluded that during periods when there is a reduction in total flow release from Crai Reservoir to the Afon Crai there are **major** to **moderate** impacts on the River Usk (Upper Usk) SSSI, fish, **moderate** to **minor** impacts on macroinvertebrates and phytobenthos and **moderate** to **negligible** impacts on macrophyte.

The HRA Screening could not conclude that implementation of a drought order would not result in likely significant effects on the brook and river lamprey, Atlantic salmon and bullhead populations within the River Usk SAC.

No cumulative effects of implementing the drought order with other existing licences, consents and plans are currently anticipated. However, this should be reviewed at the time of any future application for a drought order at Crai Reservoir.

The environmental assessment has identified significant impacts of implementation of a drought order at Crai Reservoir. Consequently, in line with the DPG, mitigation measures have been proposed and further discussion with NRW is required in order to develop suitable mitigation measures.

In summary, it has been concluded that the environmental effects on river flows and ecology of implementing a drought order at Crai Reservoir, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **major**.

APPENDIX A
HYDROLOGY AND HYDROGEOLOGY METHODOLOGY

A.1 HYDROLOGICAL AND HYDROGEOLOGY IMPACT METHODOLOGY (STAGE 1 SCREENING)

Consideration is required (by the DPG[1]) of the likely changes in flow / level regime due to implementing the drought management action, specifically:

- the perceived extent of potential impact
- the nature and duration of the potential impact
- the timing of the potential impact.

The hydrogeological and hydrological information is used together with information on the other environmental features in the study area from Stage 2 - Environmental Sensitivity (see Section 3.2.1 in main report) to identify the environmental risk of the drought order / permit.

Although the DPG informs the hydrometric data to be used as part of environmental features for consideration within the environmental assessment (see Box 1 Appendix H of the DPG), it does not provide a methodology for identifying the hydrological impact.

Cascade has developed a flexible approach[2] to identifying the spatial extent of the study area from hydrological information and characterising the hydrological impact within the study area, in terms of the scale, nature, duration and timing of impacts, although this is only appropriate to apply to reaches that do not dry naturally. A hydrological methodology for watercourses that naturally dry for part of the year is also presented that characterises the hydrological impact within the study area, in terms of the scale, nature, duration and timing of impacts. These are presented below.

Perennially flowing watercourse hydrological methodology

This methodology is applied to watercourses that flow throughout the year and that are potentially impacted on by the drought order / permit.

Core to this approach is the use of relevant long term flow statistics to inform the scale of hydrological impact and thereby delimit the zone of influence in the downstream river system. To determine these, potential reductions in flow resulting from implementation of the drought order / permit are compared with flows without the drought order / permit in place (i.e. the additional abstraction advocated by the drought order / permit over and above the existing abstraction). This helps to determine the scale of potential impact at any particular site/ feature using the matrix in **Figure A.1** or **Figure A.2** depending on the altitude of the waterbody and whether it is classified as lowland or upland[3]. Where possible, the hydrological assessments presented in previous EMPs and EARs of the drought options have been used to

1 Welsh Government / Defra / NRW / Environment Agency (2011). Water Company Drought Plan Guideline. June 2011.
2 Hydrological impact approach used in previous drought plan environmental assessments for water companies including Thames Water, Yorkshire Water and United Utilities
3 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.
The Directions set out the principles of classification of surface water and groundwater bodies, including the use of 80m above Ordnance Datum as the altitude that differentiates water quality requirements for upland and lowland biology. Where there are ambiguities, or thresholds are crossed, upland is assumed to apply to ensure a precautionary assessment.

help identify the spatial extent of the study area from hydrological information and characterising the hydrological impact within the study area.

Figure A.1 Hydrological Assessment Matrix (Upland)

		Summer Q99		
	% reduction in flow	<10%	10-25%	>25%
Summer Q95	<10%	Negligible	Minor	Moderate
	10-25%	Minor	Moderate	Major
	>25%	Moderate	Major	Major

Figure A.2 Hydrological Assessment Matrix (Lowland)

		Summer Q99		
	% reduction in flow	<10%	10-25%	>25%
Summer Q95	<20%	Negligible	Minor	Moderate
	20-50%	Minor	Moderate	Major
	>50%	Moderate	Major	Major

Figure A.1 illustrates that at the time of implementation of a drought order / permit, upland river systems of relevance to each of these proposed options will exhibit high sensitivity to changes in low flow (represented by Q_{95}, summer[4]) and very high sensitivity to changes in extreme low flow (represented by Q_{99}, summer). As illustrated by **Figure A.2**, lowland rivers of relevance to each of these proposed options are considered to be less sensitive to reductions in summer low flows (summer Q_{95}), but similarly sensitive to reductions in extreme summer low flows (summer Q_{99}).

Figures A.1 and **A.2** are appropriate for the assessment of hydrological impacts on low flow regimes in watercourses during the spring, summer and autumn. However, in some cases there is a need to assess the impacts of drought order schemes on watercourses during the winter. For example, a reduction in compensation release may remain in force during the winter high flow period, to increase the probability of reservoir refill prior to the following year's spring/summer drawdown period. During the winter season, watercourses have relatively lower sensitivity to changes in low flow, and moderate sensitivity to changes in moderate flow. This can be reflected by the use of the matrices in **Figures A.3** and **A.4** for the assessment of drought order / permit schemes which are only likely to impact on a watercourse during the winter. The categorisation of impacts as negligible, minor, moderate or major is based on the percentage reduction in year round low flow (Q95) and year round median flow (Q50).

Figure A.3 Hydrological Assessment Matrix (Upland / Winter)

		Year round Q95		
	% reduction in flow	<10%	10-25%	>25%
Year round Q50	<10%	Negligible	Minor	Moderate
	10-25%	Minor	Moderate	Major
	>25%	Moderate	Major	Major

[4] Flow statistics indicate the proportion of days a flow is equalled or exceeded. Therefore Q95 indicates flow equalled or exceeded on 95% of days in the measured record (equivalent to an average of 347 days per year)

Figure A.4 Hydrological Assessment Matrix (Lowland / Winter)

		Year round Q95		
	% reduction in flow	<10%	10-25%	>25%
Year round Q50	<20%	Negligible	Minor	Moderate
	20-50%	Minor	Moderate	Major
	>50%	Moderate	Major	Major

The matrices are 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. Typically reaches have been delimited by the addition of flow from a significant tributary or discharge; although the similarity of geomorphological characteristics of the reach may also be important in reach specification. The matrices can be applied to a variety of upland or lowland catchments respectively including those dominated by groundwater, and can be applied until the tidal limit.

In addition to the information provided by summary flow statistics in the matrix, information on the timing, duration and relevant seasons of the drought order / permit impacts have been informed by licence details and river gauging data have also been used to characterise the likely nature of the drought order / permit impacts.

If the drought order / permit does not impact on the magnitude of low flows in a watercourse, but does cause changes in the duration of low flow periods (which can be quantified), then the matrix in **Figure A.5** may be appropriate. The assessment is based on the percentage increase in the number of days for which flow is at or below the low flow (Q95) value. Typically this would be the case when the low flow regime in a watercourse downstream of a reservoir is protected by a statutory compensation release from the reservoir, but the reservoir may be drawn down below top water level for longer periods due to increased direct abstraction under the drought order / permit conditions.

If low flows in a watercourse are adversely affected in both magnitude and duration, then the impacts on magnitude are always used to determine the significance of hydrological impacts, using the appropriate matrix from **Figures A.1** to **A.4** inclusive. **Figure A.5** is only used when the impacts on low flows are on duration only.

Figure A.5 Hydrological Assessment Matrix (Low Flow Duration)

Percentage increase in low flow duration	Significance
<5%	Negligible
5-10%	Minor
10-25%	Moderate
>25%	Major

Intermittently flowing watercourse hydrological methodology

This methodology is applied to watercourses, potentially impacted on by the drought order / permit, that flow for most of the time but seasonally or occasionally ceasing to flow in response to decreased water availability e.g. due to increased evapotranspiration or bed seepage. . Such watercourses are identified from previous investigations and available data. Examples of watercourses where this methodology would be applied include winter bournes or watercourses that dry along their route due to losses to underlying aquifers. The impact classification of this methodology is as follows:

- Major - If the drought order / permit resulted in sections drying that did not dry up anyway
- Moderate - If the drought order / permit resulted in sections drying earlier (by more than a week) and / or recovering later (by more than a week) and hence flow reduction occurring in the channel for more than a week
- Minor - If the drought order / permit resulted in sections drying earlier (up to a week) and/or recovering later (by up to a week) and hence flow reduction occurring in the channel for up to a week OR if the drought order / permit were a secondary flow driver (e.g. flow through gravels being primary cause of flow losses rather than the drought order / permit)
- Negligible - No significant impact

In addition to the derived classifications, information on the timing, duration and relevant seasons of the drought order / permit impacts have been informed by licence details, available data and findings of previous investigations. These have been used to characterise the likely nature of the drought order / permit impacts.

Reservoir hydrological methodology

More recently Cascade has developed a similar approach to categorise the significance of hydrological impacts of drought order / permit operations on reservoirs. The assessment requires an estimate of the relative change in duration of reservoir drawdown (i.e. the period for which water in the reservoir is below top water level), and the percentage decrease in the minimum reservoir level reached during the drawdown period. These two parameters are then compared against the reservoir impacts hydrological assessment matrix in **Figure A.6**.

This approach would be a suitable method to assess the impacts of a drought order / permit which involves significant changes to the reservoir water level regime (that would not normally be experienced during a drought without any additional measures implemented). For example, a drought order / permit may involve increasing daily or annual licensed abstraction limits to allow an increased rate of direct abstraction from the reservoir. This may enable some or all of a reservoir's emergency storage volume to be utilised, but is likely to lead to both lower water levels and increased periods of time below top water level.

Figure A.6 Hydrological Assessment Matrix (Reservoir Impacts)

	% Increase in duration of reservoir drawdown			
% Decrease in minimum reservoir level	<5%	5-10%	10-25%	>25%
<5%	Negligible	Negligible	Minor	Moderate
5-10%	Negligible	Minor	Moderate	Major
10-25%	Minor	Moderate	Major	Major
>25%	Moderate	Major	Major	Major

Additional Considerations

For groundwater schemes, hydrogeological data, where available, has been reviewed to inform the study area and duration of any impacts (noting impacts on groundwater may extend beyond the six month period of drought order / permit implementation - see below). An increase in groundwater abstractions would lead to an increased cone of depression in groundwater levels for groundwater abstraction. This impact can affect other non-surface water receptors such as other wells, springs or groundwater dependent ecosystems. It could also mean that surface water impacts would extend upstream of the abstraction point or, in significant instances, to other watercourses some distance from the abstraction.

For groundwater abstractions, the impact of a drought order / permit could extend beyond the six month period (time limited) of abstraction depending on the local hydrogeology of the area. During drought situations, where there is limited recharge to the aquifer system, the abstraction can be mainly at the expense of groundwater stored in the aquifer. This can, in the long run, delay groundwater level recovery and have a knock on effect on baseflow contributions to watercourses. Flows could, therefore, be reduced for longer than the six month period during which the drought order / permit could be implemented and, as such, has been considered as part of the assessment described in this report.

APPENDIX B
HYDROLOGY AND PHYSICAL ENVIRONMENT ASSESSMENT

B1 INTRODUCTION

This appendix assesses the potential impacts on the physical environment of the Crai Reservoir and the downstream Afon Crai and River Usk catchments during the period of implementation of the drought order.

For the purposes of this assessment, the "without drought order" baseline includes the continuation of Welsh Water's existing abstraction and compensation flow release arrangements at Crai Reservoir, with the statutory compensation flow release rate set to 6.82Ml/d. The assessed drought order assumes a reduced rate of compensation flow release of 3.42Ml/d.

B.1.1 Welsh Water's Existing Operations

Welsh Water's licence (number 20/56/53/0002) to abstract water under the Water Resources Act at Crai Reservoir (see **Figure B1.1**) includes the following conditions:

- 15,774 million litres (Ml) authorised to be abstracted per annum.
- At an abstraction rate not exceeding 43.2Ml/d.
- Provision of a uniform statutory compensation water discharge of 6.82Ml/d at all times.

The abstraction for potable supply is made directly from the reservoir and piped by gravity to Crai Water Treatment Works (WTW) for treatment. Distribution is by mains to towns in the Tawe valley and north Swansea, with overlap into the Felindre zone.

B.1.2 Welsh Water's Proposed Drought Order Operations

The drought order involves a proposed reduction in the statutory compensation release from Crai Reservoir to the Afon Crai from 6.82Ml/d to 3.42Ml/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought, and improve the probability of reservoir winter refill. The drought order scheme will influence the downstream Afon Crai and may influence the upper River Usk.

The timing of the reduction in the compensation release is most likely to occur during the period from August to November inclusive. This is based on modelling of Crai Reservoir performance under normal operating conditions, together with Welsh Water's experience of operating the source.

The study area is shown on **Figure B1.1**.

The physical environment includes consideration of hydrology and hydrodynamics, geomorphology and water quality. The assessment has three principal objectives:

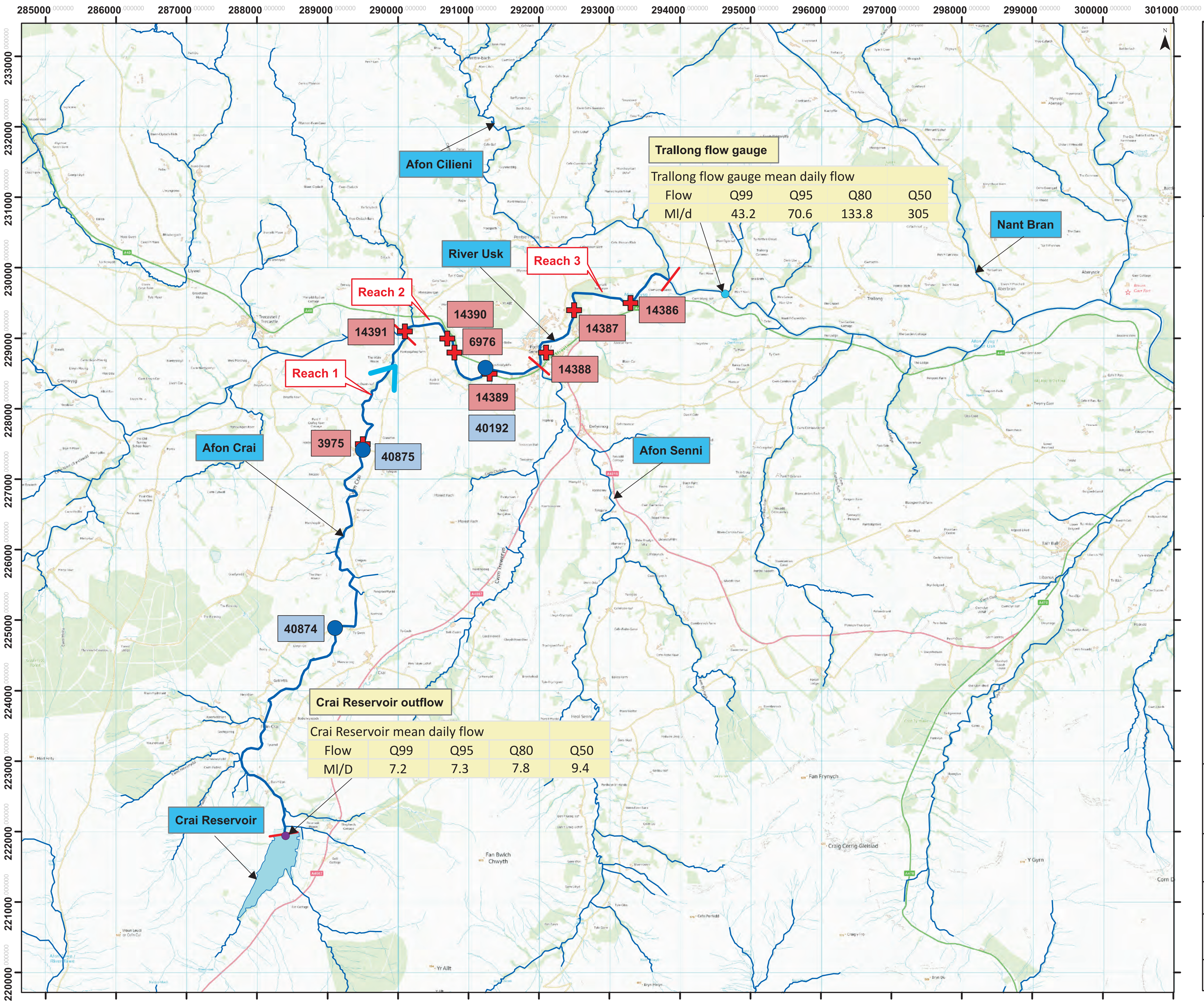
1. To "list the likely impacts to the flow, level, channel/riparian form and sediment due to

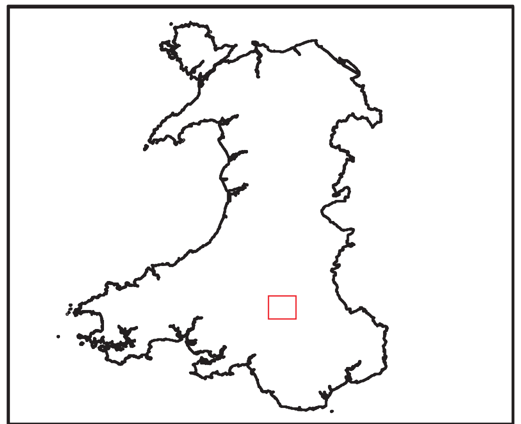
action being in place" as required by the DPG[1] and set out in Figure 2 of the DPG.

2. It is used to support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Section 5 of the main report.
3. Where sensitive features are the physical environment itself, it provides supporting technical information for their screening and assessment.

This appendix is set out in the following sections:

[1] Natural Resources Wales (2017) *Water Company Drought Plan Technical Guideline*. Available at https://cdn.naturalresources.wales/media/684414/final-wc-drought-plan-guidance-2017.pdf?mode=pad&rnd=131656713580000000, Accessed 04 February 2019.





Legend

- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- Abstraction
- RHS Site
- WQ Site
- Flow Gauge

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Note: All locations are approximate
This drawing incorporates Ordnance Survey Information

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Hydrological Overview: 8201-1 Crai Reservoir

Figure Number: Figure B1.1

Date: February 2019

B2 HYDROLOGICAL IMPACT

B.2.1 Reference Conditions

B.2.1.1 Catchment Overview

This small river catchment (33km² total drainage area from upstream of Crai Reservoir to the River Usk confluence) is located in the Brecon Beacons National Park in south Wales. The Afon Crai flows into the upper River Usk 9.3km downstream of Crai Reservoir. The River Usk is one of the largest rivers in Wales, and is over 120km long from its source on the northern slopes of the Black Mountain to its confluence with the Severn Estuary below Newport. The upper River Usk catchment includes the headwaters of the River Usk (including Usk reservoir) and the tributaries of the Afon Crai, Afon Senni, Afon Cilieni and Nant Bran.

Crai Reservoir was constructed between 1898 and 1906. The 28m high concrete embankment holds back a maximum usable storage of 4,204Ml with a surface area of 40ha (at top water level) at an altitude of around 310m. The 11.4km² catchment draining into the reservoir has high rainfall on upland moors and unimproved grassland with large areas now given over to conifer plantations, and includes the Cnewr catchment which is diverted into the reservoir.

The compensation release from Crai Reservoir sustains flow in the downstream Afon Crai in the upper catchment of the River Usk. There are no significant tributaries to the Afon Crai downstream of Crai Reservoir, until the confluence with the River Usk. The compensation releases from Crai Reservoir will be a substantial proportion of the flow during low flow periods. The Afon Crai is a significant tributary of the upper River Usk and the drought order may have hydrological impacts in the upper River Usk. Flow in the upper River Usk is influenced by the impoundment of Usk Reservoir and compensation release requirements. Further major tributaries, the Afon Senni, Afon Cilieni and Nant Bran flow into the River Usk downstream of the Afon Crai confluence (see **Figure B1.1**). The hydrological impacts of the drought order on the River Usk may result in a minor reduction in wetted width and wetted depth, but will reduce successively downstream of each tributary. These impacts may not be identifiable downstream of the Afon Senni confluence and will most probably be immeasurable downstream of the Afon Cilieni confluence.

A review of the flows and physical habitat characteristics of the river network around Crai Reservoir has identified the study area for this assessment. The study area includes the Afon Crai and the River Usk, comprising three distinct hydrological reaches as listed in in **Table B2.6** and **Table B2.7** and identified on **Figure B1.1**. The potential hydrological impact of the drought order has been reviewed separately for the reservoir and each of the three hydrological reaches. This is discussed in Section B.2.2.

B.2.1.2 Baseline Data Availability

Continuous monitoring is undertaken by Welsh Water to monitor its operations at Crai Reservoir, including:

- Weekly Crai Reservoir storage volumes: 1989 to 1991.
- Daily Crai Reservoir storage volumes: 1992 to date.
- Daily abstractions from Crai Reservoir: 1991 to date.

The monitoring of compensation flow releases and the overflow (spill) of excess water from Crai Reservoir is undertaken by Welsh Water at a flow measuring gauge on the Afon Crai downstream of the impoundment:

- Daily mean Afon Crai flows downstream of Crai Reservoir: 2013 to date (with a period of missing data from October 2016 to February 2017).

Continuous monitoring of river level is undertaken by Natural Resources Wales (NRW) at the Trallong flow gauge on the upper River Usk and flow data are available for this gauge prior to 1984. A rating equation is available which has been used to convert measured levels to river flow from 1984 onwards, however there are considerable uncertainties as to whether the historic rating is still valid. The available flow data include:

- NRW Trallong River flow gauge on the River Usk: daily river flow from 1970 to 2015 (some periods missing, in particular 1984 to 1986).

As the Trallong gauge only records river levels, and the validity of the rating curve is uncertain, flows derived from this record have been used only as a comparator. The best available set of flow data for the upper River Usk has been derived as part of a recent modelling project and provided by NRW for the purposes of this assessment; further details are given in section B.2.2.2.

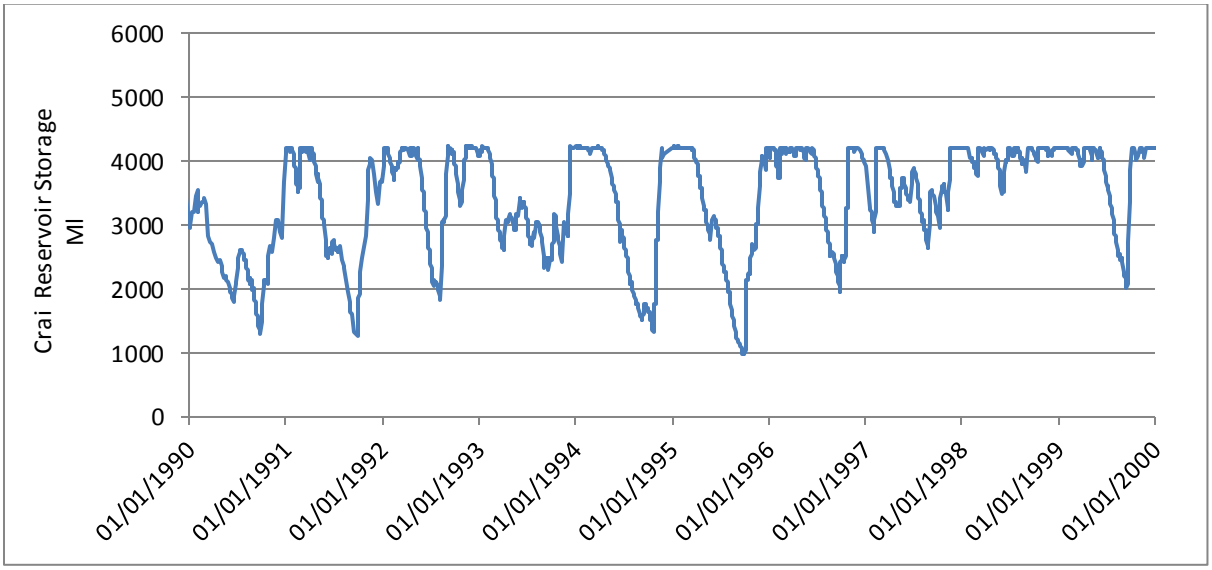
The reference conditions of the Crai Reservoir and Afon Crai and upper River Usk catchments are summarised below.

B.2.1.3 Hydrology

Crai Reservoir

Storage in Crai Reservoir ranges from a minimum of 1,170Ml (around 28% of live capacity) to 4,204Ml (full) over the period 1989 to 2018. The lowest storage of 1,170Ml occurred in September 1995. **Figure B2.1** illustrates the pattern of reservoir storage over a ten-year period from 1990 to 1999, which includes some notably dry periods.

Figure B2.1 Crai Reservoir Storage, 1990 to 1999



Afon Crai at Crai Reservoir

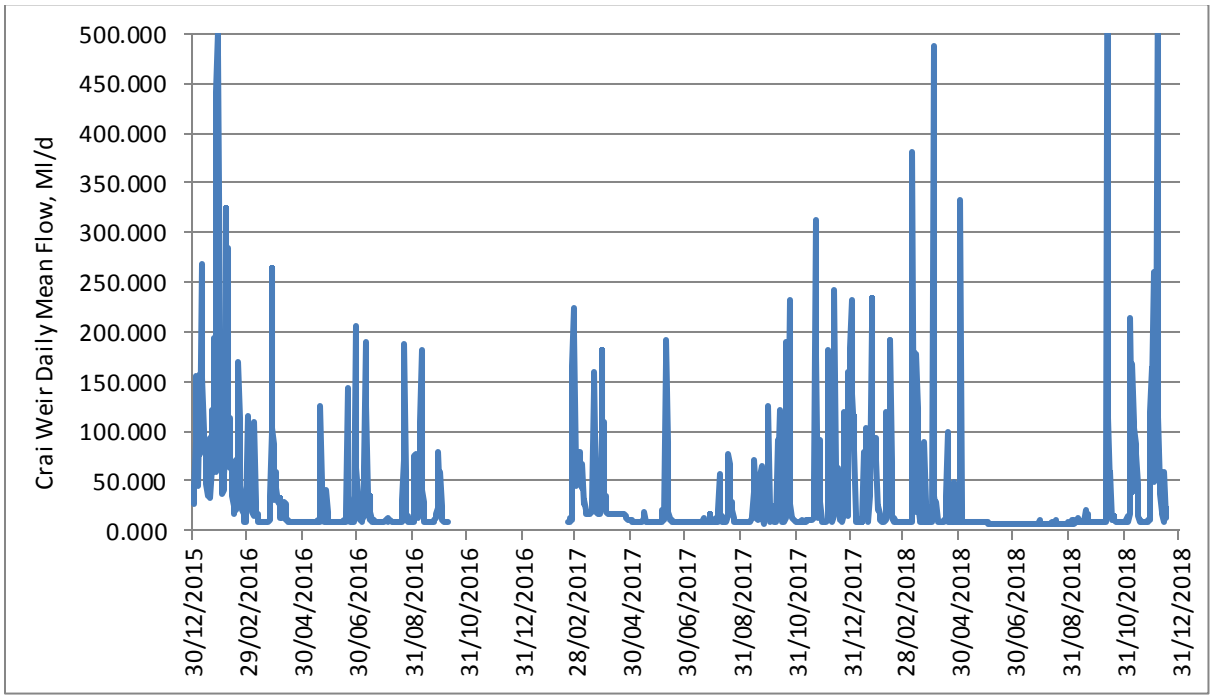
Flow is measured in the Afon Crai just downstream of the Crai Reservoir impoundment. A summary of the available daily flow data from 2013 onwards is provided in **Table B2.1** below. Note that these flow statistics exclude a period of missing data from October 2016 to February 2017. The low flow statistics for the summer period (1st April to 30th September inclusive) are: Summer Q_{95} = 7.21Ml/d; Summer Q_{99} = 7.10Ml/d.

Figure B2.2 shows the typical pattern of flows at Crai Reservoir in normal weather conditions from 2015 to 2018. The flow profile is clearly heavily influenced by the compensation releases, which appear to be set at a rate of around 7Ml/d. Additional spills significantly above this rate only occur for around 10% of the time, and this reflects the regular pattern of reservoir drawdown below top water level as indicated in **Figure B2.1**.

Table B2.1 Summary of Recorded Mean, Maximum and Minimum Daily Flow in Afon Crai Downstream of Crai Reservoir (2013 to 2018)

Percentage of time river flow equalled or exceeded	Mean daily flow Ml/d, per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum flow	501.0	419.8	380.2	488.2	332.2	326.7	189.5	234.2	181.8	793.1	375.6	567.9	793.1
10% (high flow)	227.6	186.6	92.6	32.1	26.2	20.3	23.6	41.3	40.8	59.1	171.7	182.1	101.8
50%	77.8	43.9	17.9	9.0	8.5	8.2	8.0	8.4	8.4	9.1	17.2	38.5	9.4
80%	34.3	8.8	8.4	7.7	7.9	7.4	7.3	7.4	7.4	7.9	8.9	10.6	7.8
90%	17.6	8.1	8.0	7.5	7.7	7.4	7.2	7.3	7.3	7.8	8.1	8.5	7.4
95% (low flow)	8.6	7.9	7.7	7.4	7.6	7.3	7.2	7.2	7.2	7.8	8.1	8.2	7.3
99% (extreme low flow)	8.0	7.8	7.6	7.3	7.4	6.5	7.1	7.2	6.6	7.1	7.9	8.1	7.2
Minimum flow	7.9	7.7	7.5	7.3	7.3	3.0	7.1	5.1	4.6	7.1	7.9	8.1	3.0

Figure B2.2 Afon Crai at Crai Reservoir Flows (2015 to 2018)



River Usk at Trallong

Continuous monitoring of the river level on the River Usk at the Trallong level gauging station (grid reference SN947295) at an altitude of 166m AOD is conducted by NRW. The data record is available as daily river flows from 1963 to 1984. From 1984 onwards the station has been continued as a level-only gauge but a historic rating equation has been provided and recorded levels from 1984 onwards have been converted into flow values. The full record from 1963 to 2015 is summarised in **Table B2.2**; note however that there are some missing periods in the data record, most notably the two year period from June 1984 to May 1986. Note also, as referred to earlier, that there is uncertainty as to whether the rating equation is still valid for the current level-only gauge.

The low flow statistics for the summer period (1st April to 30th September inclusive) are: Summer Q_{95} = 58.3Ml/d; Summer Q_{99} = 36.3Ml/d.

Figure B2.3 shows the typical flow patterns in the River Usk from 1975 to 1976, a period which includes the notably dry summer of 1976. The flow duration curve for this gauging station is shown in **Figure B2.4**.

Table B2.2 Summary of Recorded Mean, Maximum and Minimum Daily Flow in the River Usk at Trallong gauging station (1963 - 2015)

Percentage of time river flow equalled or exceeded	Mean daily flow Ml/d, per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum flow	8,354	13,714	13,332	4,147	3,898	2,994	2,878	3,431	5,336	11,371	7,099	12,580	13,714
10% (high flow)	2,520	1,858	1,255	829	663	473	399	464	847	1,417	1,879	2,405	1,360
50%	726	501	401	278	214	159	130	148	172	348	592	675	305
80%	355	265	216	152	127	98	76	78	85	152	297	317	134
90%	248	200	159	124	99	77	60	60	64	102	222	231	94
95% (low flow)	191	170	130	99	82	61	47	54	52	76	168	174	71
99% (extreme low flow)	129	143	100	68	53	20	34	34	40	39	111	126	43
Minimum flow	114	120	78	53	45	12	13	28	29	34	37	94	12

Figure B2.3 River Usk at Trallong (1975 to 1976)

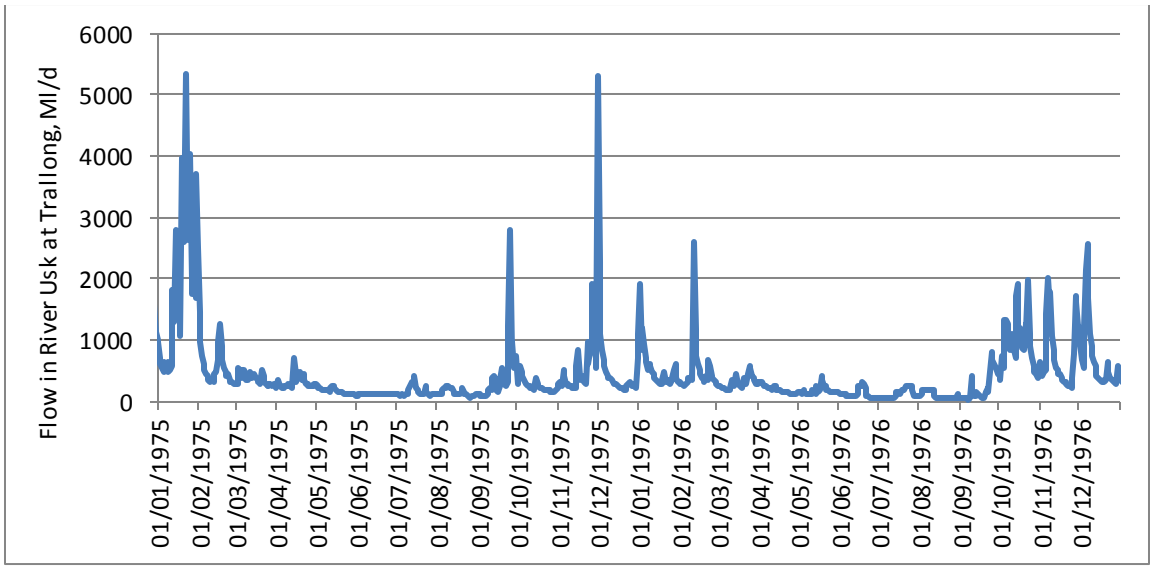
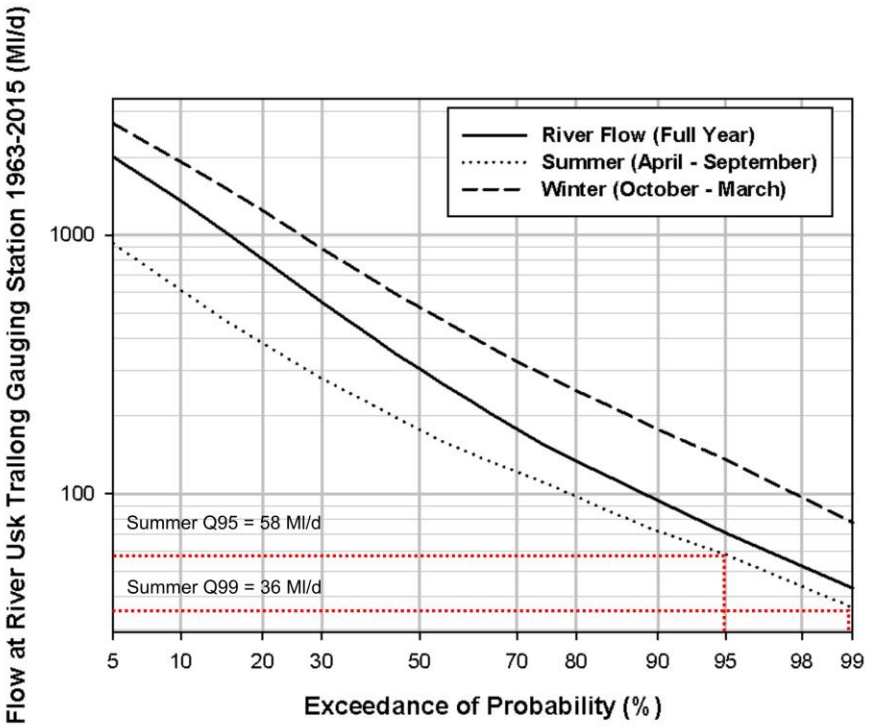


Figure B2.4 River Usk at Trallong Flow Duration Curve (1963 to 2015)



B.2.2 Hydrological Impact

B.2.2.1 Hydrological Zone of Influence

The study area includes Crai Reservoir, the downstream Afon Crai and the River Usk from the Afon Crai confluence down to the confluence with Afon Cilieni, comprising four distinct hydrological reaches as shown in **Figure B1.1**:

- Reach 1 is the Afon Crai, from the Crai Reservoir outflow to the River Usk confluence.
- Reach 2 is the River Usk, from the Afon Crai confluence to the Afon Senni confluence.
- Reach 3 is the River Usk, from the Afon Senni to the Afon Cilieni confluence.

The potential hydrological impacts of the drought order option have also been considered for Crai Reservoir itself. **Table B2.6** and **Table B2.7** provide a summary of the hydrological impacts at the end of this section whilst the details of the assessment are presented below.

B.2.2.2 Hydrological Impact Assessment

Crai Reservoir

The impact on Crai Reservoir would be a marginal increase in levels / storage, relative to the position without the drought order, due to the reduced outflow which would help to conserve water in storage. The length of time of shoreline exposure would be slightly shorter, compared to the baseline drought scenario, as the reservoir would reach top water level slightly earlier during the winter refill period. This is considered a **minor beneficial** impact and has not been assessed further.

Assessment of River Reach Impacts

In order to assess the potential hydrological impacts on each of the three river reaches, estimates of key flow statistics are required. There are limited spot flow gauging data available between the reservoir outflow gauge and the gauging station at Trallong, mainly undertaken during summer 2003 by Environment Agency Wales (now NRW) as part of its Catchment Abstraction Management Strategy (CAMS) assessments (see **Table B2.3** which includes data (shaded rows) for the lower Afon Crai downstream of Crai Reservoir). As a consequence, the summer (April to September inclusive) and year-round flow statistics for the River Usk at locations downstream of the Crai Reservoir flow gauge have been estimated from the modelled data set provided by NRW ("historic" scenario). The modelled data is based on historic gauged reservoir outflow combined with modelled natural accretion downstream. The data covers the period 1973 to 2011 for a number of locations between the Usk Reservoir outflow and the confluence with the Afon Clydach, including locations on the Afon Crai. **Table B2.4** summarises the key flow statistics at the relevant locations in reaches 1 and 2 (the modelled data does not cover Reach 3), and **Figure B2.5** shows the modelled flow duration curve at the top of reach 2 (River Usk downstream of the Afon Crai confluence).

For comparison, and in particular for reach 3 which is not covered by the modelled data, flow statistics have also been calculated from the Trallong flow record, by apportionment based on relative catchment areas and spot flow data where appropriate. A summary of the catchment areas and estimates of key flow statistics at relevant locations within the study area is given in **Table B2.5**.

Table B2.3 Summary of Spot Flow Gauging in the Study Area

Spot Gauge	Date	Location	Spot Flow (Ml/d)	Reservoir flow gauge (Ml/d)[1]	Trallong (Ml/d)	Trallong Summer Q statistic	Trallong Year-round Q statistic
Usk03	04/07/2003	Lower Afon Crai	25.4	7.3	60.5	94	96.5
Usk03	09/07/2003	Lower Afon Crai	31.5	7.3	57.9	95	97
Usk03	15/07/2003	Lower Afon Crai	15.4	7.3	55.3	96	97.5
Usk03	05/09/2003	Lower Afon Crai	23.4	6.8	51.8	96.5	98
Usk03	19/09/2003	Lower Afon Crai	18.4	8.0	45.8	98	99
Usk04	04/07/2003	Reach 2	50.6	10.4	60.5	94	96.5
Usk04	09/07/2003	Reach 2	50.8	11.6	57.9	95	97
Usk04	15/07/2003	Reach 2	43.6	9.9	55.3	96	97.5
Usk04	05/09/2003	Reach 2	45.1	10.4	51.8	96.5	98
Usk04	19/09/2003	Reach 2	31.9	11.1	45.8	98	99
Usk05	04/07/2003	Lower Afon Senni	17.0	10.4	60.5	94	96.5
Usk05	09/07/2003	Lower Afon Senni	15.2	11.6	57.9	95	97
Usk05	15/07/2003	Lower Afon Senni	12.5	9.9	55.3	96	97.5
Usk05	05/09/2003	Lower Afon Senni	8.8	10.4	51.8	96.5	98
Usk05	19/09/2003	Lower Afon Senni	9.6	n/a	45.8	98	99

[1] (Gauged flows measured downstream, of Usk Reservoir or Crai Reservoir, as applicable)

Table B2.4 Summary of Key Flow Statistics from Modelled Data: River Usk Catchment

Location	Estimated Key Flow Statistics Ml/d			
	Summer Q_{99}	Summer Q_{95}	Year round Q_{95}	Year round Q_{50}
Afon Crai compensation outflow (Upper Reach 1)	2.3	5.9	5.9	7.6
Afon Crai upstream of River Usk confluence (Lower Reach 1)	11.2	13.5	14.9	50.3
River Usk downstream of Afon Crai confluence (Upper Reach 2)	29.3	36.9	41.9	140.7
River Usk downstream of Afon Clydach confluence (Upper Reach 2)	30.4	38.7	44.1	151.2

Figure B2.5 Modelled Flow Duration Curve Ml/d – River Usk downstream of Afon Crai confluence (upper reach 2)

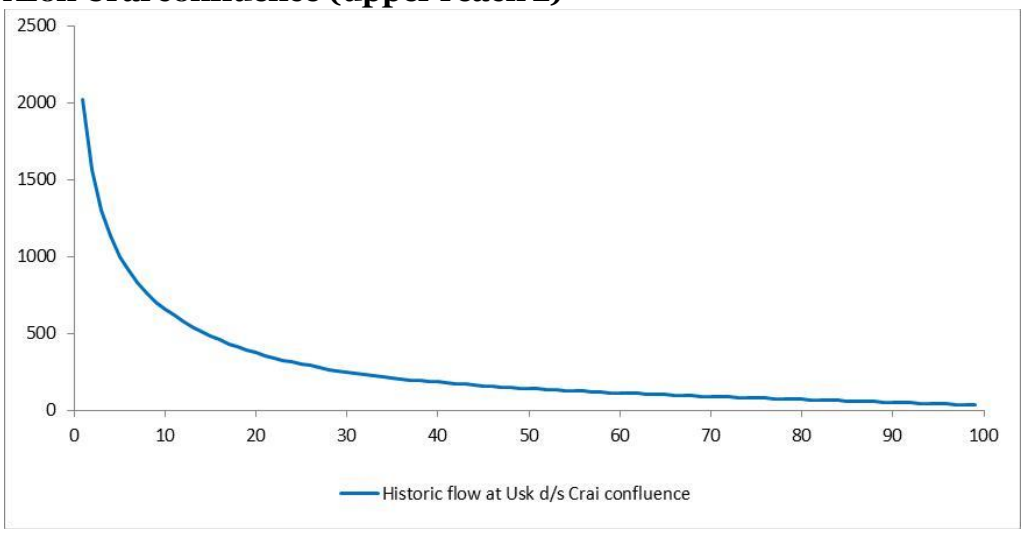


Table B2.5 Summary of Subcatchment Areas and Key Flow Statistics: Afon Crai and River Usk Catchments

Area/ location	Catchment area	Area-flow proportion at Trallong flow gauge	Estimated Key Flow Statistics Ml/d			
			Summer Q_{99}	Summer Q_{95}	Year round Q_{95}	Year round Q_{50}
Afon Crai downstream of Crai Reservoir (Upper Reach 1)	11.4km²	6% of gauged flow	2.1	3.4	4.1	17.7
Afon Crai upstream of Reach 2 (Lower Reach 1)	33km²	17% of gauged flow	6.2	9.9	12.0	52
River Usk (Upper Reach 2)	99km²	50% of gauged flow	18.2	29.1	35.3	153
River Usk (Lower Reach 2)	106 km²	54% of gauged flow	19.6	31.5	38.1	164.7
River Usk (Upper Reach 3)	148 km²	76% of gauged flow	27.6	40.5	53.7	232
River Usk (Lower Reach 3)	152 km²	78% of gauged flow	28.3	45.5	55.1	237.9
River Usk (Trallong flow gauge)	196km²	100% of gauged flow	36.3	58.3	70.6	305

Reach 1 – Afon Crai from Crai Reservoir outflow to River Usk confluence

The Afon Crai monitoring reach is the 9.3km linear river corridor restrained by a steep sided-valley from Crai Reservoir to the River Usk. With the exception of the Crai Reservoir impoundment and associated compensation discharge, there appears to be no other significant influences on flow or water level in the Afon Crai catchment.

In all but the wettest years there is no spill from Crai Reservoir during the period June to September. On average, there is a period of 180 consecutive days without spill from the reservoir, typically from March to November. During these periods, when effective rainfall is low, flow in the Afon Crai is sustained by compensation releases of a minimum of 6.82Ml/d from the Crai Reservoir, and minor flow accretion from the surrounding areas within the catchment. The reservoir impoundment also influences moderate and high flows in the catchment.

It is estimated that summer low flow conditions (summer Q_{95}) in lower Reach 1 are approximately 13.5Ml/d, based on the Usk modelled data set provided, whilst the summer extreme low flow (summer Q_{99}) in lower Reach 1 is estimated as 11.2Ml/d. These values are slightly lower than the low flows recorded as spot flow measurements, however we have used the lower values for the assessment as a precautionary approach.

During drought order implementation, summer low and extreme low flow would reduce by 50% in upper Reach 1, and by around 25% to 30% in lower Reach 1, due to the compensation reduction of 3.4Ml/d. Hydrological impacts associated with a reduction in compensation discharge will include a significant reduction in wetted width and wetted depth below those normally observed in the Afon Crai, affecting the stretch from Crai Reservoir to the confluence with the River Usk. The hydrological impact of the drought order on Reach 1 has therefore been assessed as **major** during the summer months of August to September inclusive.

During the winter months of October to November inclusive, year round low and median flow would reduce by 50% in upper Reach 1, due to the reduction in compensation which would be in place during the implementation period of the drought order. In lower Reach 1, the year round low and median flow statistics based on the Usk model data set are 14.9Ml/d (Q_{95}) and 50.3Ml/d (Q_{50}). The 3.4Ml/d flow reduction due to the reduced compensation therefore represents percentage reductions of 23% and 6.8% in the year round low and median flow values. This would be assessed as a **minor** hydrological impact.

The hydrological impact of the drought order on Reach 1 has therefore been assessed as **major** during the winter months of October to November inclusive, although it reduces to **minor** at the lower end of the reach.

Reach 2 – River Usk, from Afon Crai confluence to Afon Senni confluence

Low flows in the Afon Crai are supported by the year-round compensation flow releases of 6.82Ml/d from Crai Reservoir. Hydrological impacts associated with a reduction in compensation flow releases will include a moderate reduction in wetted width and wetted depth in this part of the River Usk.

In upper Reach 2, key summer flow statistics based on the Usk modelled data set are as follows: summer Q_{95} = 36.9Ml/d, summer Q_{99} =29.3Ml/d. A reduction of 3.4Ml/d in the compensation release rate therefore represents reductions of 9.2% and 11.6% in the summer Q_{95} and Q_{99} respectively. The hydrological impact of the drought order on Reach 2 has therefore been assessed as **minor** during the summer months of August to September inclusive**.**

For comparison**,** flow statistics based on area-flow proportions with Trallong flow gauge are as follows: summer Q_{95} = 29.1Ml/d, summer Q_{99} =18.2Ml/d. A reduction of 3.4Ml/d in the compensation release rate would therefore represents reduction of 11.7% and 18.7% in these values, and the hydrological impact of the drought order on Reach 2 would be assessed as moderate. The difference is mainly due to a significantly lower summer Q_{99} value estimated from the Trallong gauge as compared to the Usk modelled data set.

During the winter months of October to November inclusive, the year round flow statistics in Reach 2 based on the Usk modelled data set are as follows: Q_{95} = 41.9Ml/d, Q_{50} =140.7Ml/d. The flow reduction of 3.4Ml/d represents reductions of 8.1% and 2.4% respectively in these flow values and therefore the hydrological impact of the drought order would be assessed as **negligible** during the winter months. Again, for comparison the reductions were calculated using flow statistics based on area-flow proportions with Trallong flow gauge; the flow reduction of 3.4Ml/d represents reductions of 9.6% and 2.2% in the year round Q_{95} and Q_{50} values respectively. These were similar to the values calculated from the Usk model data set and would also be assessed as a **negligible** impact during the winter months of October to November inclusive.

Reach 3 – River Usk, from Afon Senni confluence to Afon Cilieni confluence

Reach 3 stretches from below the confluence between the River Usk and the Afon Senni to the confluence between the River Usk and the Afon Cilieni. The potential for flow impacts as a result of the drought order is reduced in comparison to upstream reaches, mainly due to the contribution of flow from the upstream reaches of the River Usk, the Afon Senni and flow accretion in the reach. Available flow data indicate that the Afon Senni contributes a similar flow to Reach 3 of the the River Usk as the Afon Crai. In addition, at low flow conditions, flow in the River Usk quadruples from upstream of the Afon Crai (upstream of Reach 2) to downstream of the Afon Cilieni (downstream of Reach 3). As such, impacts downstream of the Afon Cilieni confluence are assessed as **negligible** and are not discussed further.

In upper Reach 3, key flow statistics based on area-flow proportions with Trallong flow gauge

are estimated as follows: summer Q_{95} = 40.5Ml/d, summer Q_{99} = 27.6Ml/d. The low flow estimates based on area-flow proportions are somewhat lower than the 2003 spot flows for the relevant percentile dates of the Trallong record, at the lower end of Reach 2 and the Afon Senni tributary, but as a precautionary approach the lower values have been used for the assessment. A reduction of 3.4Ml/d in the compensation release rate therefore represents reductions of 8.4% and 12.3% in the summer Q_{95} and Q_{99} respectively, and the hydrological impact of the drought order on Reach 3 has therefore been assessed as **minor** during the summer months of August to September inclusive.

The year round flow statistics based on area-flow proportions with Trallong flow gauge are: Q_{95} = 53.7Ml/d, Q_{50} = 232Ml/d. The 3.4Ml/d flow reduction therefore represents reductions of 6.3% and 1.5% in the year round low and median flow values respectively, and the hydrological impact of the drought order on Reach 3 has therefore been assessed as **negligible** during the winter months of October to November inclusive.

Habitats Directive Ecological River Flow

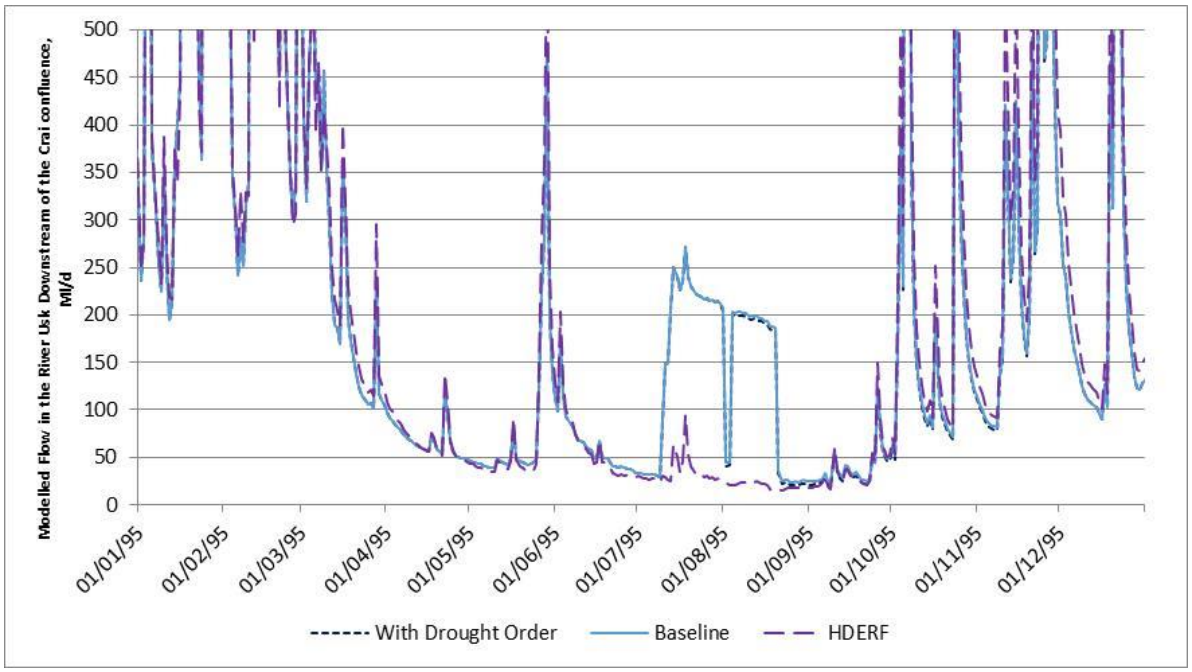
Generic flow indicators can also be considered and these include the Habitats Directive Ecological River Flow (HDERF) which is defined in the Usk SAC Site Action Plan (March 2010) as follows:

- At flows above Q_{50} the maximum reduction in natural flows is 10%
- Up to 10% reduction in natural flows between Q_{50} and Q_{95}
- Up to 1-5% reduction in natural flows below Q_{95}

The naturalised flow record of the river Usk downstream of the Crai confluence (from the Usk model data set) was used to determine a HDERF flow series for the river reach downstream of the Afon Crai confluence. Daily HDERF flow values were calculated using the year-round Q_{50} and Q_{95} flow statistics to determine the maximum percentage reductions in natural daily flows as specified above. A less stringent Usk combined river flow objective has also been adopted in the Usk Review of Consents studies, however at low flows this is equivalent to the HDERF.

Figure B2.6 below illustrates the change in flow in the River Usk downstream of the Crai confluence due to the drought order in a representative dry year (1995). Note that the vertical scale is limited to 500Ml/d in order to highlight the changes in the low flow regime, so higher flows above 500Ml/d are not shown. The HDERF flow series for the River Usk downstream of the Crai confluence, based on modelled data as outlined above, is also shown on each hydrograph.

Figure B2.6 Modelled Mean Daily Flow in the River Usk downstream of the Afon Crai confluence, Baseline and With Drought Order (1995)



Analysis of the modelled flows downstream of the Crai confluence indicates that for the baseline case the HDERF daily flow objective is met on 169 days or 46% of the calendar year of 1995. With the drought option in place, the HDERF flows are met on 162 days or 44% of the same period, a reduction of just 2% of the days overall. The estimated potential impact of the drought option is to increase the number of days that the HDERF is not met in the year of implementation, by around 1 week. However this estimate should be treated with caution as it is based on a modelled data set and the impact on the HDERF objective will vary with the characteristics of any future drought event.

B.2.2.3 Hydrological Impact Summary

Three river reaches have been considered for which the assessed hydrological impacts range from **minor** to **major** during the summer months of August to September and from **negligible** to **major** during the winter months of October to November. The impacted reaches are shown in **Table B2.6** and **Table B2.7** and establish the full in-channel zone of influence of the drought order for environmental sensitivity screening (see **Figure B1.1**). The hydrological impact on Crai Reservoir itself has been assessed as **minor beneficial**.

Table B2.6 Reaches in the Study Area – Summer Impact (August to September)

Reach		Reach boundary		Reach length	% flow reduction		Hydrological Impact - Summer
		Upstream	Downstream		Summer Q_{95}	Summer Q_{99}	
Crai Reservoir		n/a	n/a	n/a	n/a	n/a	**Minor beneficial**
1	Afon Crai	Crai Reservoir outflow	River Usk confluence	9.3km	50%	50%	**Major**
2	River Usk	Afon Crai confluence	Afon Senni confluence	2.7km	9.2%	11.6%	**Minor**
3	River Usk	Afon Senni confluence	Afon Cilieni confluence	2.9km	8.4%	12.3%	**Minor**

Table B2.7 Reaches in the Study Area – Winter Impact (October to November)

Reach		Reach boundary		Reach length	% flow reduction		Hydrological Impact - Winter
		Upstream	Downstream		Year round Q_{50}	Year round Q_{95}	
Crai Reservoir		n/a	n/a	n/a	n/a	n/a	**Minor beneficial**
1	Afon Crai	Crai Reservoir outflow	River Usk confluence	9.3km	50%	50%	**Major**
2	River Usk	Afon Crai confluence	Afon Senni confluence	2.7km	2.4%	8.1%	**Negligible**
3	River Usk	Afon Senni confluence	Afon Cilieni confluence	2.9km	1.5%	6.3%	**Negligible**

B3 PHYSICAL ENVIRONMENT ASSESSMENT

B.3.1 Geomorphology

Geomorphology data for the study area are limited in the Afon Crai, but have good coverage in the River Usk. Data are available for one NRW River Habitat Surveys (RHS) site (3975) in Reach 1, and seven sites (6976, 14389, 14390, 14391, 14386, 14387, 14388) in Reach 2.

Reach 1 is characterised by a steep-sided valley and a narrow valley floor overlain with morainic drift. Local gullies and hillside streams are a source of fine sediment to this monitoring reach, with the fine sediment transported downstream by high flow velocities (the Afon Crai falls 80m in 9.3km). Reach 2 on the River Usk is a sinuous channel of cobble and bedrock in a wide floodplain. Flow is smooth with occasional riffle and pool features. This reach provides storage of coarse sediment with transport downstream at high flows.

Review of NRW RHS data for Reach 2 indicate a semi-natural river, with the channel modified by cattle poaching and local bank reinforcement (Habitat Modification Score (HMS) Class 3). The seven RHS sites in Reach 2 indicate a semi-natural river with local bank reinforcement and structures, and a ford present at one site in the upper area of Reach 2. Habitat Modification Scores (HMS) vary between 1 and 3 in Reach 2.

Assessment

Reduction in flow and associated reductions in wetted with and depth, has the potential to impact sediment transport and geomorphology within the reaches.

The reaches are adapted to transporting high calibre bedload sediment, which is likely to occur in higher flows such as when the reservoirs are spilling. Due to the reduction in flow due to this option, bedload transport will be affected; this impact is assessed as minor for Reach 1. There could be an increased chance of fine sediment deposition supplied by local gullies due to the reduced capacity of the river due to the drought option, however this is considered unlikely. This is due to the steep gradients of the reaches. Due to the steep gradients there will be enough energy in the system to transport fine sediment. However, siltation may be localised, for example, behind in-channel structures, however any silt that is deposited will be mobilised when higher flows return.

Wetted width will be impacted in areas of shallow bank, as Reach 2 has some management impacts are assessed as negligible. As Reach 3 becomes more urbanised, changes in wetted width are assessed as negligible. In Reach 1, impacts on wetted width are assessed as minor – however, towards the reservoir and outfall, the impacts on wetted width will decrease.

Overall the geomorphology risk is assessed as **minor** for bedload transport in Reach 1 and **negligible** for Reaches 2 and 3; and **negligible** for fine grain sedimentation within all reaches. Wetted width and depth change is assessed as **minor** for Reach 1 and **negligible** for Reaches 2 and 3.

B.3.2 Water Quality

This section sets out the baseline water quality and examines changes over time and with respect to river flows. Environmental pressures on river water quality (such as discharges from Sewage Treatment Works (STWs)), which may cause increased deterioration in water quality with the drought order in place, are discussed separately in Section B.3.3.

To support the assessment of potentially sensitive environmental features (see Section 5 of the main report), an understanding has been developed of the water quality of the rivers within the zone of influence of the drought order, including trends over time and with respect to river flow. For the Water Framework Directive (WFD) classification, the Environment Agency has set out following United Kingdom Technical Advisory Group (UKTAG) evidence what pressures, including water quality pressures, each biological quality element is capable of responding to. For the purposes of assessment here, the supporting water quality parameters are set out: for fish and macroinvertebrates (where identified as sensitive features) as dissolved oxygen saturation and total ammonia concentration; and for macrophytes and algae (phytobenthos / diatoms, where identified as sensitive features) as soluble reactive phosphorus (SRP). Specifically, for macrophytes, if the hydrological impacts of drought order implementation have been identified within the main macrophyte growing season (April to September), an assessment of SRP has been undertaken.

Potential impacts on other water quality parameters, such as temperature, have been considered where appropriate (e.g. temperature influences dissolved oxygen and if sufficient information is available on dissolved oxygen and is being reviewed it may not be necessary to undertake a separate temperature assessment). Where data are lacking, the assessment has been undertaken using professional judgement.

NRW routine monitoring data were reviewed to provide an overview of water quality in the zone of impact. In the Afon Crai catchment, within the extent of influence of the Afon Teifi drought order there are three NRW water quality sampling sites, as detailed in **Table B3.1 and Figure B3.1**.

Where data is lacking the assessment has been undertaken using professional judgement. Values at the limit of detection were halved in line with standard NRW practice.

Table B3.1 Details of NRW Water Quality Sampling Points on the Afon Crai

Reach	Site Name	NRW Site Code	Grid reference
1	AFON CRAI AT LLWYN-Y-NEUADD	40874	SN8910924890
	AFON CRAI AT TAN-Y-GRAIG	40875	SN8950027420
2	RIVER USK - CONF AFON CRAI TO CONF AFON SENNI	40192	SN9124328582

These reaches fall within the Usk SAC and as such have been be compared against the specific conservation objectives. The specific water quality objectives for this SAC are given in **Table**

B3.2.

Table B3.2 – Usk SAC specific water quality objectives

Dissolved Oxygen	Biological Oxygen demand	Total ammonia	Unionised ammonia	pH	Hardness	Dissolved copper	Total Zinc
80	2.5	0.25	0.021	6-9	<10 >10 and <50 >50 and <100 >100	5 22 40 112	30 200 300 500

Reach 1 – Afon Crai source to conference to River Usk

Water quality analysis for this reach (affected by a major hydrological impact) has been undertaken based on the data available at the water quality monitoring sites listed in **Table B3.1**.

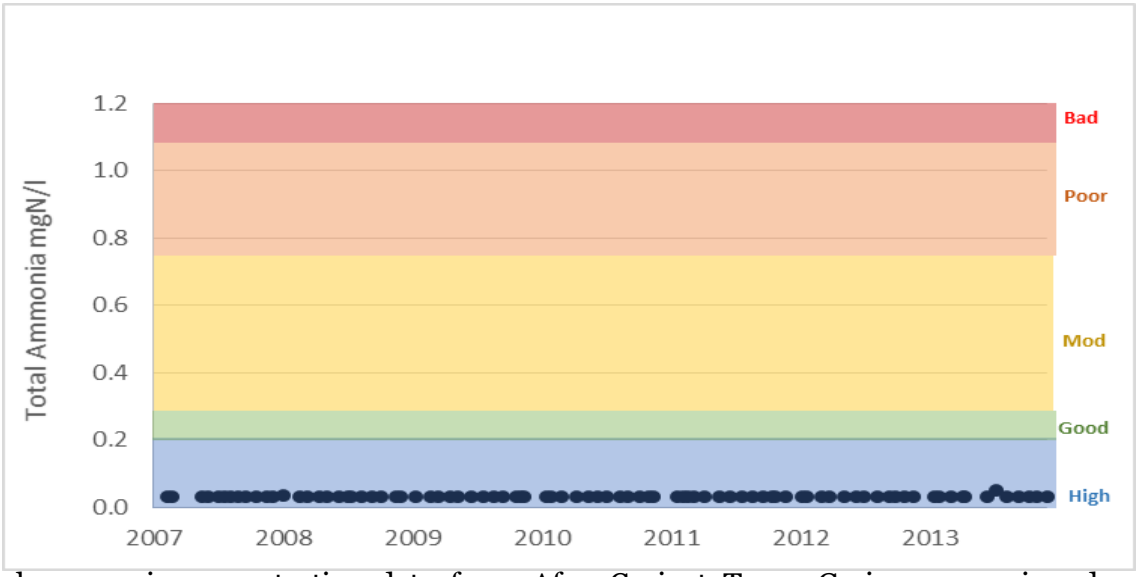
pH and Temperature

Average pH in the Afon Crai at Llwyn-y-Neuadd and Afon Crai at Tan-y-Graig was 7.5 and 7.6 respectively. Maximum water temperature in Afon Crai at Llwyn-y-Neuadd and Afon Crai and Tan-y-Graig was 16.1°C and 15.2°C respectively. pH is in line with the conservation objectives for the Usk SAC.

Total Ammonia Concentrations

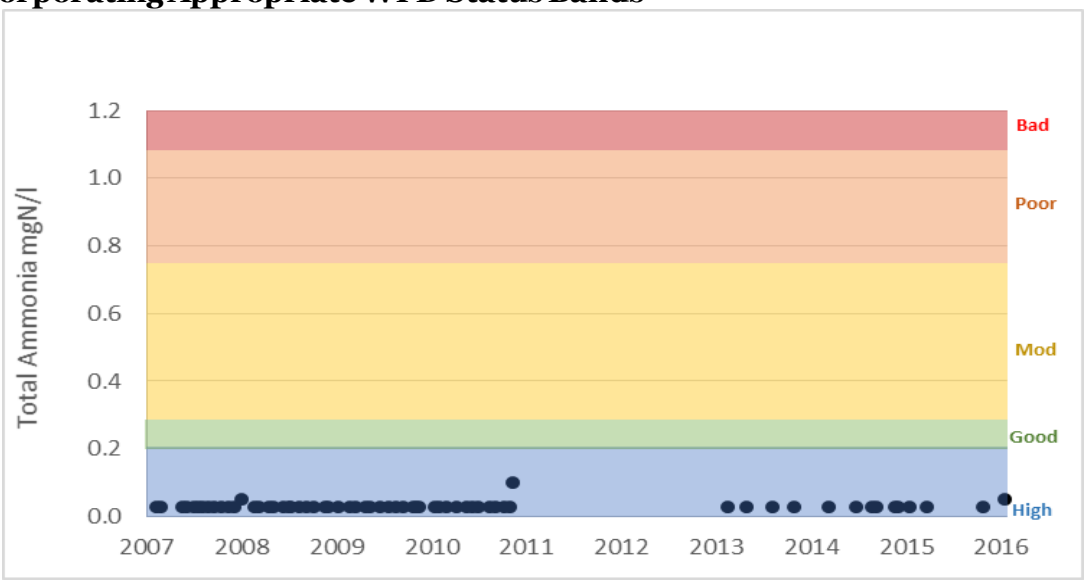
Total ammonia concentration data from Afon Crai at Llwyn-y-Neuadd were reviewed and presented in **Figure B3.1** against the relevant WFD standards for an upland low alkalinity river. Total ammonia concentration measurements at Afon Crai at Llwyn-y-Neuadd were compliant with the WFD standard to support high status (0.2 mg/l) for fish and invertebrates for an upland low alkalinity river.

Figure B3.1 Total Ammonia Concentration at Afon Crai at Llwyn-y-Neuadd, Incorporating Appropriate WFD Status Bands



Total ammonia concentration data from Afon Crai at Tan-y-Graig were reviewed and presented in **Figure B3.2** against the relevant WFD standards for an upland low alkalinity river. Total ammonia concentration measurements at Afon Crai at Tan-y-Graig were compliant with the WFD standard to support high status (0.2 mg/l) for fish and invertebrates for an upland low alkalinity river. There is one event on 25/04/2017 where concentrations peak at 0.62 mg/l however this appears to be an isolated incident.

Figure B3.2 Total Ammonia Concentration at Afon Crai at Tan-y-Graig, Incorporating Appropriate WFD Status Bands

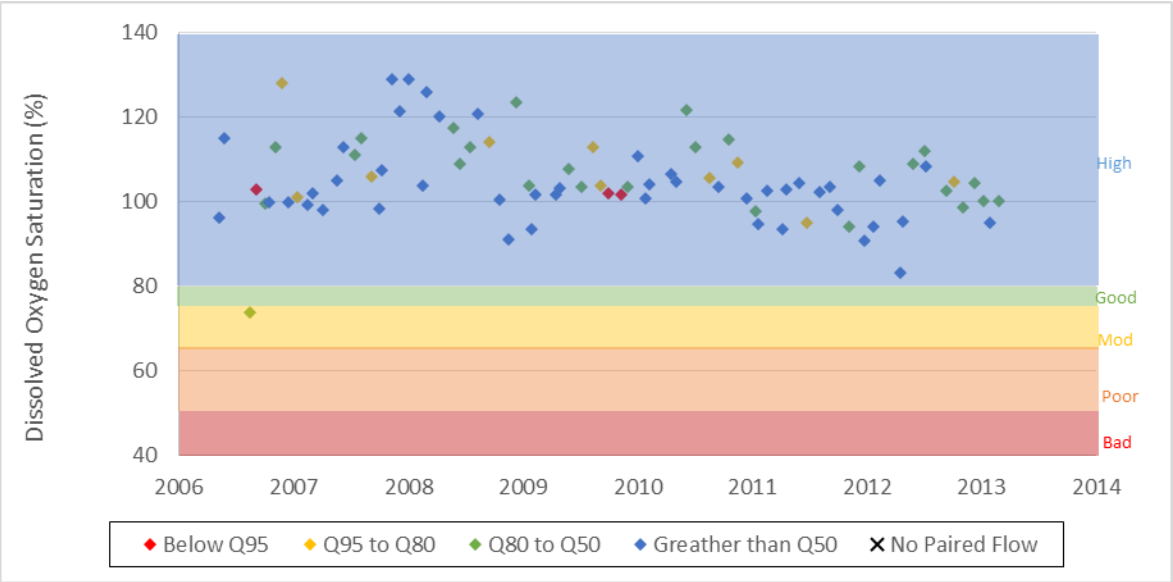


Dissolved Oxygen Saturation

Dissolved oxygen saturation data from Afon Crai at Llwyn-y-Neuadd were reviewed and presented in **Figure B3.3** against the relevant WFD standards for an upland low alkalinity

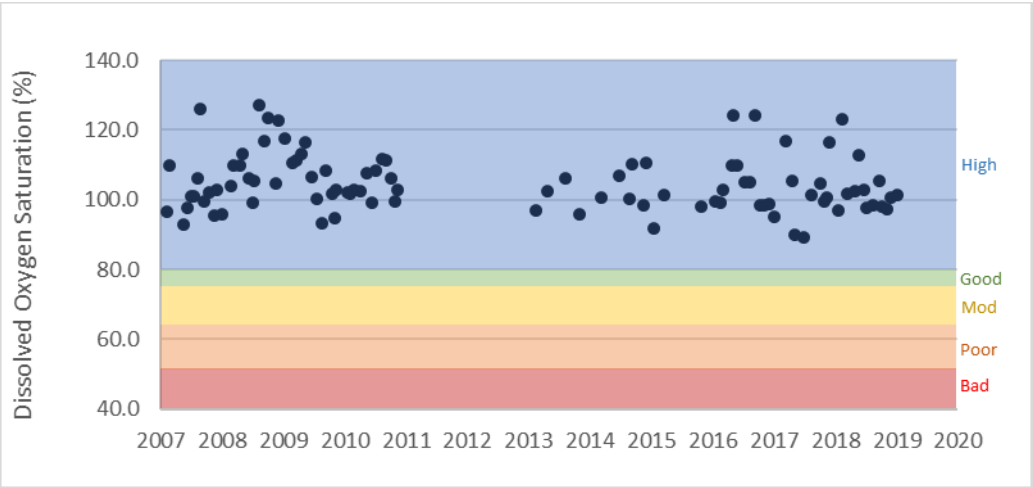
river. Dissolved oxygen saturation measurements at Afon Crai at Llwyn-y-Neuadd were compliant with the WFD standard to support high status (80% saturation) for fish and invertebrates for an upland low alkalinity river. Only one occasion on which the dissolved oxygen saturation was below high/good standard is noted in the record. There is no association between flow and dissolved oxygen concentrations.

Figure B3.3 Dissolved Oxygen Saturation at Afon Crai at Llwyn-y-Neuadd, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation data from Afon Crai at Tan-y-Graig were reviewed and presented in **Figure B3.4** against the relevant WFD standards for an upland low alkalinity river. Dissolved oxygen saturation measurements at Afon Crai at Tan-y-Graig were compliant with the WFD standard to support high status (80% saturation) for fish and invertebrates for an upland low alkalinity river.

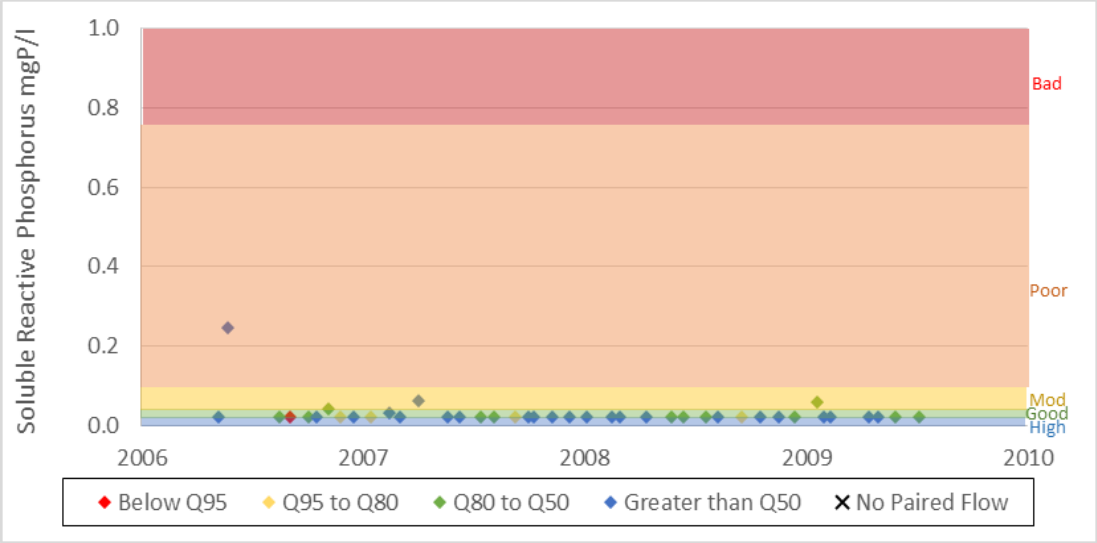
Figure B3.4 Dissolved Oxygen Saturation at Afon Crai at Tan-y-Graig, Incorporating Appropriate WFD Status Bands



Soluble Reactive Phosphorus Concentrations

Soluble reactive phosphorus concentrations at Afon Crai at Llwyn-y-Neuadd were reviewed and data are presented in **Figure B3.5** against the relevant WFD site specific standards provided by the EA[2]. Soluble reactive phosphorus concentrations at Afon Crai at Llwyn-y-Neuadd were mostly consistent with the WFD standard to support high or good status (0.03mgP/l) for fish and invertebrates for an upland low alkalinity river, occasionally falling short of this standard and crossing into the 'moderate' (two instances) and respectively 'poor' (one instance) status bands. No association with river flows is apparent at this location.

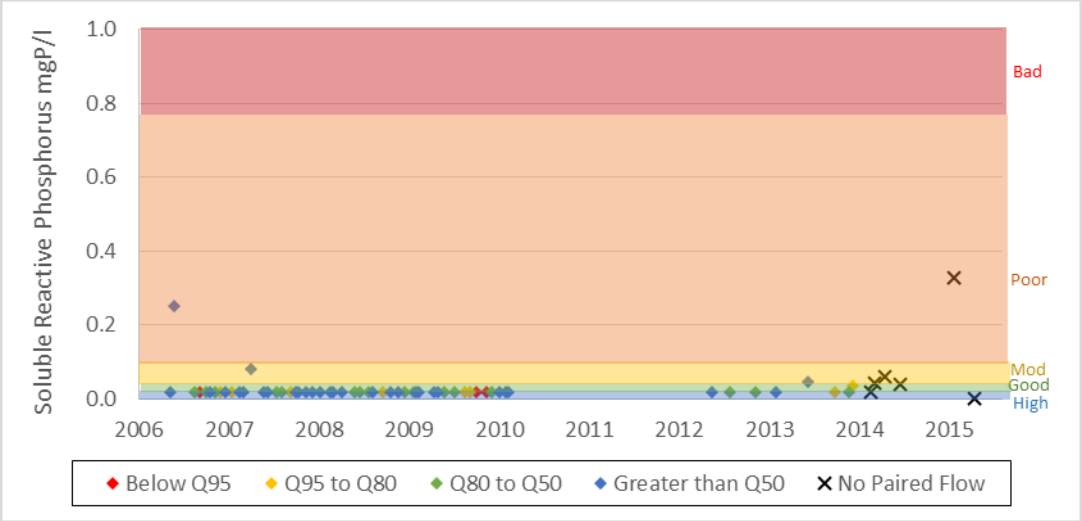
Figure B3.5 Soluble Reactive Phosphorus at Afon Crai at Llwyn-y-Neuadd, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentrations at Afon Crai at Tan-y-Graig were reviewed and data are presented in **Figure B3.6** against the relevant WFD site specific standards provided by NRW[3]. Soluble reactive phosphorus concentrations at Afon Crai at Tan-y-Graig were mostly consistent with the WFD standard to support high or good status (0.03 mgP/l) for fish and invertebrates for an upland low alkalinity river, occasionally falling short of this standard and crossing into the 'moderate' (six instances) and respectively 'poor' (three instances) status bands respectively. No association with river flows is apparent at this location.

[2] The Water Environment (Water Framework Directive) (England and Wales) Directions 2015. ISBN 978-0-85521-192-9.
[3] The Water Environment (Water Framework Directive) (England and Wales) Directions 2015. ISBN 978-0-85521-192-9.

Figure B3.6 Soluble Reactive Phosphorus at Afon Crai at Tan-y-Graig, Incorporating Appropriate WFD Status Bands



Reach 2 - River Usk from the Afon Crai confluence to the Afon Senni confluence

Water quality analysis for this reach (affected by a medium hydrological impact) has been undertaken based on the data available at one water quality monitoring site listed in **Table B3.1**.

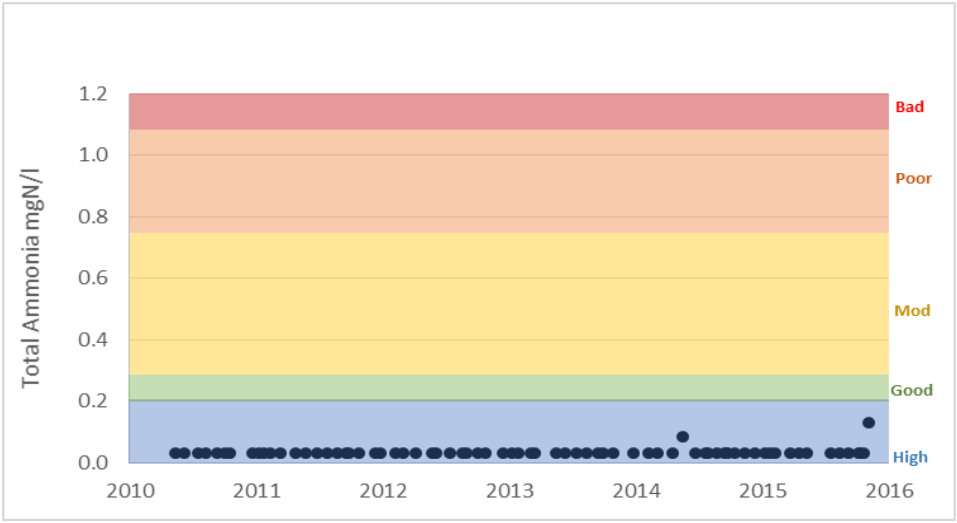
pH and Temperature

Average pH measured at River Usk from the Afon Crai confluence to the Afon Senni confluence was 7.9 and maximum water temperature was 16°C.

Total Ammonia Concentrations

Total ammonia concentration data from the River Usk from the Afon Crai confluence to the Afon Senni confluence monitoring site were reviewed and presented in **Figure B3.7** against the relevant WFD standards for an upland low alkalinity river. Total ammonia concentration measurements at River Usk from the Afon Crai confluence to the Afon Senni confluence were compliant with the WFD standard to support high status (0.2 mg/l) for fish and invertebrates for an upland low alkalinity river.

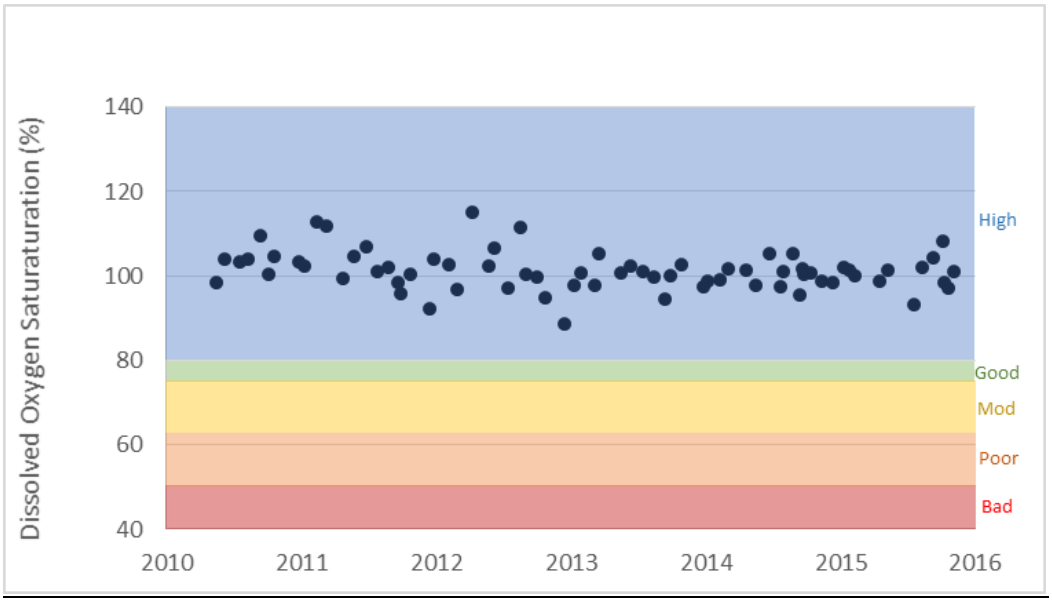
Figure B3.7 Total Ammonia Concentration at River Usk from the Afon Crai confluence to the Afon Senni confluence, Incorporating Appropriate WFD Status Bands



Dissolved Oxygen Concentrations

Dissolved oxygen saturation data from the River Usk from the Afon Crai confluence to the Afon Senni confluence monitoring site were reviewed and presented in **Figure B3.8** against the relevant WFD standards for an upland low alkalinity river. Dissolved oxygen saturation measurements at River Usk from the Afon Crai confluence to the Afon Senni confluence were compliant with the WFD standard to support high status (80% saturation) for fish and invertebrates for an upland low alkalinity river.

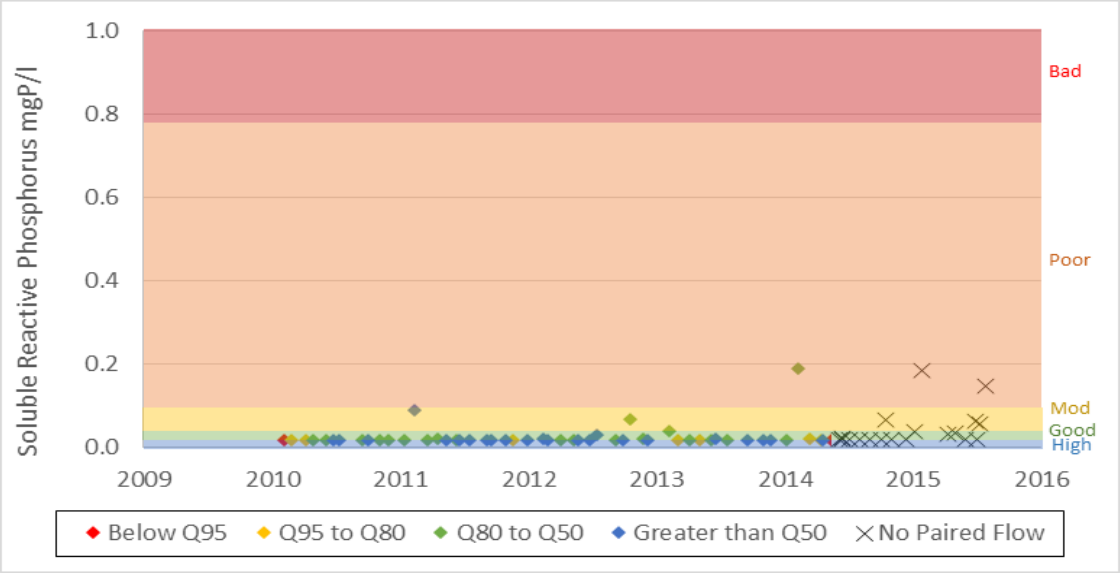
Figure B3.8 Dissolved Oxygen Saturation at River Usk from the Afon Crai confluence to the Afon Senni confluence, Incorporating Appropriate WFD Status Bands



Soluble Reactive Phosphorus Concentration

Soluble reactive phosphorus concentrations at Afon Crai at Tan-y-Graig were reviewed and data are presented in **Figure B3.9** against the relevant WFD site specific standards provided by the EA[4]. Soluble reactive phosphorus concentrations at River Usk from the Afon Crai confluence to the Afon Senni confluence were mostly consistent with the WFD standard to support high or good status (0.03mgP/l) for fish and invertebrates for an upland low alkalinity river, occasionally falling short of this standard and crossing into the 'moderate' (five instances) and respectively 'poor' (three instance) status bands. No association with river flows is apparent at this location.

Figure B3.9 Soluble Reactive Phosphorus at River Usk from the Afon Crai confluence to the Afon Senni Confluence, Incorporating Appropriate WFD Status Bands



Reach 3 - River Usk, from Afon Senni confluence to Afon Cilieni confluence

No water quality data was available for the sampling sites in this reach.

Water Quality Summary

Assessment of risk of water quality deterioration as a result of the Afon Teifi drought order has been undertaken considering the water quality as well as the nature of the hydrological impact within Reach 1 and Reach 2.

Total ammonia concentrations were consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Afon Teifi drought order. Therefore, the risk of water quality deterioration with respect to total ammonia is assessed to

[4] The Water Environment (Water Framework Directive) (England and Wales) Directions 2015. ISBN 978-0-85521-192-9.

be **low** throughout Reaches 1 and 2. Similarly, dissolved oxygen concentrations were consistent with the standard to support high status for fish and invertebrates throughout Reaches 1 and 2. The risk of water quality deterioration with respect to dissolved oxygen is therefore assessed as **low**. With respect to the risk of water quality deterioration associated with SRP, this was assessed as being **medium** due to a history of SRP standard failure at the monitoring stations in Reaches 1 and 2. Water quality deterioration risks for total ammonia, dissolved oxygen and SRP are assumed **medium** in Reach 3, due to the presence of Sennybridge STW.

These reaches fall within the Usk SAC and as such have been compared against the specific conservation objectives. Reaches 1 and 2 are both compliant with the targets for dissolved oxygen, un-ionised and total ammonia, pH, dissolved copper and total zinc. In Reach 1 BOD is predominantly compliant with the SAC objective however concentrations have exceeded it on two occasions in 2008 and three in 2016. No BOD data was available for Reach 2 however it may be inferred from Reach 1 that it is predominantly compliant. The same may not be true in Reach 3 as in the absence of monitoring data the influence of the Sennybridge WwTW on the water quality objective is unknown however this is expected to be negligible. This is also true of all other water quality objective in Reach 3 as no water quality data is available for this Reach. It is therefore assumed that the risk to deterioration against the SAC targets is **low** in Reaches 1 and 2, owing to occasional peaks in BOD, and is assumed **low** in Reach 3 due to increased water quality pressures which may influence multiple SAC targets.

B.3.3 Environmental Pressures

B.3.3.1 Flow Pressures

There are no licensed surface water abstractions in the study area.

B.3.3.2 Water Quality Pressures

Discharges put pressure on water quality during a drought as lower than normal river flows mean that there is less water available to dilute discharges such as final effluent from STWs. Discharges impacting the oxygen balance and ammonia concentration in the river reaches have been reviewed; significant pressures relate to discharges of over 0.5Ml/d. Any discharges may be considered as beneficial to river flow but may also pose risks to water quality (noting that only abstractions are considered as flow pressures in the section above).

Treated effluent from Sennybridge WwTW (**Table 3.2**) is a significant consented discharge in Reach 3. However, increased environmental impacts to the River Usk are unlikely during the drought order. This is a result of flow accretion having occurred prior to the WwTW discharge point sufficiently so that any changes in flows due to the drought order are minimal.

Table B3.2 Summary of Intermittent Water Quality Pressures

Permit no.	Site name	Location	Max daily total (Ml/d)	Dry weather flow (Ml/d)	BOD: 5 Day ATU (mg/l)	Ammoniacal N (mg/l)	Suspended Solids @ 105 C (mg/l)	Zone of influence (<500m)	Consideration of water quality pressure (during baseline low flow conditions)
AC0140301	Sennybridge Army Camp STW	SN9253029450		0.451	40		60	Reach 3	Negligible
AN0246901	Sennybridge STW Storm Sewage Overflow	SN9251029430						Reach 3	Negligible
AB0043501	Coedwaungaer STW Sennybridge	SN9255029380						Reach 3	Negligible
AD0000601	Sennybridge STW	SN9205028900						Reach 3	Negligible

B4 PHYSICAL ENVIRONMENT IMPACT SUMMARY

Potential impacts on the physical environment associated with the Crai Reservoir Drought Order are summarised in **Table B4.1.**

Table B4.1 Summary of Potential Changes to the Physical Environment of the Impacted Reaches from Implementation of Crai Reservoir Drought Order

Afon Crai (Reach 1)	
Flows in the Afon Crai *Major impacts during the period August to November inclusive*	• Up to 50% reduction in low flows at any time of year
Geomorphology in the Afon Crai *Minor to negligible impacts for up to 6 months' duration of drought order during the period August to November inclusive*	• Minor impacts on wetted width and bedload transport. • Negligible impacts on suspended sediment.
Water quality in the Afon Crai *Low to Medium impacts for up to 6 months' duration of drought order during the period August to November inclusive*	• Low risk of water quality deterioration with respect to total ammonia and dissolved oxygen • Moderate risk of water quality deterioration for soluble reactive phosphorus due to history of good standard failure
River Usk (Reach 2)	
Flows in the River Usk *Minor impacts during the period from August to September inclusive; negligible impacts during the period from October to November inclusive*	• Up to 11.6% reduction in summer low flows, with moderate reductions in wetted width / wetted depth, and up to 8.1% reduction in year round low flows
Geomorphology in the River Usk *Negligible impacts for up to 6 months' duration of drought order during the summer/autumn period*	• Negligible impacts on wetted width and sediment.
Water quality in the River Usk *Low to Medium impacts for up to 6 months' duration of drought order during the summer/autumn period*	• Low risk of water quality deterioration with respect to total ammonia and dissolved oxygen • Moderate risk of water quality deterioration for soluble reactive phosphorus due to history of good standard failure
River Usk (Reach 3)	
Flows in the River Usk *Minor impacts during the period from August to September inclusive; negligible impacts during the period from October to November inclusive*	• Up to 12.3% reduction in summer low flows, with minor reductions in wetted width / wetted depth and up to 6.3% reduction in year round low flows
Geomorphology in the River Usk *Negligible impacts for up to 6 months' duration of drought order during the summer/autumn period*	• Negligible impacts on wetted width and sediment.
Water quality in the River Usk *Unquantified risk, assumed medium for up to 6 months' duration of drought order during the summer/autumn period*	• No water quality data was available at the monitoring sites in this reach • The water quality deterioration risk is assumed moderate due to the influence of Sennybridge STW

B5 CUMULATIVE IMPACTS

The focus of this EAR is the Crai Reservoir drought order. The assessment, as described in previous sections, has considered how the proposed drought permit may affect the environment in combination with the effects of existing licences and consents. In accordance with the DPG the assessment also considers the potential cumulative effects of Welsh Water implementing other drought permits / orders within a similar timeframe. The potential for options to act in combination is set out in **Table B5.1**.

Consideration has also been given to the potential for cumulative impacts of drought options implemented by neighbouring water companies (see **Table B5.1**). The assessment of the potential for cumulative impacts of Welsh Water's supply side and drought permit / order options with drought options listed in neighbouring water companies' drought plans has also been undertaken as part of the Strategic Environmental Assessment (SEA) of Welsh Water's Draft Statutory Drought Plan. The SEA was informed by the most recent information available on the neighbouring water companies' drought plans.

Table B5.1 Cumulative Impacts of the Crai Reservoir Drought Order with other Drought Options

Organisation	Potential In-combination Impacts	Further Consideration Required (Yes/No)
Welsh Water - other drought options in the Tywi Conjunctive Use System WRZ / River Usk catchment	8201-3 (Relax the maintained flow requirement below the Nantgaredig intake on the River Tywi) – The impacts of this option do not occur within the same catchment and therefore no in-combination impacts are anticipated.	No
	8201-4 (Reduce Llyn Brianne compensation flow by 50%) – The impacts of this option do not occur within the same catchment and therefore no in-combination impacts are anticipated.	No
Welsh Water - other drought options in the River Usk catchment	8116-3 (Pumped Abstraction from Talybont Reservoir Dead Storage) –– No in combination effects are anticipated as the 8116-3 Talybont drought order has no hydrological influence on the River Usk.	No
	8109-4 Afon Lwyd - The Afon Lwyd tributary joins the River Usk below the tidal limit and therefore no in-combination effects with other River Usk catchment options are anticipated.	No

APPENDIX C
ENVIRONMENTAL FEATURES ASSESSMENT METHODOLOGY

A.1 ENVIRONMENTAL FEATURES ASSESSMENT METHODOLOGIES

The assessments undertaken in the EARs will use available environmental data. The following methodologies detail the preferred approach to impact assessment for the sensitive receptors identified in the screening process.

However, in certain circumstances the supporting data on hydrological conditions, habitat availability and species occurrence may not be currently available. In these cases, other supporting data will be used, where available, and the assessment will be undertaken using expert judgement. An example may be where flow-induced river habitat for fish would ideally be defined through the total wetted area, depth and flow velocities to describe the habitat preferences of a species and its lifestages. Where these data are currently unavailable, the use of habitat walkover, RHS and / or aerial survey data may be used in combination with judgements on the hydrological change resulting from the drought option (e.g. reduction in river flows) to arrive at a statement on habitat reduction and consequent impact on the fish species. The analysis will detail the increased uncertainty prevalent in the approach and will therefore adopt a precautionary approach to impact prediction (possibly assigning a higher impact where fewer substantiating data are available).

The gaps in data and evidence will be noted and monitoring proposals established.

Assessment sheets are included for the following features:

- Flow pressures
- Water quality pressures.
- WFD Status: Fish
- WFD Status: Aquatic macroinvertebrates
- Environment (Wales) Act Section 7 species, designated sites and other sensitive fauna and flora.

FLOW PRESSURES

Potential Effects

In support of understanding the physical environment and the risk assessment in the zone of influence of each drought option, a review will be undertaken of additional flow pressures from licensed surface water and groundwater abstractions. Relevant pressures have been identified and risk assessed in terms of in-combination flow impacts from implementation of a drought option. Abstractions have the potential to exacerbate low river flows or, in the case of groundwater-dominated catchments where rivers seasonally run dry (ephemeral watercourses), to increase the length of river that is dry and the period of time for which it remains so, potentially beyond the period for which the drought option is in place.

As a result of a drought option, there may be less water available in the zone of influence (rivers and groundwater bodies) for licence holders to abstract, and any abstractions that do occur reduce the amount of surface water available – affecting the wetted perimeter of the habitat, velocities within the wetted area and the ability to dilute any pollutants entering the system. For surface water abstractions, this includes consumptive abstraction and partially consumptive/non-consumptive abstraction – where some or all of the water is returned to the river locally after use, with the potential to reduce flow in the river if the discharge is downstream of the abstraction.

Definition of Risk

Continuously flowing watercourses

In order to define the potential risk to flow from river and groundwater abstractions in a readily understandable manner, a series of criteria have been defined. The assessment is informed by long term gauged flow data. The impact of the drought option will be considered against baseline 'drought' conditions (without drought option implementation). The assessment will use the following criteria, based on the potential severity of the risk to river water quality and flow during an ongoing drought.

- High: A major reduction in low river flows, including the influence of the drought option - typically >25% reduction in summer Q95 (with drought option in place)
- Medium: A moderate risk to low river flows (as above) , including the influence of the drought option - typically 10-25% reduction in summer Q95 (with drought option in place)
- Low: A minor risk to low river flows, including the influence of the drought option - typically <10% reduction in summer Q95 (with drought option in place)
- Negligible: Indicative of no significant change from the "without drought" option baseline situation.

Ephemeral watercourses

In line with the methodology for hydrology, an alternative approach to risk is required for

watercourses that naturally dry for part of the year that are potentially impacted upon by the drought option. Such watercourses are identified from previous investigations and available data. The assessment will use the following criteria, based on the potential severity of the risk to river water quality and flow during an ongoing drought.

- High: If the abstraction resulted in sections drying (with drought option in place) that would not (without drought option in place)
- Medium: If the abstraction resulted in sections drying earlier (by more than a handful of days) and/or returning to flow later (by more than a handful of days) and hence flow reduction occurring in the channel for more than just a handful of days (with drought option in place)
- Low: If the abstraction resulted in sections drying earlier (by just a handful of days) and/or returning to flow later (by just a handful of days) and hence flow reduction occurring in the channel for more than just a handful of days OR if the abstraction were a secondary flow driver (e.g. flow through gravels being primary cause of flow losses rather than the drought permit) (with abstraction in place)
- Negligible: Indicative of no significant change from the "without drought" option baseline situation.

Data Requirements

- Relevant zone of influence (as identified from screening)
- Surface water and groundwater abstraction licences in the zone of influence
- River flow representative of the zone of influence (daily gauged flow and spot flow surveys) – all available records
- Flow predictions and zones of hydrological impact for each drought option.

Assessment Methodology and Uncertainty

1. Identify relevant abstraction licences within the zone of hydrological impact for the drought option: both groundwater abstractions from the aquifer(s) impacted by the drought option (confined and unconfined) and surface water abstractions from the impacted river reaches.

Groundwater abstractions

2. For groundwater abstractions, identify which aquifer they abstract from and key characteristics of the aquifer (confined/unconfined) if available. List relevant details from each abstraction licence including licence number, holder, use, depth abstracted from and maximum daily abstraction rate.
3. Use depths of abstraction to identify which of these abstractions are likely to be affected by reduced groundwater levels in the aquifer with the drought option in place. If depth information is not available, take a precautionary approach and assume all abstractions within the relevant area (or, if known, from the relevant aquifer) are affected.
4. Calculate the maximum volume of groundwater abstractions from each aquifer at low flows (i.e. the sum of abstractions of sufficient depth from the aquifer) with a drought option in place.

5. Use expert judgement to assess the in-combination significance of these groundwater abstractions on river flows in impacted reaches (both continuously flowing and ephemeral watercourses), based on known (measured or modelled) relationships between groundwater levels and river flows in that area and the definition of risk set out above.

Surface water abstractions – continuously flowing watercourses

6. Assign relevant abstraction licences to an impacted river reach, and list relevant details from the licence including licence number, holder, use, type (consumptive or non-consumptive), location (mainstem or tributary) and daily maximum abstraction rate (including any Hands-Off Flow restrictions). Identify which of these abstractions are likely to be affected by reduced water levels in the river with the drought option in place.
7. Calculate the maximum volume of surface water abstractions in each reach at low flows (i.e. the sum of consumptive, unrestricted abstractions on the main stem of the river) as a proportion of summer Q95 river flow with a drought option in place.
8. Assess the in-combination significance of these pressures on river flow with respect to hydrological assessment methodologies described in Section 2.2.2 of the main report.
9. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.

Surface water abstractions – ephemeral watercourses

10. Assign relevant abstraction licences to an impacted river reach, and list relevant details from the licence including licence number, holder, use, type (consumptive or non-consumptive), location (mainstem or tributary) and daily abstraction maximum (including any Hands-Off Flow restrictions). Identify which of these abstractions are likely to be affected by reduced water levels in the river with the drought option in place.
11. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.

All abstractions

12. For both groundwater and surface water abstractions, incorporate any flow pressure risks identified as significant into the assessment of impacts on significant features and the selection of appropriate mitigation measures for the drought option.

WATER QUALITY PRESSURES

Potential Effects

In support of the physical environment understanding and risk assessment in the zone of influence of each drought option, a review will be undertaken of additional water quality pressures from consented surface water discharges. Discharges put pressure on water quality during a drought as lower than normal river flows mean that there is less water available to dilute discharges such as final effluent from STW. A drought option may exacerbate these low flows and contribute to a reduction in water quality, with potentially detrimental impacts on sensitive features in the impacted reach. Discharges impacting the oxygen balance and ammonia concentration (to support fish and macroinvertebrates, where these are identified as sensitive features) and soluble reactive phosphorus (SRP) concentration (to support macrophytes and algae, where these are identified as sensitive features) in the river have been reviewed.

Intermittent discharges from combined sewer overflows (CSOs) may also contribute to a reduction in water quality during an environmental drought. CSOs relieve strain on the sewers during storm events by temporarily diverting water into nearby watercourses to prevent sewer flooding. As there is usually a time lag between discharges from CSOs and rises in river levels during a storm event, the potential exacerbation of low flows by the drought option may decrease the amount of water immediately available to dilute CSO discharges, leading to a temporary reduction in river water quality if a storm event occurs during implementation of the drought option.

Definition of Risk

Continuously flowing watercourses

In order to define the potential risk to water quality from discharges into the river 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 risk to water quality during an ongoing drought.

- High: A major risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); and exacerbation of the risk by the flow reduction from the drought option
- Medium: A moderate risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation of a minor risk by the flow reduction from the drought option
- Low: A minor risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation to a minor risk by the flow reduction from the drought option
- Negligible: Indicative of no significant risk without the drought option nor exacerbation of risk by the flow reduction from the drought option

Ephemeral watercourses

In line with the methodology for hydrology, an alternative approach to risk is required for

watercourses that naturally dry for part of the year that are potentially impacted upon by the drought option. Such watercourses are identified from previous investigations and available data. The assessment will use the following criteria, based on the potential severity of the risk to river water quality during an ongoing drought.

- High: A major risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); and exacerbation of the risk if the drought option resulted in sections drying (with drought option in place) that would not (without drought option in place)
- Medium: A moderate risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation of a minor risk by the flow reduction from the drought option occurring in the channel for more than just a handful of days.
- Low: A minor risk to water quality under low river flow conditions (without the drought option) which affects the suitability of the water quality to support *Good* or *High* status for fisheries and macroinvertebrates, macrophytes and algae (as relevant); or exacerbation to a minor risk by the flow reduction from the drought option occurring in the channel for just a handful of days.
- Negligible: Indicative of no significant risk without the drought option nor exacerbation of risk by the flow reduction from the drought option

Data Requirements

- Relevant zone of influence (as identified from screening)
- Surface water discharge consents in the zone of influence (including numeric water quality and flow conditions)
- Routine NRW / Environment Agency riverine water quality monitoring data for the water quality determinands dissolved oxygen saturation, SRP concentration and total ammonia concentration for relevant monitoring sites in the zone of influence and significant tributaries
- River flow representative of the zone of influence (daily gauged flow and spot flow surveys) – all available records
- Flow predictions and zones of hydrological impact for each drought option
- CSO locations and previous assessments of intermittent discharges from Welsh Water.

Assessment Methodology and Uncertainty

1. Identify sensitive features (fish, macroinvertebrates, macrophytes and algae) which may be impacted by the drought option. Use this information to determine whether assessment of oxygen balance, ammonia concentration and/or SRP concentration is required.
2. Identify all discharge consents within the zone of hydrological impact for the drought option.
3. Assign relevant discharge consents to an impacted reach, and list relevant details from the consent including consent number, holder, use, location (mainstem or tributary) and relevant numeric

consent conditions (Dry Weather Flow, BOD, ammonia (N), total phosphorous)[1].

4. Identify those discharge consents which relate to effluent from Welsh Water's sewage treatment works (STWs).

Continuously flowing watercourses

5. Model the maximum current contribution of each STW to BOD, ammonia (N) and total phosphorous concentrations (as relevant) in the river at low flows (based on the water quality consents, DWF and upstream flows).
6. Model the maximum potential increase in each STW's contribution to river BOD, ammonia (N) and total phosphorous concentrations (as relevant) at low flows as a result of the drought option (based on the water quality consents, DWF, upstream flows and maximum flow reduction from drought option).
7. Assess the potential risk that the STW could pose to river ammonia quality (using the consented discharge condition total ammonia) using modelled data and the appropriate matrix below. This combines an acknowledgement of existing conditions and potential variation as a result of the drought option.

Upland low alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [a]	<0.2mgN/l	Minor	Moderate
	≥0.2mgN/l	Moderate	Major

[a] Standards are WFD high/good threshold for ammonia (N) of 0.2mg/l for upland low alkalinity rivers[2].

Lowland high alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [b]	<0.3mgN/l	Minor	Moderate
	≥0.3mgN/l	Moderate	Major

[b] Standards are WFD high/good threshold for ammonia (N) of 0.3mg/l for lowland high alkalinity rivers[3].

8. Assess the potential risk that the STW could pose to river oxygen balance (using the consented discharge condition BOD) using modelled data and the matrix below. This combines an acknowledgement of existing conditions and potential variation as a result of the drought option.

Upland low alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to BOD concentrations at low flows [c]	<1mg/l	Minor	Minor
	1-3mg/	Minor	Moderate
	≥3mg/l	Moderate	Major

[c] Standards are WFD high/good threshold for BOD of 3mg/l and good/moderate threshold of 4mg/l for upland low alkalinity rivers[4].

Lowland high alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to BOD concentrations at low flows [d]	<1mg/l	Minor	Minor
	1-4mg/	Minor	Moderate
	≥4mg/l	Moderate	Major

[d] Standards are WFD high/good threshold for BOD of 4mg/l and good/moderate threshold of 5mg/l for lowland high

[1] Note that not all STWs have water quality consents relating to ammonia or total phosphorous (depends on size and location of STW). Consents are set with respect to total phosphorous rather than SRP.

[2] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

[3] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

[4] The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

alkalinity rivers[5].

9. Assess the potential risk that the STW could pose to river phosphorous quality (using the consented discharge condition total phosphorous) using modelled data and the matrix below. This combines an acknowledgement of existing conditions and potential variation as a result of the drought option. Consents are set with respect to total phosphorous rather than SRP (on which WFD river standards are based), therefore this approach conservatively assumes that all phosphorous from STWs is reactive and has direct implications for ecology in the river.

Upland low alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [e]	<0.2mgN/l	Minor	Moderate
	≥0.2mgN/l	Moderate	Major

[e] Standards are WFD high/good threshold for SRP of 0.02mg/l and good/moderate threshold of 0.04mg/l for upland low alkalinity rivers[6].

Lowland low alkalinity river[7]		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [f]	<0.03mgN/l	Minor	Moderate
	≥0.03mgN/l	Moderate	Major

[f] Standards are WFD high/good threshold for SRP of 0.03mg/l and good/moderate threshold of 0.05mg/l for lowland low alkalinity rivers[8].

Upland/ lowland high alkalinity river		% increase in contribution as result of drought option(s)	
		<20%	≥20%
Current contribution to ammonia concentrations at low flows [g]	<0.05mgP/l	Minor	Moderate
	≥0.05mgP/l	Moderate	Major

[g] Standards are WFD high/good threshold for SRP of 0.05mg/l and good/moderate threshold of 0.12mg/l for upland/ lowland high alkalinity rivers[9].

10. Identify those discharges which relate to effluent from Welsh Water's combined sewer overflows (CSOs).
11. If required, carry out qualitative analysis using previous assessments of intermittent discharges to evaluate whether any CSOs are likely to present a significant water quality pressure as a result of the drought option.
12. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.
13. Incorporate any water quality pressure risks identified as significant into the assessment of impacts on significant features and the selection of appropriate mitigation measures for the drought option.

Ephemeral watercourses

14. Calculate the maximum concentrations of BOD, ammonia (N) and SRP (as relevant) in the final effluent of each STW under consented conditions (i.e. concentrations in the river with no natural dilution).

5 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

6 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

7 Note that "Lowland low alkalinity" is a category that only exisits for SRP standards, and not for total ammonia or BOD.

8 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

9 The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

15. Identify those discharges which relate to effluent from Welsh Water's combined sewer overflows (CSOs).
16. If required, carry out qualitative analysis using previous assessments of intermittent discharges to evaluate whether any CSOs are likely to present a significant water quality pressure as a result of the drought option.
17. Use expert judgement to assess the significance of these pressures on river flows based on the definition of risk set out above.
18. Incorporate any water quality pressure risks identified as significant into the assessment of impacts on significant features and the selection of appropriate mitigation measures for the drought option.

WATER FRAMEWORK DIRECTIVE STATUS: FISH

Potential Effects

For WFD river waterbodies within the zone of influence of the drought option, where screening of the drought option has identified that the fish element of biological status is *High* or *Good*, the potential impact is to be investigated. This investigation is specific to the risk of deterioration below the *Good* status band to the *Moderate* status band, as advised by NRW / Environment Agency.

Definition of Impacts

In order to define the potential WFD status impacts for fish 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.

- Major: A major impact is one that results in deterioration in the WFD classification of the waterbody, or specifically the fish biological element of the classification.
- Moderate: A moderate impact on fish status occurs when the fish population is predicted to be materially influenced, including effects on density, abundance or community composition, but where no deterioration in WFD classification is predicted. Consideration should be given to the scale of the impact and the potential for recovery of the populations.
- Minor: A minor impact occurs when there is a predicted impact on fish abundance, density or community composition that is within the usual variability for the site and which will recover within a short timescale.
- Negligible: A negligible impact is one where the predicted impact will not result in a detectable change in the fish population.

Data Requirements

Fish status baseline assessment requires data from standard NRW / Environment Agency monitoring programmes 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. Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area (width and depth) as follows:

- Relevant study area (as identified in the screening report)
- Hydrology at or close to the monitoring sites to link to fish data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records
- Meteorology (where flow data insufficient) from available NRW / Environment Agency rain gauges
- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys
- Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.

Assessment Methodology and Uncertainty
The WFD classification for the waterbody will be identified and the reasons for classification established from the NRW / 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 option will be established through existing data. These will include graphing 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, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability. Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought option may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option. This will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth. Once the flow, habitat and water quality drought option predictions 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 predicted changes in supporting environmental variables (flow, depth, velocity, habitat quality, dissolved oxygen levels and temperature) due to the drought option 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 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 option reduces habitat availability significantly The assessment will consider the scale and longevity of any fish status impacts. The WFD 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 allow prediction of a deterioration in 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. The prediction 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 assessment must therefore be undertaken in recognition that the outcome prediction will be subject to large potential variability. The study will therefore adopt a precautionary approach, with potential impact highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, should an option be enacted, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the fish populations.

WATER FRAMEWORK DIRECTIVE STATUS: MACROINVERTEBRATES

Potential Effects

For Water Framework Directive (WFD) river waterbodies within the zone of influence of the drought option, where screening of the drought option has identified that the aquatic macroinvertebrate component of ecological status is *High* or *Good*, the potential impact is to be investigated. This investigation is specific to the risk of deterioration below the *Good* status band to the *Moderate* status band.

Definition of Impacts

In order to define the potential WFD status impacts for aquatic macroinvertebrates 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.

- Major: A major impact is one that results in deterioration in the WFD classification of the waterbody, or specifically the macroinvertebrate biological element of the classification.
- Moderate: A moderate impact on macroinvertebrate status occurs when the macroinvertebrate community is predicted to be materially influenced, including reduction in the LIFE score, or in community density +/or abundance, but where no deterioration in WFD classification is predicted. 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 a predicted impact on macroinvertebrate abundance, density or composition that is within the usual variability for the site and which will recover within a short timescale.
- Negligible: A negligible impact is one where the predicted impact will not result in a detectable change in the macroinvertebrate community.

Data Requirements

The baseline for macroinvertebrates will be established from existing data 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 NRW / Environment Agency 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 and BMWP scores, together with abundance and density data where available. Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area (width and depth) and other environmental variables as follows:

- Relevant study area (as identified by screening)
- Hydrology at or close to the monitoring sites to link to macroinvertebrate data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records
- Meteorology (where flow data insufficient) from available NRW / Environment Agency

rain gauges

- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys, to calculate HQA / HMS.
- Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.

Assessment Methodology and Uncertainty

Having established the baseline, the relative changes expected as a result of the drought actions (in relation to normal drought conditions) in river hydrology, geomorphology and water quality will be identified (see WFD fish assessment). An assessment will then been made of the habitat requirements of the key riverine macroinvertebrate communities present, using existing knowledge of their range of preferences. Depending on the resolution of baseline data available, detailed statistical 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 actions will be based on qualified expert judgement of the potential effects of the predicted 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.

The WFD macroinvertebrate classification for the water body will be identified and the reasons for classification established from the NRW / Environment Agency. The data used to support the assessment will be analysed to ensure that the classification is accurate.

Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These will include graphing the hydrology, water quality, and macroinvertebrate (ASPT and LIFE scores) 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, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought option may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option. This will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth. These data may have been developed for the WFD fish status assessment and duplication of effort will be avoided.

Once the flow, habitat and water quality drought option predictions have been established, their implications for the existing macroinvertebrate community will be assessed. The linkage between flow and habitat environmental envelope for upland macroinvertebrate communities is subject to continuing debate but has been shown to be linked (see for example, Dunbar et al 2009; 2010). The predicted changes in supporting environmental variables (flow, habitat quality) due to the drought option should be assessed against the macroinvertebrate community LIFE scores. Consideration will be given to the relationships between flow, habitat and LIFE scores in the DRIED-UP research papers. The predicted relative change in Q_{95} low flow value for the drought option should be compared to the Q_{95}/reduction in LIFE score; HQA/reduction in LIFE score in Dunbar *et al* 2010 to develop an approximation of the scale of change in macroinvertebrate community that could be expected.

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

Where data are not available the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments within the reservoir group.

The prediction 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. 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 outcome prediction will be subject to large potential variability. The study should therefore adopt a precautionary approach, with potential impact highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, should an option be enacted, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the macroinvertebrate community.

NOTABLE SPECIES, DESIGNATED SITES AND OTHER SENSITIVE FAUNA AND FLORA

Potential Effects

Where screening of the drought option has identified that a notable species or designated site 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. Notable species are defined as Environment (Wales) Act Section 7 species or species with significant ecological sensitivity in the specified locality including species listed on IUCN red list and those not included in the red list which are nonetheless uncommon. This investigation will consider the habitat preferences of the species and its lifestages (if appropriate) and the impacts of the variation in flow (and consequent physical habitat and ecosystem) on these preferences. Potential effects are associated either 1) directly to a reduction in river flow; 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 for sensitive ecological features in a readily understandable manner, a series of criteria have been defined. The significance of impacts upon the sensitive ecological feature will be identified following the Institute of Ecology and Environmental Managements (CIEEM) Ecological Impact Assessment (EcIA) guidance[10]. The potential significance of the impacts is identified using the following:

- **Value of the Ecological Receptor** – each ecological receptor is attributed a geographic value based upon its legislative and conservation status, as identified in Table 1.

Table 1 Value of Ecological Receptor

Ecological Value	Example
International	Existing or warranting designation as a e.g SPA and/or of significant conservation status for Europe (e.g European Protected Species (EPS)).
National	Existing or warranting designation as a SSSI and/or of significant conservation status for England (i.e. identified as a NERC / Environment Act (Wales) Section 7 species).
Regional	Habitats or species valuable at a regional level and/or of significant conservation status for the region (e.g viable breeding populations of Nationally Scarce species).
County	For example, existing or warranting designation as a County Wildlife Site (CWS) and/or of significant conservation status for the county (e.g viable breeding populations of species of county/metropolitan rarities).
District	For example, habitats or species of significant conservation status for the district (e.g viable breeding populations of species listed as rare in the district or borough).
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.

- **Positive or Negative Impact** – all impacts are considered to be negative unless

[10] CIEEM (2018) *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine.* Chartered Institute of Ecology and Environmental Management, Winchester.

otherwise stated in the feature assessment.

- **Extent** – the extent of the impact is covered as part of the magnitude consideration.

- **Magnitude** – the magnitude of the impact is identified using the criteria identified in **Table 2**

Table 2 Magnitude of Impact

Impact Magnitude	Description
High	There is a long-term large-scale (i.e. catchment) change in the ecological receptor and/or changes in the overall integrity of the ecological receptor.
Medium	There is a short-term large-scale change or long-term short-scale (i.e. reach) change in the ecological receptor, however no changes in the overall integrity of the ecological receptor.
Low	There is a short-term small-scale change in the ecological receptor, but its overall integrity is not impacted.
Negligible	No perceptible change in the ecological receptor.

- **Duration** – the duration of impact is considered to be for 6 months, which is the duration for which a drought option is implemented, unless otherwise stated.

- **Reversibility** – all impacts are considered to be reversible unless they are identified to have a likely impact upon the overall integrity of the ecological receptor.

- **Timing and Frequency** – the drought option could be implemented at any point in the year, however the different life stages of the sensitive ecological features will be taken into account. The assessment is based upon the operation of a single drought permit, with subsequent applications for a drought permit required to consider cumulative effects of multiple drought permits.

- **Probability** – all impacts are considered to be probable, unless otherwise stated.

Once the value of the ecological receptor, magnitude of impacts and other parameters listed above have been identified, these are used to inform the assessment of significance of impact on the ecological receptor.

Data Requirements

Sensitive ecological features baseline review requires data from standard NRW / Environment Agency monitoring programmes 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. It is likely that most fisheries data will be for O and O+ lifestages, with some indication of older echelons. Environmental supporting data should include habitat availability, hydrology and water quality as follows:

- Relevant study area (as identified in the screening report)
- Hydrology at or close to the monitoring sites to link to fish data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records

- Meteorology (where flow data insufficient) from available NRW / Environment Agency rain gauges
- Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys
- Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area
- Habitat preferences for the given sensitive ecological features will be described, against which habitat change can be assessed.

Assessment Methodology and Uncertainty

The NERC / Environment (Wales) Act Section 7 species status for the watercourses will be identified and the reasons for its inclusion in the NERC / Environment (Wales) Act Section 7 established from the relevant bodies (start with NRW / Environment Agency). The data used to support the Environment (Wales) Act Section 7 assessment will be reviewed to ensure that it is accurate.

Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These should include graphing the hydrology, water quality, habitat and fish variation temporally and, if multiple sites, spatially over the monitored period. The analysis will consider the relationship between sensitive ecological feature lifestages 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 the sensitive ecological features population responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability.

Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought permit may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option conditions. Ideally this will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth. 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, habitat and water quality drought option predictions have been established, their implications for the sensitive ecological features will be assessed. The flow and habitat environmental preferences of the sensitive ecological features will be described. The predicted changes in supporting environmental variables (flow, depth, velocity, habitat quality, dissolved oxygen levels and/or temperature) due to the drought option should be assessed against the sensitive ecological features 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.

The prediction 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 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 outcome prediction will be subject to large potential variability. The study will therefore adopt a precautionary approach, with potential impacts highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the sensitive ecological features populations.

Habitat Preferences

Habitat Preferences		**Unfavourable Habitat**	**Potential Impacts**
Type/ Age Class	**Description**		
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. • Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.		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

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
			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 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
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

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
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,		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

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
	in the lee of large woody debris, rock ledges or other obstructions on the river bed.		Deterioration in water quality
			Increased water velocity and depth
Fine-lined pea mussel, *Pisidium tenuilineatum* and 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

APPENDIX D
ENVIRONMENTAL FEATURES ASSESSMENT

D1 INTRODUCTION

This appendix presents information regarding the environmental features associated with the Crai Reservoir drought order. Baseline data and the impact assessments are presented for the environmental features that form part of the scope of the assessment (established by the screening exercise described in Section 3.2.2 of the Environmental Assessment Report (EAR), the results of which are summarised in Section 5.2). The features assessment presented in full below is summarised in Section 5.3 of the EAR. Points of interest referred to throughout this report are indicated in **Figure D1.1**.

The approach to the assessment addresses the following: i) potential effects on each sensitive receptor; ii) definitions for impacts (adverse / beneficial), i.e. the significance criteria (quantitative and / or qualitative measures used to grade the severity of impacts of the drought order for the impact criteria major, moderate, minor, negligible; following the requirements of the DPG); iii) the data requirements; iv) assessment methodology (including the treatment of uncertainty where the complete data requirements are not available).

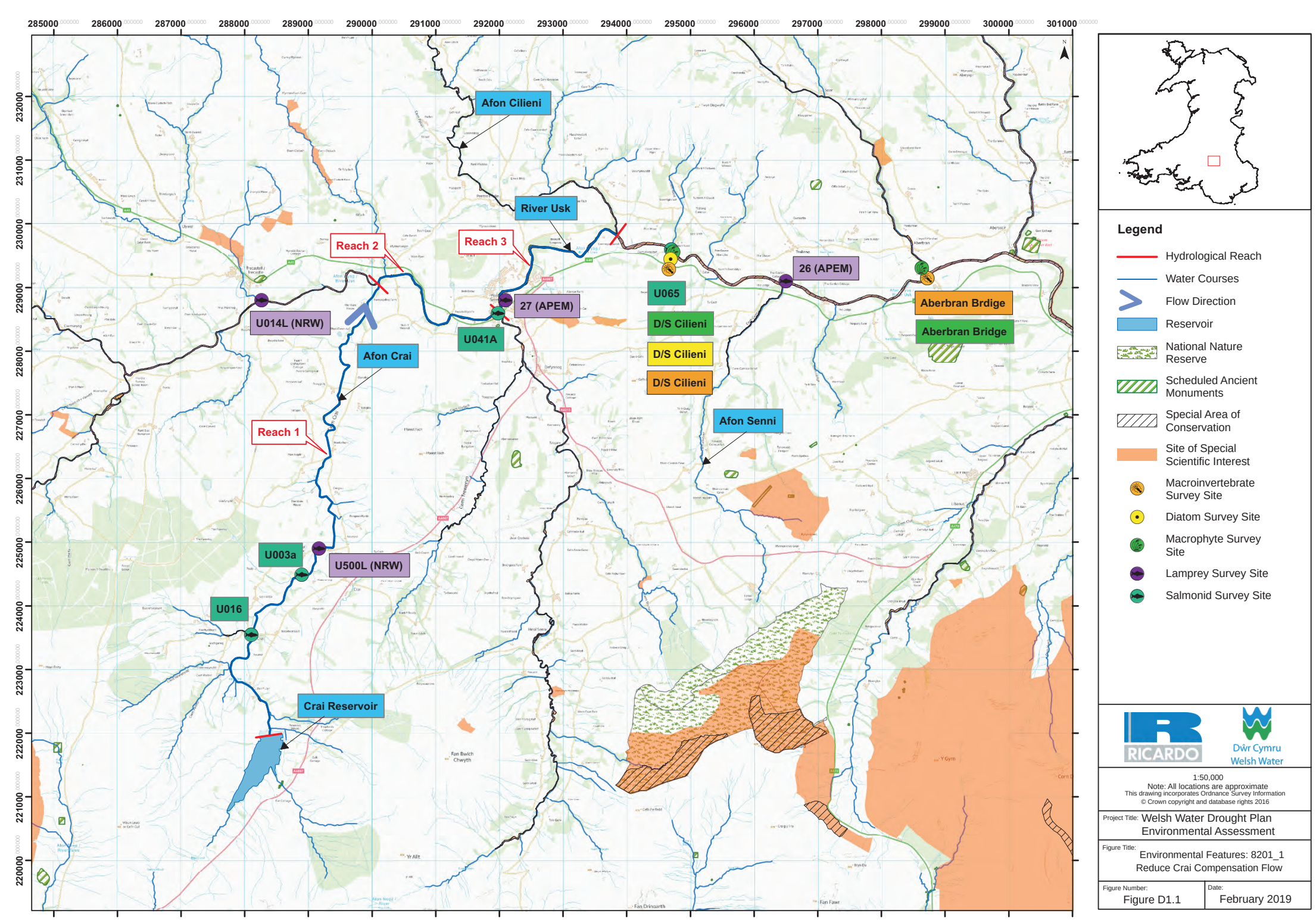
The assessment of environmental features is informed by the assessment of the physical environment (which includes hydrology and hydrodynamics; geomorphology; and water quality), this is summarised in Section 4 of the EAR and presented in full in **Appendix B**.

The ecological assessment has been undertaken recognising the Institute of Environmental Management and Assessment (IEMA)[1][2] and the Chartered Institute of Ecology and Environmental Management (CIEEM) study guidelines[3]. The assessment of impacts on other environmental receptors e.g. recreation and landscape has been carried out largely by qualitative expert judgement. Specific assessment methodologies for key environmental features are set out in **Appendix C**.

Desk-based assessments have been completed for each of the sensitive receptors, where applicable, in order to determine the magnitude of impact in the relevant river reaches for the Crai Reservoir drought order. Each feature assessment describes the analyses carried out and a statement of the assessed impact. All impacts are considered to be negative / adverse unless otherwise stated in the feature assessment.

This appendix is set out in the following sections:

[1] IEMA (2004) Guidelines for Environmental Impact Assessment.
[2] IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK
[3] CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland.



Legend

- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- National Nature Reserve
- Scheduled Ancient Monuments
- Special Area of Conservation
- Site of Special Scientific Interest
- Macroinvertebrate Survey Site
- Diatom Survey Site
- Macrophyte Survey Site
- Lamprey Survey Site
- Salmonid Survey Site

RICARDO

Dŵr Cymru Welsh Water

1:50,000

Note: All locations are approximate

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Environmental Features: 8201_1 Reduce Crai Compensation Flow

Figure Number: Figure D1.1

Date: February 2019

D2 DESIGNATED SITES

The impact assessment for the designated sites identified follows guidance provided by CIEEM. It provides an impact significance which takes into consideration the magnitude of impact alongside the value of the feature (for the full assessment methodology, see **Appendix C**).

D.2.1 River Usk Tributaries SSSI and SAC

D.2.1.1 Baseline

The River Usk Special Area of Conservation (SAC) and River Usk (tributaries Site of Special Scientific Interest (SSSI) are designated for both ecological and geological features. Its character spans a wide range of types from an upland base-poor stream to a large lowland river with extensive tidal reaches. Its overall diversity is a product of its geology, soil types, adjacent land-use and hydrology.

The Afon Crai forms part of the River Usk (tributaries) SSSI. This designation extends for the full extent of the hydrological influence of this site. This is an important wildlife corridor and a key breeding area for internationally and nationally important species. The SSSI is also of special interest for its mosses, lichens, floating and submerged plants and fish and otter *Lutra lutra* populations.

The River Usk SAC contains the qualifying Annex I habitat of "watercourse of plain to montane levels with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation".

The qualifying Annex II species of the River Usk SAC are:

- Brook lamprey *Lampetra planeri*.
- River lamprey *Lampetra fluviatilis*.
- Atlantic salmon *Salmo salar*.
- Bullhead *Cottus gobio*.
- Otter *Lutra lutra*.

The Usk is one of the finest salmon rivers in Wales, and is renowned as a quality brown trout (*Salmo trutta*) fishery. White-clawed crayfish (*Austropotamobius pallipes*) are known to be present in the Usk catchment, and other notable species include water vole (*Arvicola amphibious*), lesser horseshoe bat (*Rhinolophus hipposideros*) and river valley birds.

The majority of salmon spawning for the whole Usk catchment occurs in these streams. In addition, all the tributaries provide good salmon nursery habitat and the correct instream conditions to enable young salmon, at both the fry and parr stage, to thrive. River and brook lamprey have been recorded in many of the tributaries and bullhead are ubiquitous. Other

species of fish occur in these tributaries include brown trout, grayling *Thymallus thymallus* and stone loach *Noemacheilus barbastulus*.

The upper Usk and its tributaries support one of the strongest populations of otters in England and Wales. This species is threatened by habitat destruction, disturbance and pollution throughout its European range. Otters rely heavily on woodland, scrub and tall bankside vegetation for cover. Their holts can be located on the river bank or in other suitable dense vegetation at some distance from the edge of the river channel. European otter is a mobile species that can adapt to changes in river levels, and may potentially benefit from easier predation of fish species, consequently they are not considered further.

The site is of special interest for it is internationally important populations of otter *Lutra lutra*, Atlantic salmon *Salmo salar*, bullhead *Cottus gobio*, brook lamprey *Lampetra planeri* and river lamprey *Lampetra fluviatile*. These species thrive in the largely un-modified streams and medium sized rivers that comprise the Usk tributaries.

D.2.1.2 Assessment

The hydrological assessment has identified major to minor impacts in Reaches 1 to 3, which will manifest as a reduction (up to 50%) in Q_{95} and Q_{99} flows in the months of August and September and up to 50% reduction in Q_{50} and Q_{95} flows in October and November as a result of the drought order. This would lead to corresponding reductions in wetted width, depth, and flow velocity of the Afon Crai and in the River Usk downstream of Afon Crai confluence for the full duration of the drought order.

Atlantic salmon, river lamprey, brook lamprey and bullhead (Annex II species for which the SAC has been designated) are present within the reaches. Impacts on these fish species have been assessed as major to minor (see Section D3.3). Therefore, the overall impact on the River Usk SAC / River Usk (tributaries) SSSI is assessed as **major**.

Table D2.1 Summary of Impacts on Designated Sites

Feature	Impact	Significance of Impact
Reaches 1, 2, 3 and 4		
River Usk SAC	• Impacts on Atlantic salmon, river lamprey, brook lamprey, and bullhead (Annex II species for which the SAC has been designated) have been assessed as major to minor during drought order implementation.	**Major**
Upper Usk SSSI	• Impacts on Atlantic salmon, river lamprey, brook lamprey, bullhead, and freshwater pearl mussel have been assessed as major to minor during drought order implementation.	**Major**

D3 WFD STATUS AND COMMUNITY ASSESSMENT / NOTABLE SPECIES

D.3.1 Macrophytes and lichen

D.3.1.1 Baseline

No baseline data is available from Natural Resources Wales (NRW) for the impacted reaches of the Afon Crai or River Usk. However, baseline data is available from two monitoring sites on the River Usk downstream of impacted Reach 3, i.e., D/S Cilieni and Aberbran Bridge. Whilst these sites are outside of the drought order zone of influence, they are considered to be indicative of the communities present in the impacted reaches. Due to the paucity of data within the study period of 2005 to 2018 inclusive (particularly in the Afon Crai), additional results from monitoring in 2002 and 2003 have been included to provide additional context.

Considering the spatial and temporal constraints on the baseline information, which are not considered to be sufficient to characterise the whole watercourse, care must be taken in their interpretation. In particular, the age of the data is of concern. In addition to the possible changes to environmental conditions and therefore macrophyte communities over time, the changes in macrophyte survey methods for the development of the LEAFPACS classification system (i.e. expanded recorded taxa list, particularly in relation to riverine bryophytes) in the intervening period mean that the data available may not represent as complete a record of the macrophyte community as would be gathered by current macrophyte monitoring protocols.

The description and assessment provided below is based on the assumption that the data available provides a relatively reliable representation of the likely communities present within the impacted reaches. However, macrophyte survey of the impacted reach is strongly recommended in order to increase confidence in this assessment.

Macrophyte analysis results were provided by NRW using the standard LEAFPACS2 methodology[4] in accordance with the requirements of the Water Framework Directive (WFD). This methodology is based on the principle that different combinations, quantities, and numbers of macrophytes are associated with different flow conditions and nutrient availability in a river. The LEAFPACS2 method assesses the condition of river macrophyte communities using data on presence and abundance of species and groups of species recorded during a standard survey comprising a 100m river section. These indices are briefly described below:

(i) River Macrophyte Nutrient Index (RNMI): an index of eutrophication (high scores indicate enriched conditions);

(ii) Number of macrophyte taxa which are truly aquatic, i.e. hydrophytes (NTAXA);

(iii) Number of functional groups of macrophyte taxa which are hydrophytes (NFG): an assessment of the structural diversity of the plant community; and

[4] WFD-UKTAG (2014) UKTAG river assessment method – macrophytes and phytobenthos (River LEAFPACS2).

(iv) Percentage cover of all green filamentous algal taxa over the whole of the surveyed river sections (ALG).

In addition to the above scores, River Macrophyte Hydraulic Index (RMHI), observed Mean Trophic Rank (MTR), and Macrophyte Flow Ranking (MFR) scores were also provided. **Table D3.1** provides a summary of RMNI, MTR and MFR scores recorded at sites within the study reach. RMNI and RMHI are biotic indices used to determine the nutrient preference and flow preference of macrophyte communities respectively, and are updated versions of the MTR and MFR biotic indices. To calculate RMNI scores, macrophyte communities are identified and assessed on a scale of 1 to 10 based on individual species cover values and their combined preference for nutrient enrichment. High scores are associated with communities in eutrophic waters, low scores are associated with oligotrophic waters. Following the same premise, communities with high RMHI scores are associated with low energy flow velocities and low scores are associated with high energy flow velocities. **Table D3.2** and **Table D3.3** identify the interpretation of MFR and MTR scores.

Table D3.1 Macrophyte Monitoring Data for the River Usk

Site	Grid Reference	Year	MFR	MTR	RMNI	RMHI
D/S Cilieni	SN-94730-29560	2002	2.69	49.1	5.64	5.69
		2005	2.92	49	5.59	5.72
Aberbran Bridge	SN-98724-29148	2003	3.00	54.4	5.68	5.83

Table D3.2 Interpretation of MFR Scores Used for this Assessment

MFR Score	Interpretation of Score
1	Community preferring slow flow velocity
2	Community preferring slow to moderate flow velocity
3	Community preferring moderate flow velocity
4	Community preferring moderate to fast flow velocity
5	Community preferring fast flow velocity

Table D3.3 Interpretation of MTR Scores (from Holmes *et al.*, 1999[5])

MTR Score	Interpretation of Score
<25	Site is badly damaged by eutrophication, organic pollution, toxicity or is physically damaged.
25-65	Site is likely to be either eutrophic or at risk of becoming eutrophic
>65	Site is unlikely to be eutrophic

Environmental variables would allow for the use of the LEAFPACS tool for in depth interpretation of biotic indices scores. LEAFPACS is a data classification tool that calculates what the macrophyte communities should be like at reference state for any given site based on its environmental variables. It compares these predictions with the actual results recorded from surveys carried out at the site. Through these means we would be able to produce WFD classifications for individual surveys. As the environmental data was not available, this assessment is based on the interpretation of all available indices scores and raw survey data.

The D/S Cilieni and Aberbran Bridge sites located on the River Usk downstream of Reach 3 had similar RMNI scores which ranged from 5.64 to 5.68, indicating macrophyte community associated with mesotrophic to eutrophic conditions. This is also reflected by MTR scores between 49 and 54. The RMHI scores between 5.69 and 5.83 indicates the presence of macrophyte communities associated with moderate flow velocity habitats.

The macrophyte community has relatively sparse cover and contains a high proportion of bryophyte species; the most numerous species being *Rhynchostegium riparioides* with 5 to 10% cover. At these sites the algal community consists of *Lemanea fluviatilis, Hildenbrandia rivularis* and *Cladophora aegagropila,* three species considered to be a normal part of the flora in oligo-mesotrophic upland streams and rivers, and not typical of algal blooms associated with high nutrient levels.

Whilst no baseline data is available for Reaches 1 to 3 the macrophyte communities present are likely to be similar to recorded at the D/S Cilieni and Aberbran Bridge sites and have been assessed as such.

Notable Species

No notable species were present in the available macrophyte survey data. No records were returned for key species of the Annex II habitat Rivers with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation communities within the impacted reaches. This habitat is considered "not present" within this Management Unit (Unit 6) of the Usk SAC (see Section D2.1). These communities are therefore not considered to be receptors for this scheme.

[5] Holmes, N T H, Newman, J R, Chadd, S, Rouen, K J, Saint, L and Dawson, F H (1999) *Mean Trophic Rank: A Users Manual.* R&D Technical Report E38, Environment Agency, Bristol.

Two additional notable species are reported to be present within the impacted reaches of the River Usk but were not present in baseline monitoring data; the lichen *Endocarpon adscendens,* and Welsh thread-moss *Bryum gemmiparum*.

Table D3.4 Summary of designations for lichens and bryophytes

Taxa	Designation	Description
Welsh thread-moss *Bryum gemmiparum*	Nationally rare	Rare and scarce species (not based on IUCN criteria): Occurring in 15 or fewer hectads in Great Britain. Excludes rare species qualifying under the main IUCN criteria.
	Endangered	A taxon is Endangered when it is not Critically endangered but is facing a very high risk of extinction in the wild in the near future. Red listing based on 2001 IUCN guidelines
	Environment (Wales) Act Section 7	Species "of principal importance for the purpose of conserving biodiversity" covered under Section 7 (Wales) of the Environment Act (2016) and therefore need to be taken into consideration by a public body when performing any of its functions with a view to conserving biodiversity.
Endocarpon adscendens	Nationally rare	Rare and scarce species (not based on IUCN criteria): Occurring in 15 or fewer hectads in Great Britain. Excludes rare species qualifying under the main IUCN criteria.
	Endangered	A taxon is Endangered when it is not Critically endangered but is facing a very high risk of extinction in the wild in the near future. Red listing based on 2001 IUCN guidelines
	Environment (Wales) Act Section 7	Species "of principal importance for the purpose of conserving biodiversity" covered under Section 7 (Wales) of the Environment Act (2016) and therefore need to be taken into consideration by a public body when performing any of its functions with a view to and therefore need to be taken into consideration by a public body when performing any of its functions with a view to conserving biodiversity.

Welsh thread-moss *Bryum gemmiparum* is a Nationally Rare and Endangered species (see Table 3.4) associated with unshaded rocks in or adjacent to rivers and streams; along the River Usk it is confined to soil-filled crevices of base-rich sandstone rock within the typical water level range where periodic inundation occurs[6]. No records of Welsh thread moss are known for Reach 1 on the Afon Crai above the River Usk confluence. An historic record of Welsh thread-moss is known from impacted Reach 2 with a small quantity recorded on a single rock exposure in 2000. However, a survey of the area in 2003 did not identify the presence of the Welsh thread-moss in this stretch and reported the habitat to be unsuitable due shading from bankside trees[7]. No survey Data is available for impacted Reach 3, but the absence of the species from survey in Reach 3 upstream and from a survey immediately downstream at Cwm – Wysg[8] indicates that is unlikely to present within Reach 3. However, as a precautionary approach for the purpose of this assessment it assumed to be present in Reaches 2 and 3 in very low abundances.

E. adscendens is a Nationally Rare and Endangered (see Table 3.4) lichen found on bare rock within the flood zone that receive periodic inundation and on the stems of the moss

[6] Callaghan, D. (2013) A survey of *Bryum gemmiparum* on the River Usk. Report to PlantLife.
[7] Callaghan, D. (2013) A survey of *Bryum gemmiparum* on the River Usk. Report to PlantLife.
[8] Callaghan, D. (2013) A survey of *Bryum gemmiparum* on the River Usk. Report to PlantLife.

Thamnobryum alopecurum[9]. It has limited distribution, in Wales the species is only known to be present on the River Usk and one location in Glamorgan[10]. In the River Usk, *E. adscendens* is principally associated with the low to mid riparian lichen zone, this zone receives periodic inundation but contains species less tolerant of prolonged immersion[11]. No records of E. adscendens are known for impacted Reach 1 on the Afon Crai. Five colonies of *E. adscendens* were recorded on boulders and bedrock within Reach 2 during a survey in 2013[12]. No colonies of *E. adscendens* were identified in 2013 at the survey site immediately downstream of Reach 3 and the habitats were deemed to have low suitability[13]. As a precautionary approach *E. adscendens* is assumed to be present in low abundances throughout impacted Reaches 2 and 3.

D.3.1.2 Assessment

The assessment of impacts on the macrophyte community should be considered in the context of the watercourse under baseline conditions and assessed as such. Baseline data indicates that the macrophyte communities in the hydrological zone of influence of the drought order are bryophyte dominated and adapted to moderate velocities. Reduction in flows could affect macrophyte communities in a number of ways:

- Reduction in velocity favouring species adapted to slower flow conditions;
- Proliferation of filamentous algae due to decreases in velocity / increases in water temperature;
- Shading of macrophyte stands by epiphytic algae and floating macrophytes, due to decreases in velocity/increases in water temperature;
- Changes to community composition as a result of water quality deterioration;
- Desiccation of macrophyte beds due to reduced wetted width and water depth;
- Encroachment of marginal emergent species into the channel; and
- Reduction or movement of the splash zone from where this usually occurs, both at the edges of the channel and around in-stream features such as boulders and exposed bedrock, leading to desiccation of species present within these areas, particularly bryophytes.

The risk of water quality deterioration associated with soluble reactive phosphorous (SRP) has been assessed as moderate for Reaches 1, 2 and 3. Increased SRP concentrations could increase the occurrence of more opportunistic, nutrient tolerant taxa, epiphytes and filamentous algae. In turn, this could affect macrophyte condition or potentially community composition if slower growing species or those that prefer lower nutrient conditions are outcompeted.

Hydrological impacts as a result of drought order implementation range from major to minor

[9] http://wales-lichens.org.uk/species-account/endocarpon-adscendens. accessed 4 April 2017
[10] Orange A. (2013) A Survey of the Lichen *Endocarpon adscendens* on the River Usk. Report to PlantLife.
[11] Orange A. (2013) A Survey of the Lichen *Endocarpon adscendens* on the River Usk. Report to PlantLife.
[12] Orange A. (2013) A Survey of the Lichen *Endocarpon adscendens* on the River Usk. Report to PlantLife.
[13] Orange A. (2013) A Survey of the Lichen *Endocarpon adscendens* on the River Usk. Report to PlantLife.

in Reaches 1 to 3, depending on time of year and distance from the reservoir. See Appendix B for further details. These hydrological impacts, associated with a reduction in compensation discharge, will include a reduction in wetted width and wetted depth below those normally observed in the Afon Crai and upper River Usk.

Due to the potential change to wetted area, velocities, splash and humidity, which could occur during the main macrophyte growing season, operation of the drought order has the potential to affect the condition, composition and extent of macrophyte communities. Low flows may also favour the proliferation of filamentous algae species due to changes in velocity, water temperature, and nutrient (SRP) levels.

Riverine bryophytes (which are likely to be dominant within the impacted reaches) are generally well adapted to tolerate desiccation and rewetting, and communities can take a long time to react to changes in environmental conditions[14]. However, given the magnitude of the drought order the effects could be significant enough to alter the composition/condition of the macrophyte community during the duration of the drought order, particularly in relation to filamentous algal levels considering effects on SRP as well as velocity and temperature.

For Reach 1 (Afon Crai), operation of the drought order is predicted to result in major hydrological impacts, due to a 50% reduction in Q_{95} and Q_{99} flows during the main macrophyte growth period. These impacts, in addition to water quality deterioration, would be expected to have a significant effect on macrophyte habitat availability and quality over and above that experienced during natural drought during the duration of the drought order.

It is expected that effects of the drought order on the macrophyte community would be limited by the short period of coincidence wit the growing period , and reversed within one to two growing seasons following return to the normal hydrological regime. Therefore, considering the limited sensitivity of the communities present within the reach and the magnitude of hydrological and water quality impacts, the impact of the drought order on macrophytes communities in Reach 1 is expected to be **moderate** adverse (**minor** between October and November) , short term, and reversible.

Hydrological impacts on Reach 2 (River Usk, Afon Crai confluence to the Afon Senni confluence) are expected to be minor, with a reduction in 9.2% and 11.6% of low and extreme low flows respectively during the main macrophyte growing period. A moderate impact to SRP concentrations is expected for this reach. The effects of the drought order on macrophyte communities are expected to be similar to those discussed for Reach 1, though of lesser magnitude. Impacts of the drought order on the macrophyte community in Reach 2 are therefore expected to be **minor** adverse (negligible during October and November), short term and reversible.

Hydrological impacts on Reach 3 (River Usk, Afon Senni confluence to the Afon Cilieni

[14] Demars, B. O. L. and Britton, A. (2011). Assessing the impacts of small scale hydroelectric schemes on rare bryophytes and lichens. *Scottish Natural Heritage and Macaulay Land Use Institute Funded Report. Scottish Natural Heritage Commissioned Report No.421*

confluence) are expected to be minor with reductions of 8.4% and 12.3% in low and very low flows respectively during the macrophyte growing period. Impacts on SRP within this reach are expected to be moderate due to the influence of Senni bridge sewage treatment works. Therefore, impacts of the drought order on the macrophyte community in Reach 3 are expected to be **minor** adverse (negligible during October and November), short term and reversible..

Notable Species

The assessment of impacts on the notable lichen and bryophyte species should be considered in the context of the watercourse under baseline conditions. The hydrological impacts associated with a reduction in compensation discharge will include a reduction in wetted width and wetted depth below those normally observed in the upper River Usk.

The reduction in flows could affect Welsh thread-moss and *E. adscendens* due a reduction or movement of the splash zone from where this usually occurs, both at the edges of the channel and around in-stream features such as boulders and exposed bedrock, leading to desiccation of species present within these areas, particularly bryophytes. The reduction in flow due to drought order implementation will also reduce the occurrence of inundation of the banks and in channel boulders. Reduction of flow in the river Usk may also change the humidity of surrounding riparian habitats adversely affecting the suitability of available habitats for both Welsh thread-moss and *E. adscendens*. Water quality deterioration linked to increased concentrations of SRP may lead to an increase in opportunistic algae, increasing competition for slow growing species such as Welsh thread-moss and *E. adscendens*.

Due to the potential change to wetted area, splash and humidity, which could occur during the main macrophyte growing season, operation of the drought order has the potential to affect the condition and extent of Welsh thread-moss and *E. adscendens* due to a reduction in habitat suitability. However, as both species are typically located above the water level and require only periodic inundation impacts over above what would be expected in natural drought conditions are likely to be limited.

Hydrological impacts on Reach 2 (River Usk, Afon Crai confluence to the Afon Senni confluence) are expected to be moderate, with a reduction in 9.2% and 11.6% of low (Q_{95}) and extreme low (Q_{99}) flows, respectively during the summer months (August and September). A moderate impact to SRP concentrations is also expected for this reach. Therefore, impacts of the drought order on Welsh thread-moss and *E. adscendens* in Reach 2 are expected to be **minor**, adverse, short term, and reversible.

Hydrological impacts on Reach 3 (River Usk, Afon Senni confluence to the Afon Cilieni confluence) are expected to be minor with reductions of 8.4% and 12.3% in low and very low flows respectively. Impacts on SRP within this reach are expected to be moderate due to the influence of Senni bridge sewage treatment works. Considering the limited duration and magnitude of hydrological impacts, impacts of the drought order on the Welsh thread-moss and *E. adscendens* community in Reach 4 are expected to be **minor**, adverse, short term, and

reversible.

Summary

The potential impacts of the Crai Reservoir drought order on the macrophyte community are summarised in **Table D3.4**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability; see Section 4.3 of the main report) and the sensitivities of the macrophyte community. The impacts presented in **Table D3.4** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.4 Summary of Impacts on Macrophyte Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Crai, from the Crai Reservoir outflow to the River Usk confluence		
Macrophytes	• Reduction in growth as a result of major impacts on water levels and flows. • Changes to community composition due to changes to flow velocities and habitat loss due to reduction in wetted width and depth. • Increase in filamentous algae levels due to moderate increase in nutrients, increases in water temperature and decreased velocity.	**Moderate** (August to September) **Minor** (October and November)
Reach 2 - River Usk, from the Afon Crai confluence to the Afon Senni confluence		
Macrophytes	• Reduction in growth as a result of moderate - minor impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Increase in filamentous algae levels due to minor increase in nutrients or water temperature and decreased velocity.	**Minor** (August to September) **Negligible** (October and November)
Reach 3 - River Usk, from the Afon Senni to the Afon Cilieni confluence		
Macrophytes	• Reduction in growth as a result of moderate - minor impacts on water levels and flows. • Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. • Increase in filamentous algae levels due to minor increase in nutrients or water temperature and decreased velocity.	**Minor** (August to September) **Negligible** (October and November)

The impacted reaches of the Afon Crai drought order fall within three WFD water bodies: Afon GB109056033080 (Crai - source to River Usk confluence), GB109056039980 (Usk, confluence Afon Hydfer to confluence Afon Senni), GB109056040081 (Usk –Afon Senni confluence to Afon Crawnon confluence). The macrophyte and phytobenthos components of the GB109056033080 and GB109056039980 waterbodies classified as having high status. The GB109056040081 is not currently classified for macrophytes and phytobenthos but is classed as having high overall biological status.

Implementation of the drought order will result in a **moderate** risk of short term deterioration in WFD status of the macrophyte and phytobenthos component of the GB109056033080 waterbody and a **minor** risk of deterioration for waterbodies GB109056040081 and GB109056039980 during the duration summer months (August to

November). However, effects would be expected to be temporary and reversible following return to a normal hydrological regime and would be considered to be of minor to negligible risk during the months of October to November

D.3.2 Macroinvertebrates

D.3.2.1 Baseline

No baseline data is available from NRW for the impacted reaches of the Afon Crai or River Usk. However, baseline data is available from two monitoring sites on the River Usk downstream of Reach 3, i.e. D/S Cilieni and Aberbran Bridge. Whilst these sites are outside of the drought order zone of influence, they are likely to be indicative of the communities present in the impacted reaches.

Considering the spatial and temporal constraints on the baseline information, which are not considered to be sufficient to characterise the whole watercourse, care must be taken in their interpretation.

Sampling was conducted by following the standard NRW protocol involving a three-minute kick / sweep sample encompassing all the available instream habitats in proportion to their occurrence. For data collected prior to 2012 macroinvertebrates were identified to family level, from 2012 onwards macroinvertebrates were identified to species or mixed taxon level. These datasets were used to calculate a series of standard biotic indices: Biological Monitoring Working Party (BMWP) scores; Average Score Per Taxon (ASPT) scores; Lotic Invertebrate Flow Evaluation (LIFE); and number of taxa (NTAXA).

BMWP is primarily used to monitor the impact of organic water quality but also responds to other pressures such as habitat reduction, siltation and toxic pollutants. High BMWPs are associated with good water and habitat quality. Comparisons between sites with BMWP scores must be used with caution as change to river type can have considerable influence over BMWP score. ASPT is derived from BMWP and provides the average BMWP sensitivity score of all the taxa found in the sample's macroinvertebrate assemblage. This index provides a more reliable means of comparing macroinvertebrate community quality between sites whilst also reducing the influence of sampling artefacts such as variable sampling effort. As such ASPT is used as the primary means of assessing macroinvertebrate response to water quality in this assessment. As a guide ASPT scores above five represent macroinvertebrate communities living in good water quality. Scores below five indicate water quality stress on the macroinvertebrate community.

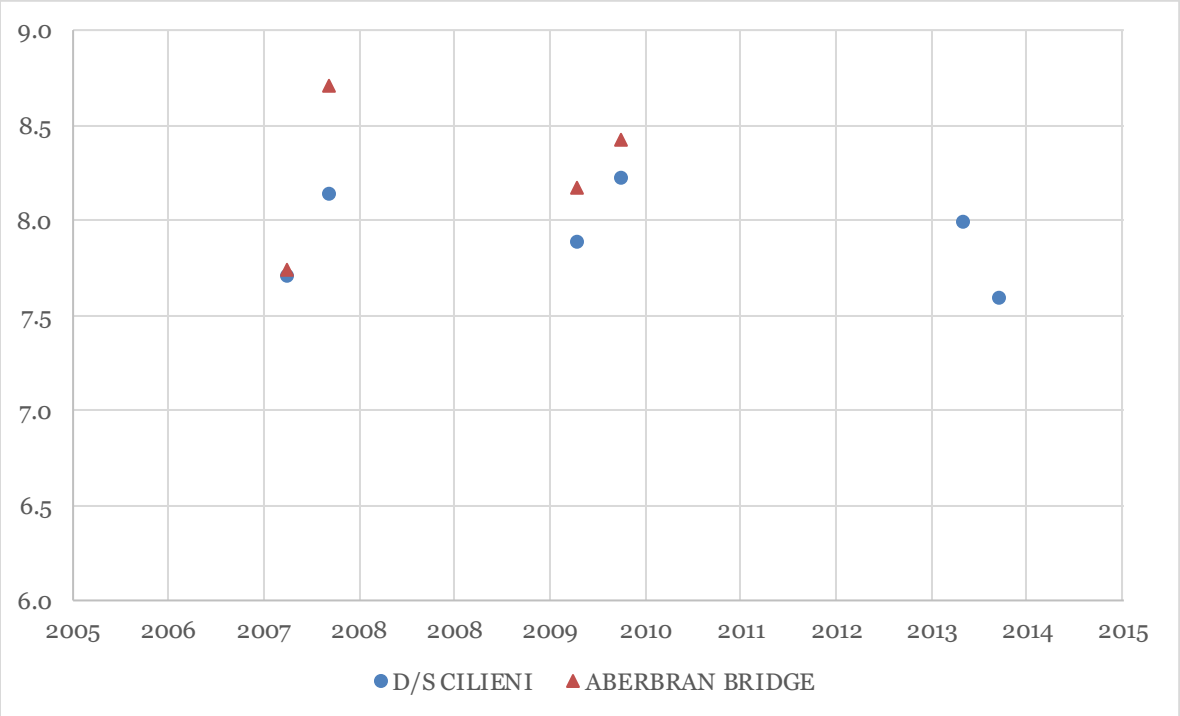
LIFE scores are used to assess how sensitive a macroinvertebrate community is to change in flow. Family LIFE scores are provided for all available data. See **Table D3.5** for interpretation.

Table D3.5 Interpretation of Macroinvertebrate Community LIFE Scores

LIFE score	Invertebrate community flow sensitivity
7.26 and above	High sensitivity to reduced flows
6.51 – 7.25	Moderately sensitive to reduced flows
6.5 and below	Low sensitivity to reduce flows

LIFE scores obtained from the D/S Cilieni and Aberbran Bridge sites in the River Usk ranged from 7.60 to 8.71 with an average score across both sites of 8.01 (**Figure D3.1**). This indicates a macroinvertebrate community which is highly sensitive to reductions in flows and therefore is consistent with that found in fast flowing water. There is no evidence for flow variation at these sites based on this data.

Figure D3.1 Family LIFE Scores for Sites Located in the River Usk



In the impacted reaches no baseline macroinvertebrate data is available. The water quality in these impacted reaches is consistent with the standard to support high status for macroinvertebrates for ammonia and dissolved oxygen. Phosphate concentrations were variable with the standard to support high status for invertebrates throughout the zone of influence of the Crai Reservoir drought order. Even so phosphate concentrations are not expected to directly influence macroinvertebrate community quality. Considering this high water quality and the high standard of the macroinvertebrate community downstream of Reach 3, the community in Reaches 1, 2, and 3 would be expected to be of good to high quality.

Overall, a relatively diverse macroinvertebrate community dominated by EPT (ephemoptera, plecoptera and trichoptera) river fly species as would be expected for this type of upland river.

The ASPT scores obtained from the D/S Cilieni and Aberbran Bridge sites in the River Usk ranged from 5.83 to 6.9 with an average of 6.32 across both sites during the period 2005 to 2015 (**Figure D3.2**). This reflects a macroinvertebrate community which is consistent with that found in good to high water quality. This was also reflected by the BMWP scores which ranged from 87 to 164 with an average of 120 across both sites during the period 2005 to 2015 (**Figure D3.3**).

Figure D3.2 ASPT Scores for Sites Located in the River Usk

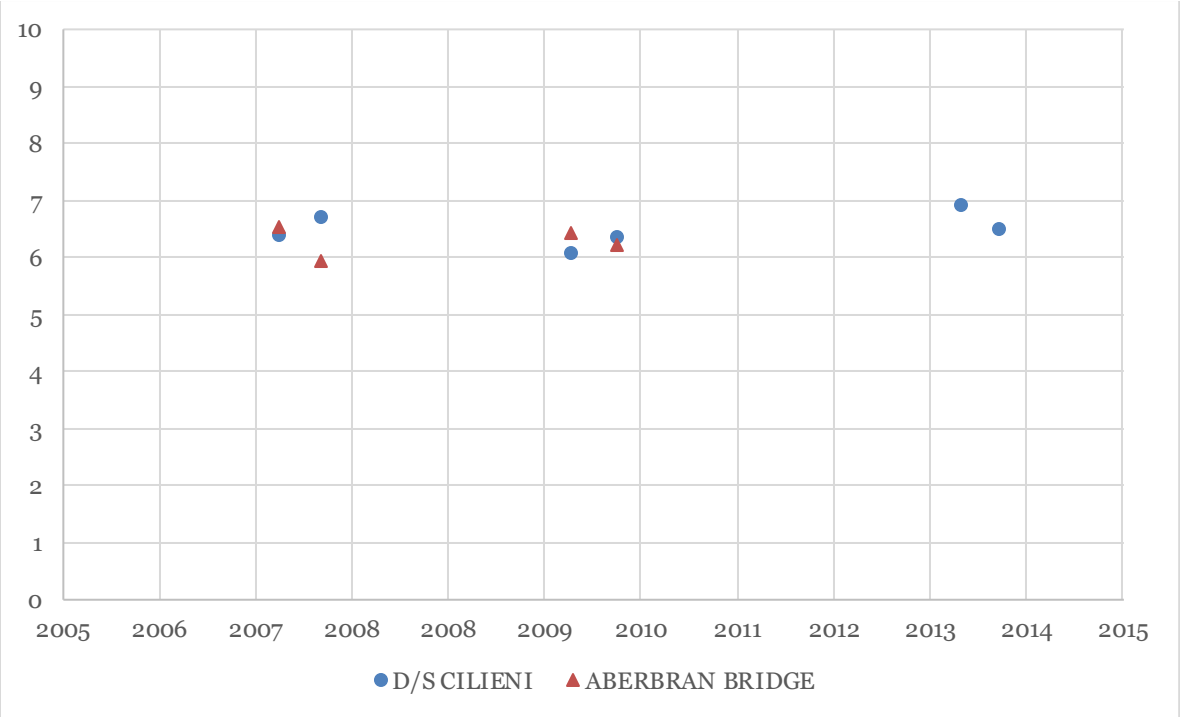
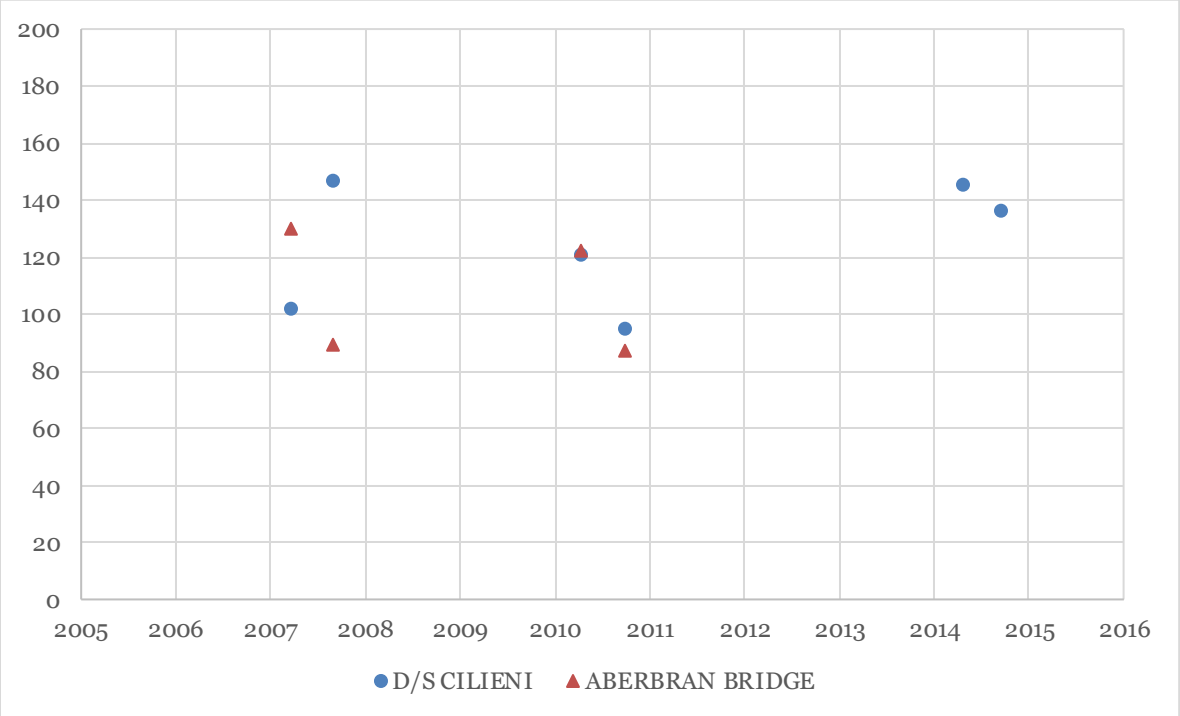


Figure D3.3 BMWP Scores for Sites Located in the River Usk



Notable Species

Freshwater pearl mussels

Freshwater pearl mussels *Margaritifera margaritifera* are listed as being present in the Upper Usk SSSI. No records of freshwater pearl mussels within the impacted reaches were received from NRW. There is limited data on the distribution of pearl mussel populations within the River Usk, although a single dead shell was found in the river in 2012 suggesting that a few old adults may still survive[15]. The only other record is from Llansantffraed Bridge in 1992, outside of the hydrological zone of impact. As the distribution of the species is uncertain it has been included in the assessment as a precautionary approach.

White-clawed crayfish

Whilst NRW data does not provide evidence for the presence of native white-clawed crayfish, the species has previously been found in the River Usk between Brecon Weir and Llansantffraed on a few occasions between 1982 and 2001. It is thought that the species is now absent from the main stem of the Usk. In addition, the River Usk and Tributaries SSSI citation only states that white-clawed crayfish have been recorded in the Caerfanell and Honddu rivers[16], as such is not located within the zone of hydrological influence of this drought order. For this reason, this species will not be considered further in this assessment.

[15] Natural Resources Wales (2013) European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC). Supporting documentation for the Third Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2007 to December 2012. Conservation status assessment for Species: S1029 - Freshwater pearl mussel. (*Margaritifera margaritifera*)
[16] Countryside Council for Wales (2003) Site of Special Scientific Interest Citation: River Usk (Tributaries)

D.3.2.2 Assessment

The hydrological impacts associated with a reduction in compensation discharge will include a reduction in wetted width and wetted depth below those normally observed in Afon Crai and upper River Usk.

Reduction in flow can modify the distribution and availability of in-stream habitat, such that detrimental effects on macroinvertebrates are possible. Marginal habitats are the most sensitive to flow reduction, with many slow-flow favouring species such as molluscs utilising this habitat. Depending on the rate of flow reduction, species in these marginal sediments may become stranded and ultimately die. Reproduction may also be impacted, in the autumn period low flows may influence macroinvertebrate species with a spring emergence, as the majority of these species lay their eggs in autumn with the eggs overwintering in the watercourse and recruitment may therefore be reduced.

For Reach 1 (Afon Crai) operation of the drought order is predicted to result in major hydrological impacts, due to a 50% reduction in low and extreme low flows in August and September and a 50% reduction in median and low flows in October and November. This magnitude of flow change would be expected to have significant effects on velocities, wetted width and depth and therefore habitat availability, particularly in flow sensitive areas of the channel, e.g. riffles, which form important habitat for macroinvertebrate species.

Baseline data indicates that the impacted reaches support macroinvertebrate communities which are highly sensitive to reduced flows, with a high proportion of species preferring fast flowing waters. It is likely that in the short-term this impact will modify the macroinvertebrate community with a loss of species which prefer fast flows and proliferation of invertebrates which favour slower flows. Although this effect would occur during drought under normal operating conditions, the operation of the drought order is likely to magnify this effect as the availability of habitat niches and velocities is further reduced. This is likely be reflected by reduced LIFE scores and numbers of taxa.

Typically, invertebrate communities can recover rapidly from short term flow impacts as a result of immigration from upstream habitats. In the context of the River Usk, recovery of the invertebrates will benefit from the unaffected section of the River Usk upstream of the Afon Crai confluence, and the many tributaries in the Upper Usk catchment. Invertebrate recovery will also involve aerial recolonization and refugium-use strategies. As such invertebrate recovery following the cessation of the drought order and return to standard compensation flow will likely be rapid within River Usk. Recruitment within Reach 1 will be limited as a result of the influence of the reservoir

In addition to effects on velocity and habitat availability, the drought order has been assessed as having a minor impact on ammonia and dissolved oxygen in Reach 1 during summer, which has the potential to affect macroinvertebrate communities during drought order implementation. This may manifest as a small reduction in pollution sensitive taxa in this reach. Taxa from families such as *Leuctridae*, *Perlodidae*, *Taeniopterygidae* and

Heptageniidae with requirement for high dissolved oxygen levels will be most susceptible. BMWP and ASPT scores from a community impacted by this pressure will be slightly reduced. A number of crustacean taxa such as the freshwater shrimps (*Gammaridae*) are particularly sensitive to ammonia. Consequently, there is potential that in the short-term this impact will modify the macroinvertebrate community, with a reduction in abundance of ammonia sensitive species.

Potential impacts on SRP concentrations in Reach 1 are assessed as medium. SRP is not expected to have a direct impact on the macroinvertebrate community, although proliferation of algal communities in response to elevated nutrients may have indirect effects, for example with fluctuations in diurnal dissolved oxygen saturation as a response to increased primary production having a deleterious effect on sensitive taxa.

However, restoration of favourable ammonia, dissolved oxygen conditions and SRP concentrations is predicted following a recovery of flow. Hence given the ability of macroinvertebrate communities to recover as a result of effective re-colonisation strategies, the magnitude of impact of water quality changes is considered to be low.

The impacts from changes in hydrology, in addition to water quality deterioration, would be expected to have a significant effect on macroinvertebrate habitat availability and quality over and above that experienced during natural drought during the duration of the drought order. Therefore, the potential impact to macroinvertebrate communities in Reach 1 is assessed as **moderate**, adverse, short term and reversible.

Hydrological impacts on Reach 2 (River Usk, Afon Crai confluence to the Afon Senni confluence) are expected to be moderate, with a reduction in 9.2% and 11.6% of low and extreme low flows respectively during August and September and a reduction of 2.4% and 8.1% in median and low flows during October and November. Water quality risk have been assessed as low for dissolved oxygen and ammonia year round, but with a medium risk to SRP. Impacts due to hydrology and water quality are anticipated to be through the same mechanisms as described for Reach 1 but at a lower magnitude. Overall, the impact of the drought order on macroinvertebrate communities of Reach 2 is therefore assessed to be **minor**, medium magnitude, adverse, short term, and reversible.

Hydrological impacts on Reach 3 (River Usk, Afon Senni confluence to the Afon Cilieni confluence) are expected to be minor with reductions of 8.4% and 12.3% in low and very low flows respectively during August and September and a reduction of 1.5% and 6.3% in median and low flows during October and November. Impacts on dissolved oxygen, ammonia and SRP within this reach are expected to be moderate due to the influence of Senni bridge sewage treatment works. Therefore, impacts of the drought order on the macrophyte community in Reach 3 are expected to be **minor**, adverse, short term, and reversible.

Notable species

Freshwater pearl mussels have previously been recorded in the River Usk. If present within the impacted reaches, freshwater pearl mussels may be affected by the drought order, however, without information on locations and population densities it is not possible to accurately assess the magnitude of impacts on this receptor. Taking a precautionary approach, the assessment below assumes the presence of freshwater pearl mussels within flow sensitive areas of the channel within each of the hydrological reaches.

Freshwater pearl mussels live buried or partly buried in coarse sand and fine gravel in clean, oligotrophic, fast-flowing and unpolluted rivers and streams. As a result, they are susceptible to reductions in flow velocities as they increases the suitability for formation of algal mats and reduces interstitial water column mixing.

The reduction in flow and wetted width as a result of the drought order may results in the uncovering of shallow riffle areas and the aggregation of detrital silt potentially causing death of mussels due to exposure out of water and reduced habitat area and suitability for both adult and juvenile mussels. Therefore, due to reduction in flow and wetted width and potential changes to algal coverage due to risk of increased SRP (see Appendix B) the impacts on freshwater pearl mussels in Reaches 2 and 3 are considered to be **moderate**, high magnitude, adverse, medium term, and reversible.

Summary

The potential impacts of the Crai Reservoir drought order on the macroinvertebrate community are summarised in **Table D3.6**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability; see Section 4.3 of the main report) and the sensitivities of the macroinvertebrate community. The impacts presented in **Table D3.6** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.6 Summary of Impacts on Macroinvertebrate Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Crai, from the Crai Reservoir outflow to the River Usk confluence		
Macroinvertebrates	• Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats • Reduction in species diversity as a result of deterioration to water quality	**Moderate**
Reach 2 - River Usk, from the Afon Crai confluence to the Afon Senni confluence		
Macroinvertebrates	• Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats • Reduction in species diversity as a result of deterioration to water quality	**Minor**
Freshwater pearl mussel	• Reduction in habitat area and suitability • Potential for mortality due to reduced flows and wetted width.	**Moderate**
Reach 3 - River Usk, from the Afon Senni to the Afon Cilieni confluence		
Macroinvertebrates	• Reduction in species diversity and abundance as a result of reduced recruitment. • Reduction in species diversity as a result of the loss of flow-sensitive taxa • Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats	**Minor**
Freshwater pearl mussel	• Reduction in habitat area and suitability • Potential for mortality due to reduced flows and wetted width.	**Moderate**

The impacted reaches of the Afon Crai drought order fall within three WFD water bodies: Afon GB109056033080 (Crai - source to River Usk confluence), GB109056039980 (Usk, confluence Afon Hydfer to confluence Afon Senni), GB109056040081 (Usk –Afon Senni confluence to Afon Crawnon confluence). The macroinvertebrate components of the GB109056033080 and GB109056039980 waterbodies are classified as having high status. The GB109056040081 is not currently classified for macroinvertebrates but is classed as having high overall biological status.

Implementation the drought order will result in a **moderate** risk of short term deterioration in WFD status of the macroinvertebrate component of the GB109056033080 waterbody and a **minor** risk of deterioration for waterbodies GB109056040081 and GB109056039980 during the duration of the drought order. However, effects would be expected to be temporary and reversible following return to a normal hydrological regime.

D.3.3 Fish

D.3.3.1 Baseline

The hydrological zone of influence of the Crai Reservoir drought order includes the Afon Crai below Crai Reservoir (Reach 1) and the River Usk from the Afon Crai confluence to the confluence with the Afon Cilieni (Reaches 2 and 3). Reaches 1 to 3 are all within the River Usk SAC and River Usk (Upper Usk) SSSI, and these designations recognise the exceptional range of fish species present in the catchment. The Habitats Directive Annex II species that are a primary reason for selection of the River Usk SAC are Atlantic salmon , brook lamprey, river lamprey, sea lamprey *Petromyzon marinus*, bullhead and twaite shad *Alosa fallax*. Allis shad *Alosa alosa* are also included in the citation as an Annex II species present as a qualifying feature, but not a primary reason for site selection.

A general baseline was provided in the Environmental Monitoring Plan (EMP) for Crai Reservoir (SW4)[17] and this text has been revised and updated to take into account recent NRW fish survey data and an updated summary baseline is provided below.

In the sections which follow, the existing data and its limitations are described followed by a general description of the species assemblage across the hydrological zone of influence and then more detailed descriptions of individual species status (where possible).

Existing data

A paucity of fisheries monitoring data was highlighted in the 2007 EMP[17] and recommendations for detailed additional monitoring were included, however very little further monitoring has been undertaken in the interim. Limited additional monitoring, particularly lamprey-specific electric fishing surveys, has been undertaken by NRW in recent years alongside routine salmonid monitoring. Data resulting from a modest lamprey survey of the River Usk undertaken by APEM in 1998[18] was analysed in the EMP and is also summarised below.

In addition, more general monitoring of SAC features and the Atlantic salmon population is undertaken as part of SAC condition assessment and principal salmon river monitoring respectively. The combination of these data allows a relatively good understanding of the species assemblage and Atlantic salmon populations at the catchment-scale but gives little resolution at the reach scale or in terms of smaller tributaries which are not routinely monitored by NRW.

Fish survey data from a number of sites within hydrological Reaches 1 to 3 were provided by NRW following a data request to inform this assessment. The routine NRW juvenile salmonid sampling sites where recent data (taken as the last ten years) are available are given in

[17] Cascade (2007). DCWW. Provision of an Environmental Monitoring Plan. Environmental Monitoring Plan for Crai Reservoir (SW4). Final. 11th June 2007. Produced for DCWW by Cascade in association with APEM.
[18] APEM (1999). Lamprey habitat assessment using RHS in the River Usk. Project Reference: 517.

Table D3.7 along with the sampling years.

Table D3.7 Recent NRW Routine Juvenile Salmonid Monitoring Sites, Locations and Sampling Years

Reach	NRW Site Name (Code)	Location	Sample Years
1 (Afon Crai from the Crai Reservoir outflow to the River Usk confluence)	U003a	SN8889824489	2008 - 2010
	U016	SN8810723550	2007, 2008, 2010, 2013
2 (River Usk, from the Afon Crai confluence to the Afon Senni confluence)	U041A	SN9198028596	2007, 2013
3 (River Usk, from the Afon Senni confluence to the Afon Cilieni confluence)	None	-	-
n/a	U065 (1km d/s Reach 3)	SN9470029600	2007, 2013

Site U065 is located approximately 1km downstream and has been used to provide context for the likely species assemblage in Reach 3.

No long-term datasets are available for juvenile salmonid monitoring sites within the hydrological zone of influence, and sites have not been sampled consistently either across years or in terms of methodology[19], reducing spatial and temporal comparability. However, the geographical coverage gives a useful insight into the likely species assemblage within the hydrological zone of influence.

The locations of lamprey-specific monitoring undertaken within, and in the vicinity of, the hydrological zone of influence are given in **Table D3.8** below. Density estimates are only available for site U014L.

[19] Sites have been sampled using single run semi-quantitative and three-run quantitative methodologies as well as timed single run (CPUE) in some cases.

Table D3.8 Lamprey-specific Monitoring Locations

Reach	Site Name	Location	Sampling Year/s
1 (Afon Crai from the Crai Reservoir outflow to the River Usk confluence)	U500L (NRW)	SN8916924900	2014
2 (River Usk, from the Afon Crai confluence to the Afon Senni confluence)	U014L (NRW)	SN8826728798 (~2.5km upstream Reach 2)	2011, 2015
3 (River Usk, from the Afon Senni confluence to the Afon	27 (APEM)	SN9210028800	1998
	26 (APEM)	SN9650029100 (~3km downstream Reach 3	1998

Condition assessment of the River Usk SAC features carried out in 2008 by CCW[20] revealed that, with the exception of brook and river lamprey, all listed fish species were in unfavourable condition. However, this conservative assessment was largely due to uncertainty resulting from a lack of survey data.

'Principal' Atlantic salmon *Salmo salar* rivers (numbering 64 in England in England and Wales) are assessed annually with the most recent report[21], published in 2016. The River Usk is classified as a principal salmon river. The status of individual river stocks in England and Wales is evaluated annually against their stock conservation limits (CLs) and management targets (MTs). In England and Wales, CLs have been developed that indicate the minimum spawning stock levels below which stocks should not be allowed to fall. The CL for each river is set at a stock size (defined in terms of eggs deposited) below which further reductions in spawner numbers are likely to result in significant reductions in the number of juvenile fish produced in the next generation. In reviewing management options and regulations, NRW also use an over-arching management objective that a river's stock should be meeting or exceeding its CL in at least four years out of five (i.e. >80% of the time) on average. A management target (MT) is set for each river, representing a spawning stock level for managers to aim at in order to meet this objective.

The River Usk is classified as currently 'probably at risk' (5 – 50% probability of meeting the management objective) with a predicted classification of 'probably at risk' in 2020.

This classification is significant for this assessment as it highlights the ongoing vulnerability of the Atlantic salmon population of the Usk catchment. Maintaining migratory corridors and

[20] CCW (2008). Core Management Plan Including Conservation Objectives for River Usk Special Area of Conservation. Version: 1.5. Date: 7 March 2008.
[21] Cefas. 2016. Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2015. Preliminary assessment prepared for ICES, March 2016.

spawning and nursery areas for Atlantic salmon is recognised as particularly important in this instance.

The 'Afon Crai from the Crai Reservoir outflow to the River Usk confluence' waterbody (GB109056033080), a heavily modified waterbody, was assessed as being at moderate status for fish in both 2009 and 2015. The 'River Usk, from the Afon Crai confluence to the Afon Senni confluence' waterbody (GB109056040010) was not assessed for fish in 2009 and at good in 2015. The 'River Usk, from the Afon Senni confluence to the Afon Cilieni confluence' waterbody (GB109056040081) was assessed as being at moderate status for fish in 2009, but was not assessed for fish in 2015.

Data limitations

The available data is not sufficient to adequately describe the fisheries baseline. There is uncertainty surrounding the status of fish populations present including protected species (e.g. Atlantic salmon, bullhead and lamprey species) and no juvenile salmonid monitoring data was made available more recent than 2013. Where data is available, spatial and temporal coverage is generally limited and there is inconsistency in terms of monitoring techniques and sample years.

In addition, there are limitations in terms of the NRW data made available. Individual measured lengths for bullhead were only provided for 2015, and bullhead were not recorded prior to 2003 so there is particular uncertainty around the status of this protected species. Also, few lamprey-specific surveys have been undertaken within the hydrological zone of influence, and no density estimates for sites other than U014L are available. There is therefore significant uncertainty around the lamprey species present and their status in the relevant reaches of the Afon Crai and River Usk.

The precautionary principle has therefore been used, where necessary, in the following assessment which is based on a conservative approach assuming that significant populations of the species listed above exist in all reaches.

In order to obtain a suitable baseline, a suite of electric fishing surveys and lamprey-specific monitoring in one year with adequate coverage of the hydrological reach would be required as a minimum. A suitable monitoring programme was described in the EMP[17].

Species composition

Only four fish species have recently been recorded within the hydrological zone of influence, i.e. Atlantic salmon and bullhead (both Environment (Wales) Act Section 7 and Habitats Directive Annex II species), brown/sea trout *Salmo trutta* (Environment (Wales) Act Section 7 species) and European eel *Anguilla anguilla* (Environment (Wales) Act Section 7 species and IUCN Red List 'Critically Endangered'). Unidentified lamprey (*Lampetra* sp.)

ammocoetes[22] have also been recorded in NRW surveys. This is due to the fact that brook and river lamprey ammocoetes are indistinguishable in the field[23]. River lamprey may therefore be present and have been included in this assessment as part of a precautionary approach.

Minnow *Phoxinus phoxinus* have been recorded at site U065, ~1km downstream of Reach 3, and the species is therefore assumed to also be present within the hydrological zone of influence.

There are no records of allis shad, twaite shad or sea lamprey within or near to the hydrological zone of influence. This is likely to be the result of barriers to the free passage of these species (mostly notably Crickhowell Bridge) limiting spawning migrations to the lower reaches of the River Usk only.

Atlantic salmon and sea trout are known to be able to migrate past obstructions which limit penetration of shad and lamprey species in the Usk catchment, and salmonid spawning grounds occur throughout River Usk tributaries and headwaters. There is a small but significant run of sea trout in the Usk which tend to spawn in a few of the tributaries, notably the Afon Hydfer[24]. Therefore, the River Usk in Reaches 2 and 3 is likely to constitute an important migratory pathway for the species.

Atlantic salmon

Atlantic salmon fry and parr densities are presented in **Table D3.9**. No long-term datasets are available, however, densities from less comprehensive datasets for sites U003a (Reach 1), U016 (~2.5km upstream of Reach 2) and U065 (~1km downstream of Reach 3) have been included to provide an indication of likely spatial trends within the hydrological zone of influence. Timed run data is available for site U041A, which provides presence absence data only.

At U003a, fry (0+) and parr (>0+) densities showed considerable variation between 2008 and 2010 (Grade A to E[25]). At U016, fry densities were variable (Grade B to E) and parr densities were generally at or above average (Grade B to C) between 2007 and 2013. At U065, fry and parr densities were poor in both sample years (Grade D to F).

[22] Lamprey larvae are known as ammocoetes. When ammocoetes mature prior to migration (either to estuaries for river lamprey or upstream to spawn for brook lamprey) they are known as transformers.
[23] Harvey J & Cowx I (2003). Monitoring the River, Brook and Sea Lamprey, *Lampetra fluviatilis*, *L. planeri* and *Petromyzon marinus*. Conserving Natura 2000 Rivers Monitoring Series No.5, English Nature, Peterborough.
[24] Environment Agency Wales (1998) Local Environment Agency Plan, Rural Usk Area. Consultation Report, November 1998. Environment Agency Wales.
[25] For salmonids, a grading system is used based on the original Fisheries Classification System called the National Fisheries Classification (NFC). The electric fishing data are analysed to produce a juvenile salmon and trout density score for each site, using average values from the early 1990s as a baseline. The proportion of sites falling into different salmon abundance Classes (A to F) provides a measure of the health of the juvenile salmon populations for each river. Sites are typically grouped into those that are at or above average (Classes A to C), below average (Class D) and well below average or fishless (Classes E or F).

Table D3.9 Atlantic Salmon Fry and Parr Densities and Equivalent NFC Grades for NRW Sites U003a, U016 and U065

Sample year	NRW monitoring site U003a		NRW monitoring site U016		NRW monitoring site U065	
	0+ density (NFC Grade)	>0+ density (NFC Grade)	0+ density (NFC Grade)	>0+ density (NFC Grade)	0+ density (NFC Grade)	>0+ density (NFC Grade)
2007	-	-	13.67 (D)	10.94 (B)	0.60 (E)	0.8 (E)
2008	103.11 (A)	8.07 (C)	75.00 (B)	7.42 (C)	-	-
2009	8.10 (E)	0.48 (E)	-	-	-	-
2010	33.67 (C)	2.55 (E)	6.67 (E)	7.92 (C)	-	-
2013	-	-	33.94 (C)	7.00 (C)	0.02 (E)	0.01 (E)

The individual length data made available for sites U016 and U041a clearly show that Atlantic salmon recruitment occurs in Reach 1 with at least two year classes, 0+ and >0+, present in 2013. Length frequency data from 2013 is given in **Figure D3.4** and **Figure D3.5** below. The 2013 data for site U041A (Reach 2) suggest low fry and parr densities and, alongside the very poor juvenile densities exhibited at site U065 downstream of Reach 3, the likelihood is that this is a factor of juvenile salmonid habitat preferences (i.e. for smaller stream size and riffle dominated habitat). Juvenile densities therefore tend to decrease with increased river width/depth associated with distance downstream.

Figure D3.4 Length Frequency Histogram for Atlantic Salmon at Site U016 (Reach 1) in 2013.

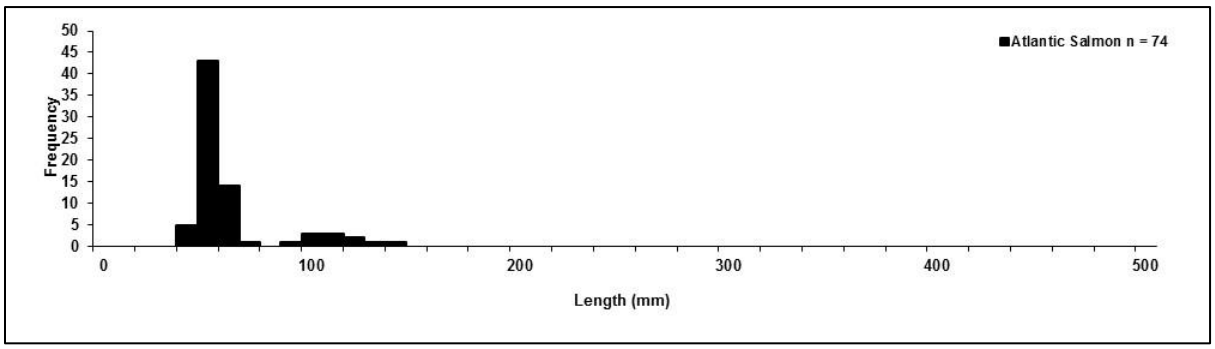
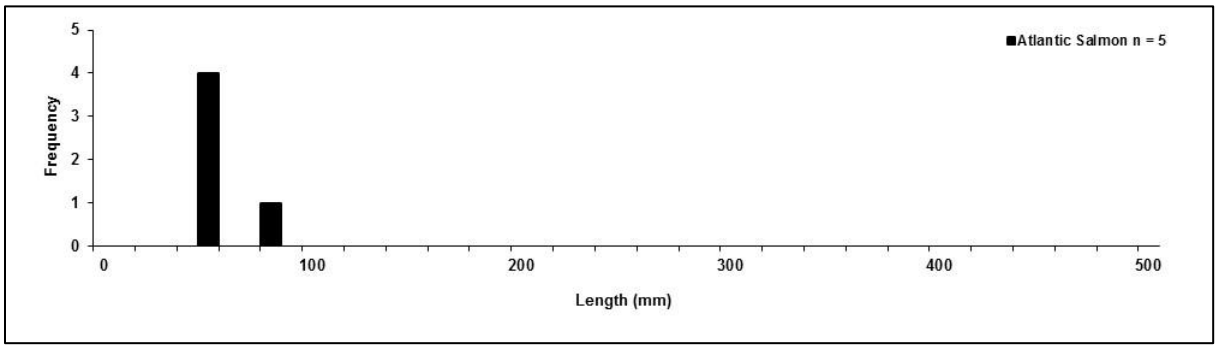


Figure D3.5 Length Frequency Histogram for Atlantic Salmon at Site U041a (Reach 2) in 2013.



Therefore, the available data suggest that the River Usk within the hydrological zone of influence constitutes an essential migratory pathway for Atlantic salmon whilst Reach 1 provides important spawning and nursery habitat.

Brook and river lamprey

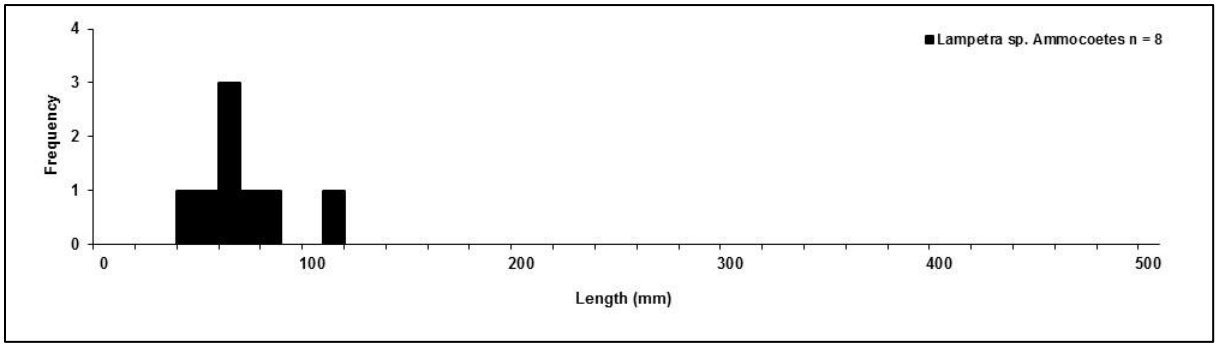
With the exception of one lamprey-specific survey site (U500L) located in Reach 1, there is limited NRW data available to establish the status of brook and/or river lamprey within the hydrological zone of influence, however, records of low densities of unidentified lamprey species were recorded at NRW salmonid site U003a (Reach 1) in 2008 and 2009 although none were recorded at salmonid site U016 (also Reach 1). This suggests that the Afon Crai is used, at least to some extent, as a spawning and juvenile nursery.

Lamprey monitoring was undertaken by NRW at site U500L (Reach 1) in 2014 and at site U014L (upstream Reach 2) in 2011 and 2015. Quantitative sampling in 2011 recorded *Lampetra* sp. (i.e. brook and/or river lamprey ammocoetes) densities of $1m^{-2}$ at U014L. In addition, transformers[22] positively identified as brook lamprey were also present at $1m^{-2}$ at U014L. Semi-quantitative sampling at U500L in 2014 recorded four *Lampetra* sp. ammocoetes, however, no density data is available. Semi-quantitative sampling at U014L in 2015 recorded a *Lampetra* sp. density of $13m^{-2}$. To provide some context, the brook/river lamprey ammocoete density threshold for compliance with favourable conservation status in SAC rivers is $>10m^{-2}$ in optimal habitat and $>2m^{-2}$ across a catchment[23].

Given the barriers to migration downstream on the River Usk, it is unlikely that river lamprey are present within the hydrological zone of influence. However, the data is equivocal due to the difficulty in speciating brook/river lamprey ammocoetes and so a precautionary approach is used assuming that both species are present.

Individual length data provided (see **Figure D3.6**) suggest multiple year classes of river and/or brook lamprey ammocoetes present, suggesting successful ongoing recruitment over time. Individual length data was not made available for U500L.

Figure D3.6 Length Frequency Histogram for *Lampetra* sp. (River and Brook Lamprey) Ammocoetes at Site U014L (~2.5km upstream Reach 2) in 2015.



Monitoring undertaken by APEM in 1998 found lamprey at only one site (located on the River Usk well upstream of Reach 2) of six monitored. This is not corroborated by more recent NRW data which suggests low densities of brook and/or river lamprey ammocoetes present across the hydrological zone of influence. The sampled lamprey were transformers rather than ammocoetes, and were positively identified as brook lamprey.

The available data is not adequate to accurately assess lamprey population status in Reaches 1 to 3 and, whilst the data provided suggest low densities of *Lampetra* sp. within the hydrological zone of influence, targeted surveys would be required to corroborate this assumption.

Bullhead

A short-term dataset from NRW site U016 (Reach 1) was made available and bullhead densities for most years between 2007 and 2013 are presented in **Table D3.10**. The data suggest considerable variability in density between years with figures both above and well below the 20/100m² target for SAC favourable conservation status in upland streams[26]. No individual length data was made available for bullhead.

Table D3.10 Bullhead Densities at NRW Site U001 (reach 1)

Sample year	Bullhead density (per 100m²)
2007	7.81
2008	10.16
2010	2.08
2013	26.94

Brown/sea trout

Brown/sea trout fry and parr densities are presented in **Table D3.11**. No long-term datasets are available, however, densities from less comprehensive datasets for sites U003a (Reach 1),

[26] Cowx, I.G. & Harvey, J.P. (2003). Monitoring the Bullhead, *Cottus gobio*. Conserving Natura 2000 Rivers Monitoring Series No. 4, English Nature, Peterborough.

U016 (~2.5km upstream of Reach 2) and U065 (~1km downstream of Reach 3) have been included to provide an indication of likely spatial trends within the hydrological zone of influence. Timed run data is available for site U041A, which provides presence absence data only, however, brown/sea trout were not recorded at this site in either 2007 or 2013.

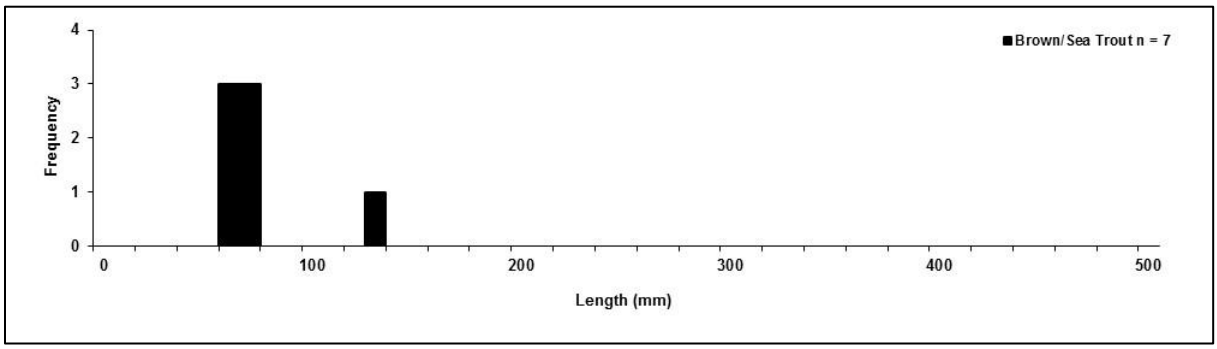
At U003a, fry (0+) and parr (>0+) densities were generally very poor between 2008 and 2010 (Grade D to F[25]). At U016, fry densities were variable (Grade C to E) and parr densities were generally very poor (Grade D to E) between 2007 and 2013. At U065, fry and parr were absent in both sample years (Grade F).

Table D3.11 Brown/Sea Trout Fry and Parr Densities and NFC Grades for NRW Sites U003a, U016 and U065

Sample year	NRW monitoring site U003a		NRW monitoring site U016		NRW monitoring site U065	
	0+ density (NFC Grade)	>0+ density (NFC Grade)	0+ density (NFC Grade)	>0+ density (NFC Grade)	0+ density (NFC Grade)	>0+ density (NFC Grade)
2007	-	-	1.17 (E)	2.73 (D)	0.00 (F)	0.00 (F)
2008	5.76 (D)	1.15 (E)	10.94(C)	2.73 (D)	-	-
2009	0.48 (E)	0.00 (F)	-	-	-	-
2010	0.00 (F)	1.53 (E)	1.25 (E)	1.25 (E)	-	-
2013	-	-	3.23 (D)	0.54 (E)	0.00 (F)	0.00 (F)

The density and individual length data made available for site U016 confirm that limited brown/sea trout recruitment occurs in Reach 1 with at least two year classes, 0+ and >0+, present in 2013. Length frequency data from 2013 is given in **Figure D3.7** below. However, the available data do not suggest that the Afon Crai is of particular importance in terms of brown/sea trout spawning or nursery habitat. This is corroborated by the fact that the River Usk sea trout population is known to spawn in the Afon Hydfer[24] in particular.

Figure D3.1 Length Frequency Histogram for Brown/Sea Trout at Site U016 (Reach 1) in 2013.



Therefore, the available data suggest that the Reaches 2 and 3 (the River Usk) within the hydrological zone of influence constitute an essential migratory pathway to sea trout spawning grounds upstream, but that spawning and nursery areas for brown/sea trout are generally confined to the tributaries and upper reaches of the River Usk upstream of the hydrological

zone of influence.

European eel

The available data suggest that European eel are present in low densities throughout the hydrological zone of influence, with elver recorded suggesting limited ongoing recruitment.

Other species

The available data gives little indication of minnow distribution within the hydrological zone of influence, however the species is likely to be present in low densities in all three reaches.

Ecological value of fisheries receptors

Atlantic salmon, brook and river lamprey and bullhead are Environment (Wales) Act Section 7 and Habitats Directive Annex II species that are a primary reason for selection of the River Usk SAC, and are considered to be of international importance. Brown/sea trout (Environment (Wales) Act Section 7 species) and European eel (Environment (Wales) Act Section 7 species and IUCN Red List 'critically endangered' species) are considered to be of national importance. Minnow are considered to be of site only importance.

D.3.3.2 Assessment

Hydrological variability in rivers can have a significant influence on the distribution of fish. When extreme low flows, or prolonged periods of low flow, are experienced, for example under continued water abstraction during drought conditions, the resultant changes in the hydrological regime can have significant impacts on resident fish communities. Abstraction of water from a river or stream reduces the wetted area and volume with the potential for subsequent impacts on fish populations as a result of, for example, intra- and inter-specific interactions (e.g. increased competition for optimal habitat and food)[27,28], reduced water quality and reduced reproductive success, growth and condition[29].

Potential impacts relating to habitat loss, water quality and migration are of relevance. These are discussed for key fish species in the sections which follow with particular focus on those aspects of fish ecology (e.g. migrations and juvenile life stages) most susceptible during the likely summer and autumn (taken to be April to December) impact period.

Reach 1 is predicted to undergo a reduction in flow of up to 50% with a drought order and, whilst mortality under these conditions is likely to be high, fish species have evolved mechanisms in order to cope with low flow conditions, for example, avoidance behaviour (i.e. moving downstream as water levels drop) or the ability to persist in pooled areas of deeper water. However, flow sensitive species such as Atlantic salmon and bullhead are, nonetheless,

[27] Magoulick, D.D. (2000). Spatial and temporal variation in fish assemblages of drying stream pools: the role of abiotic and biotic factors. Aquatic Ecology 34, 29-41
[28] Davey A.J.H. & Kelly D.J. (2007). Fish community responses to drying disturbances in an intermittent stream: a landscape perspective. Freshwater Biology 52, 1719–1733.
[29] Magoulick, D.D. and Kobza, R.M. (2003). The role of refugia for fishes during drought: a review and synthesis. Freshwater Biology 48, 1186-1198.

susceptible to reduced flows.

Atlantic salmon

Atlantic salmon migration

The River Usk within the hydrological zone of influence is an important migratory corridor for Atlantic salmon. The River Usk, like the nearby River Wye, is known for its modest spring run (April to June) of often very large Atlantic salmon, however, the majority of migrating Atlantic salmon are likely to enter the hydrological zone of influence later in the year (from September to December) and there is the potential for drought order-related impacts on flow to effect the timing of this migration. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature. As such the drought order is unlikely to impact on smolt migration. The impact on Atlantic salmon migration should be considered in the context of extreme low flows and drought conditions as a baseline. Periods of increased flow are considered to be a primary cue in initiating Atlantic salmon migration and very low flows are likely to delay migration.. The drought order is unlikely to impact on migration cues in the early part of implementation (August to September). During the months of October and November, the drought order is also unlikely to impact on migration in the main River Usk as Q_{50} flows will only decrease by 2.4% and 1.5% within Reaches 2 and 3 respectively. There remains some uncertainty with regards to the potential impact on migration into the Afon Crai as limited information regarding the impact of a 50% reduction in compensation flows on wetted width and depth was available at the time of this assessment. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on Atlantic salmon migration is therefore considered to be **major adverse** (uncertain) in Reach 1 from and **minor adverse** in Reach 2 and Reach 3.

Water quality

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in habitat to increase stress and subsequent loss of condition. Atlantic salmon are susceptible to poor water quality and particularly dissolved oxygen and water temperature. The effects of reduced water quality are likely to impact particularly sensitive juvenile life stages. The impact on water quality has been assessed as being up to medium magnitude, and the impact on Atlantic salmon is therefore considered to be **moderate adverse** in Reaches 1 to 3.

Juvenile Atlantic salmon

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Provided minimum low flows are available, juvenile Atlantic salmon are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. If gravels containing redds and/or eggs (likely to occur from December to January) become de-watered, this is likely to have a more significant effect with the

potential for significant mortality due to desiccation and increased predation. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on juvenile Atlantic salmon is therefore considered to be **major adverse** (uncertain) in Reach 1 and **minor adverse** in Reach 2 and Reach 3.

Brook and river lamprey

Juvenile (ammocoete and transformer) lamprey habitat

There is the potential for reduced flow to result in a decrease in river levels and wetted width. This has particular significance for juvenile (ammocoetes and transformer) lamprey habitat which tends to consist of silt in shallow, marginal areas. There is therefore the potential for a loss or degradation of this habitat. Provided minimum low flows are available, juvenile lamprey may relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase and increased mortality is likely. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on juvenile lamprey habitat is therefore considered to be **major adverse** in Reach 1 and **minor** Reach 2 and **minor adverse** in Reach 3.

Water quality

Water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) are not expected to have a significant impact on brook or river lamprey which are not particularly sensitive to these effects. The impact on brook and river lamprey is therefore considered to be **minor** in Reaches 1 to 3.

Migration of river lamprey

Mature river lamprey are thought to migrate upstream into freshwater in the autumn (from October to December[30]). This migration window overlaps with the timing of impacts on flow. River lamprey ammocoetes metamorphose after three to five years in freshwater and then descend to estuarine and marine environments. The migration tends to occur over the period July to September[30] and therefore a drought order would also affect this life stage. Upstream migration requires a reasonable flow of water to aid passage past natural and non-natural in-channel barriers. Low flows may limit upstream passage and hinder downstream passage, leaving both migratory life stages exposed to higher risks of predation and ultimately a reduction in recruitment. The impact is therefore considered to be of medium magnitude, short-term, temporary and reversible. The impact on river lamprey migration is therefore considered to be **major adverse** in Reach 1 and **minor adverse** in Reaches 2 and 3.

Bullhead

Bullhead are likely to be present throughout the hydrological zone of influence. The species is flow sensitive and spawning and egg incubation takes place from March to May. These life

[30] Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura2000 Rivers Ecology Series No.5. English Nature, Peterborough

stages are therefore unlikely to be affected by the drought order. Particularly susceptible juvenile life stages are likely to be affected by reduced flows (and likely reduced water quality) associated with implementation of a drought order. In particular, the young-of-the year individuals that depend on flows for distribution along the watercourse. A reduction in flow of up to 50% in Reach 1 is likely to have a significant impact on bullhead populations in particular. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on bullhead is therefore considered to be **major adverse** in Reach 1 and **minor adverse** in Reaches 2 and 3.

Brown/sea trout

Sea trout migration

The River Usk hosts a significant sea trout run and the hydrological zone of influence constitutes an important migratory corridor to spawning grounds located predominantly in the tributaries but also within Reach 1. It is likely that the majority of migrating sea trout would enter the river from September to November. The drought order is unlikely to affect the timing of this migration, but could hinder passage into Reach 1. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature, and will not be affected by the drought order. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on sea trout migration is therefore considered to be **major adverse** in Reach 1, and **minor adverse** Reaches 2 and 3.

Water quality

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in habitat to increase stress and subsequent loss of condition. Brown/sea trout are susceptible to poor water quality and particularly dissolved oxygen and water temperature. The effects of reduced water quality are likely to impact particularly sensitive juvenile life stages. The impact on water quality has been assessed as being up to medium magnitude and the impact on brown/sea trout is therefore considered to be **moderate adverse** in Reaches 1 to 3.

Juvenile brown/sea trout

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Provided minimum low flows are available, juvenile brown/sea trout are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. If gravels containing redds and/or eggs (likely to occur in November to January) become de-watered, this is likely to have a more significant effect with the potential for significant mortality due to desiccation and increased predation. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on juvenile brown/sea trout is therefore considered to be **major adverse** in Reach 1 and **minor adverse** in Reaches 2 and 3.

European eel

Elver enter rivers in early spring and a general upstream migration occurs throughout the year. Elver migration is not linked to periods of increased flow and low flow conditions are unlikely to impact migration. The downstream migration of mature (silver) eel tends to occur between September and December in most rivers and increased flow is considered to be an important migratory cue. There is therefore the potential for drought order-related impacts on flow to affect the timing of the latter part of this migration. European eel of a wide age range are likely to be present in low densities throughout the River Usk, but the species is tolerant of high temperatures and relatively poor water quality and is considered resilient to drought conditions. The impacts on European eel are therefore limited to silver eel migration but are considered to be **moderate adverse** in Reach 1, **minor adverse** in Reach 2 and **negligible** in Reach 3.

Other fish species

Minnow spawning and egg incubation occurs within the period May to July (outside the implementation period). These vulnerable life stages are likely to be particularly susceptible to impacts associated with drought order low flows and so the impact is considered to be of high magnitude, short-term, temporary and reversible. The impact on minnow is therefore considered to be **minor adverse** in Reach 1 and **negligible** in Reaches 2 and 3.

Summary

The potential impacts of the Crai Reservoir drought order on the fish community are summarised in **Table D3.12**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability; see Section 4.3 of the main report) and the sensitivities of the fish community. The impacts presented in **Table D3.1** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.12 Summary of Impacts on Fish Community

Species	Impact	Significance of Impact
Reach 1 – Afon Crai, from the Crai Reservoir outflow to the River Usk confluence		
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Major**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
Brook and river lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Major**
	• Reduced water quality	**Minor**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Major**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Major**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Major**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Moderate**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**
Reach 2 - River Usk, from the Afon Crai confluence to the Afon Senni confluence		
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Minor**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
Brook and river lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Minor**
	• Reduced water quality	**Minor**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Negligible**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Minor**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Minor**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**
Reach 3 - River Usk, from the Afon Senni to the Afon Cilieni confluence		
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Minor**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
Brook and river lamprey	• Reduction in spawning and ammocoete survival due to habitat loss.	**Minor**
	• Reduced water quality	**Minor**
	• Delays and potential cessation of adult and transformer migrations due to reduced flows.	**Negligible**
Bullhead	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**

Species	Impact	Significance of Impact
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Minor**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Minor**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Minor**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**

There is a risk of short-term deterioration in status of the fish component of the GB109056033080 (Crai - source to River Usk confluence), GB109056039980 (Usk, confluence Afon Hydfer to confluence Afon Senni), GB109056040081 (Usk –Afon Senni confluence to Afon Crawnon confluence) waterbodies due to the drought order. Impacts of drought order implementation on the fish communities of the impacted reaches have been summarised as negligible to major adverse, short-term, temporary and reversible. Consequently, the fish component of these waterbodies is considered to be at **major** to **moderate** risk of short-term deterioration.

D.3.4 Diatoms

D.3.4.1 Baseline

Baseline

No baseline monitoring data is available from NRW for the impacted reaches of the Afon Crai or River Usk, but was available from a monitoring site, Downstream Cilieni (see **Table 3.13**), downstream of Reach 3 on the River Usk. In the absence of baseline information from the impacted reaches, data from the Downstream Cilieni site has been used to give an indication of the diatom communities present within the study area. Due to the paucity of data additional data, monitoring data from 2002 has been included to improve the understanding of the communities present.

Considering the temporal constraints on the baseline information, care must be taken in their interpretation.

The Trophic Phytobenthos Index (TDI) describes the nutrient preferences of a phytobenthos community (**Table D3.13**). It ranges from 1 (preference for extremely low nutrient levels) to 100 (preference for extremely high nutrient levels). The data provided were used to calculateTDI3 scores for all available data and TDI4 Scores in 2014, with TDI4 being the most recent version of the index. Percentage Motile Taxa is also provided, this gives the relative proportions of phytobenthos taxa within the community which are motile. When there are high numbers of motile taxa, this can indicate that light availability is influencing the community, this can be brought about by pressures such as siltation and high covers of

filamentous algae.

Table D3.13 DARLEQ Metrics for Phytobenthos Data from the River Usk.

Site/Station Name	Reach	Sample Date	River TDI3	River TDI4	Motile%
Downstream Cilieni	D/S Reach 3	19-Sep-02	38.38	13	4
		20-Sep-02	52.66	31	27
		29-Sep-05	41.64	16	11
		22-Sep-2005	57.27	36	27
		26-Jul-06	48.44	10	7
		27-Sep-06	59.30	63	45

The phytobenthos community at Cilieni site was relatively diverse but showed a community dominated by *Achnanthidium minutissimum*, a species common and often abundant in upland streams with mobile substrates. The species composition of the phytobenthos community is typical of the upper and mid reaches of upland, relatively high velocity rivers without significant acidification. The community at the D/S Cilieni site also shows periodic high proportion of motile taxa, suggesting higher levels of siltation or suspended solids.

TDI3 and TDI4 scores, which range from 38.38 to 59.30 at the site D/S Cilieni suggest relatively low nutrient levels consistent with oligo-mesotrophic conditions in Reach 1, with nutrient levels increasing downstream, however it is impossible to know whether this change is gradual or a result of the input of the Cilieni at the end of the impacted reach. Soluble reactive phosphorus concentrations were variable, with the standard to support high status for fish and invertebrates occasionally exceeded throughout the zone of influence of the drought order. Diffuse agricultural enrichment is a likely pressure in this area and may account for any elevation in nutrient tolerant phytobenthos taxa.

Assessment

Impacts on the phytobenthos assemblages of the Afon Crai and River Usk within Reaches 1 to 3 could occur due to the operation of the drought order, including changes in community composition due to decreases in flow, changes to grazing pressure, increases in nutrient level, increases in water temperature and increases in filamentous algae smothering the substrate. Due to the short lifecycle of algal species, phytobenthos communities can respond rapidly to environmental change and a response in phytobenthos community composition to the reduction in flows due to the drought order would be expected.

WFD Ecological Quality Ratio metrics for phytobenthos (TDI4 in DARLEQ)[31] are designed to detect differences in nutrient levels, particularly SRP. Implementation of the drought order in Reaches 1, 2, and 3 is expected to result in moderate risk to water quality deterioration. Any increase in SRP is likely to affect the phytobenthos community in terms of TDI score and associated WFD status.

Due to the rapid response of phytobenthos communities to environmental variables, this effect

31 WFD-UKTAG (2014) Phytobenthos: Phytobenthoss for Assessing River and Lake Ecological Quality (River DARLEQ2)

is expected to be short lived, with communities recovering rapidly following return to the normal hydrological regime.

The impacts of the drought order on phytobenthos communities are therefore assessed as **moderate** for Reach 1 and **minor** for Reaches 2 and 3. All impacts are deemed to be temporary, short term, and reversible.

Summary

The potential impacts of the Crai Reservoir drought order on the phytobenthos community are summarised in **Table D3.14**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability; see Section 4.3 of the main report) and the sensitivities of the phytobenthos community. The impacts presented in **Table D3.14** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.14 Summary of Impacts on Phytobenthos Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Crai, from the Crai Reservoir outflow to the River Usk confluence		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Moderate increase in SRP affecting phytobenthos community composition and TDI score	**Moderate**
Reach 2 - River Usk, from the Afon Crai confluence to the Afon Senni confluence		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition Moderate increase in SRP affecting phytobenthos community composition and TDI score	**Minor**
Reach 3 - River Usk, from the Afon Senni to the Afon Cilieni confluence		
Phytobenthos	• Decrease in flow affecting phytobenthos community composition • Moderate increase in SRP affecting phytobenthos community composition and TDI score	**Minor**

The impacted reaches of the Afon Crai drought order fall within three WFD water bodies: GB109056033080 (Crai - source to River Usk confluence), GB109056039980 (Usk, confluence Afon Hydfer to confluence Afon Senni), GB109056040081 (Usk –Afon Senni confluence to Afon Crawnon confluence). The macrophyte and phytobenthos components of the GB109056033080 and GB109056039980 waterbodies are classified as having high status. The GB109056040081 is not currently classified for macrophytes and phytobenthos but is classed as having high overall biological status.

Implementation the drought order will result in a **moderate** risk of short term deterioration in WFD status of the macrophyte and phytobenthos component of the GB109056033080 waterbody and a **minor** risk of deterioration for waterbodies GB109056040081 and

GB109056039980 during the duration of the drought order. However, effects would be expected to be temporary and reversible following return to a normal hydrological regime.

D4 LANDSCAPE, RECREATION AND ARCHAEOLOGY

D.4.1 Landscape

D.4.1.1 Baseline

The Crai Reservoir is located in the north-western part of the Usk catchment, which is part of the Brecon Beacons National Park. The catchment as a whole is predominantly rural and sparsely populated with the exception of the three main towns, i.e. Brecon, Abergavenny and Newport. The dominant land use in the north-western part of the Usk catchment is agriculture, with sheep grazing and forestry as the major components.

D.4.1.2 Assessment

Water width/depth directly affects the landscape and visual amenity value of the site, although this will only be temporary and will be ameliorated once the drought has passed. No impacts on landscape or visual amenity are anticipated, therefore, the impacts are summarised as **negligible**.

D.4.2 Recreation

D.4.2.1 Baseline

The Afon Crai, River Usk, and adjacent riparian land are used for a range of recreational activities including canoeing, fishing (the River Usk being one of the finest salmon rivers in Wales and is renowned as a quality brown trout fishery), walking, cycling and bird watching (NRW, 2014[32]). As the site lies within the Brecon Beacons National Park, it attracts visitors in search of outdoor recreation and support the local economy through tourism.

D.4.2.2 Assessment

Any reduction in compensation releases to the river and therefore in wetted width and depth may influence water-dependant activities such as angling and canoeing due to changes in flow. However, water levels will be naturally low in times of drought and impacts will be temporary in nature, therefore, the impacts are expected to be **negligible**.

D.4.3 Archaeology

Baseline

The Usk valley has played a strategic role as a key route and transport corridor; used by the Romans in the first Century AD and the Normans in the late eleventh century. There are also a diverse number of important archaeological features including Iron Age hillforts, Medieval

[32] NRW (2014) Usk Management Catchment Summary, Natural Resources Wales

mottes and castles (NRW, 2014[33]). There were three Ancient monument sites found within 500m of the study site, i.e. Castell-Du, Sennybride – a medieval defence site, Pont Gihirych – a post medieval transport site, and Waunewydd standing stone – a prehistoric religious/ritual site.

Assessment

Three Scheduled Ancient Monuments are located in proximity to the zone of hydrological influence, however, none are considered to be water dependant and therefore, influenced by the drought order, therefore, the impacts are summarised as **negligible**.

Table D4.1 Summary of Impacts on Landscape, Recreation, and Archaeology

Feature	Impact	Significance of Impact
Landscape	• Flows during a drought will be low such that further reduction in flows due to the drought order would not result in a further loss of aesthetic value	**Negligible**
Recreation	• Impacts on recreation activities (e.g. angling, canoeing, walking) are not anticipated over those from the natural drought conditions	**Negligible**
Archaeology	• No water dependant archaeological features are present within the zone of impact.	**Negligible**

[33] Brecon Beacons National Park Authority (2012) Landscape character area 11: Eastern Usk valley, Brecon Beacons National Park Landscape Character Assessment