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Dŵr Cymru Welsh Water

# Environmental Assessment of Crowhill Drought Order (8206-1)

Final

March 2019

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**Produced By**

**Authorised for Release By**



.....  
**Dr Anne Fairhead**  
**Principal Environmental Scientist**

.....  
**John Sanders**  
**Technical Director**

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#### **CONTACT DETAILS:**

Ricardo Energy & Environment  
Bright Building, First Floor  
Manchester Science Park  
Pencroft Way  
Manchester  
M15 6SGZ

Tel: +44 (0)1235 753000



## NON-TECHNICAL SUMMARY

### INTRODUCTION AND PURPOSE OF THIS REPORT

Welsh Water's 2015 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 Crowhill on the Western Cleddau River, over and above those arising due to natural effects of drought and those which would occur under "normal" abstraction licence conditions.

The Western Cleddau River is located in Welsh Water's Pembrokeshire Water Resource Zone (WRZ) which covers the far south west corner of Wales, stretching from Pendine Sands in the east to the Pembrokeshire Coastal National Park in the west, and from the village of Manobier in the south to Fishguard in the north.

The Western Cleddau forms a component of the Afonydd Cleddau / Cleddau Rivers Special Area of Conservation (SAC) and the Western Cleddau Special Site of Scientific Interest (SSSI), and discharges into the Pembrokeshire Marine 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 Crowhill, 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 Pembrokeshire WRZ in the event of a future severe drought, Welsh Water would make an application to the Welsh Ministers for a drought order to vary the conditions of abstraction from the Western Cleddau at the Crowhill abstraction intake.

If granted the drought order would change the abstraction conditions at the Crowhill intake. The prescribed flow licence condition of 22.3 Ml/d means that at river flows of less than 49.6 Ml/d, the full licensed volume cannot be abstracted at the Crowhill intake. The drought order would instead allow river abstraction from the Western Cleddau to continue subject to a revised daily prescribed flow of 11.1Ml/d, enabling more water to be abstracted in drought conditions. The drought order is most likely to occur during the summer months of April to September inclusive.

The revised abstraction arrangements would legally be authorised for four months. Use of the drought order powers 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 Crowhill. 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 **moderate** impact on flows in the Western Cleddau as a result of implementing the drought order during the period April to September which leads to **minor** 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 WFD status and Community Assessment / Habitats Directive designated habitats and species, SSSI designated features and Environment (Wales) Act Section 7 species and recreation (angling only) as environmental features for which an environmental assessment was required. The assessment has concluded that there are **moderate** impacts on fish (lamprey), and **minor** impacts on other fish species, macroinvertebrates, macrophytes and phytobenthos.

The HRA Screening concluded that implementation of a drought order has the potential to result in likely significant effects on the populations of brook, river and sea lamprey in the Cleddau Rivers SAC, but no likely significant effects are anticipated to the qualifying features of the Pembrokeshire Marine SAC

### ***Cumulative Impacts***

No cumulative effects of implementing the drought order with 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 Crowhill.

### **MITIGATION AND MONITORING**

The environmental assessment has identified significant impacts of implementation of a drought order at Crowhill. Consequently, in line with the DPG, an Environmental Monitoring Plan has been proposed. Potential mitigation measures for fish (lamprey) 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 Crowhill, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **moderate**.

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**Appendix B – Hydrology and Physical Environment Assessment**

**Appendix C – Environmental Features Assessment Methodologies**

**Appendix D – Environmental Features Assessment**

# 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 change the abstraction licence conditions at the Crowhill intake. The prescribed flow licence condition of 22.3 Ml/d means that at river flows of less than 49.6 Ml/d, the full licensed volume cannot be abstracted at the Crowhill intake. The drought order would allow river abstraction from the Western Cleddau to continue subject to a revised daily prescribed flow of 11.1Ml/d, enabling more water to be abstracted in drought conditions.

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 the Natural Resources Wales (NRW) for a drought order at Crowhill. 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 period August to November. 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. 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<sup>1</sup> (DPG); specifically Section 5 and Appendices I and J, and Welsh Government / Defra / NRW / Environment Agency guidance on drought permits and drought orders<sup>2</sup>.

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 order). Data were requested from key consultees (including Natural Resources Wales).

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 Natural Resources

<sup>1</sup> Welsh Government / Defra / Natural Resources Wales / Environment Agency (2011) *Water Company Drought Plan Guideline*.

<sup>2</sup> Welsh Government / Defra / Natural Resources Wales / Environment Agency (2015) [Apply for a drought order or emergency drought order](https://www.gov.uk/guidance/apply-for-a-drought-order-or-emergency-drought-order#after-youve-received-your-drought-order), <https://www.gov.uk/guidance/apply-for-a-drought-order-or-emergency-drought-order#after-youve-received-your-drought-order>, Accessed 1 March 2016.



Wales 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 Crowhill, 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

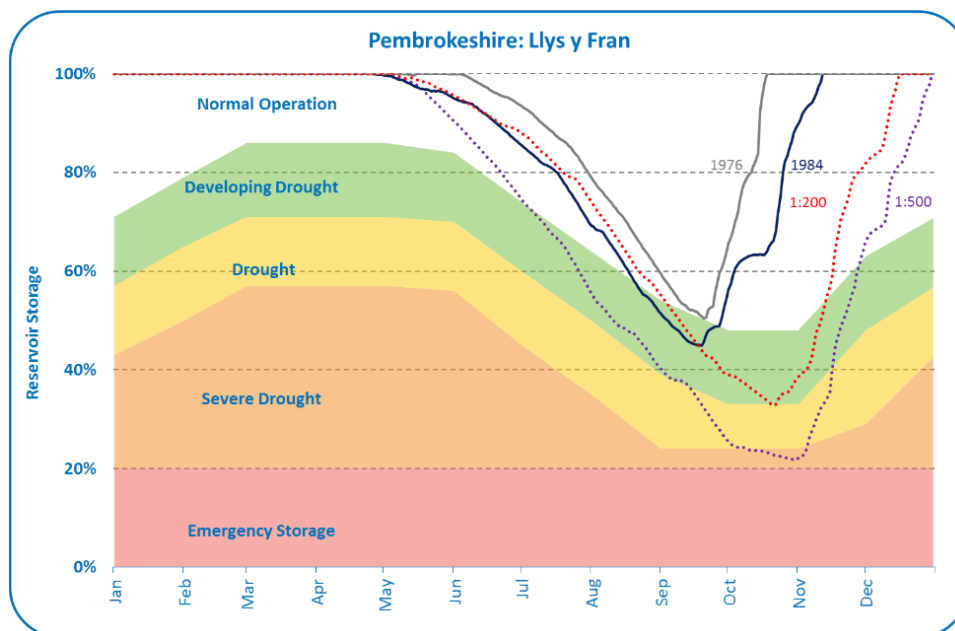
Welsh Water supplies water to more than 3 million people. The Welsh Water supply area covers the majority of Wales and a small part of England. It is split into 24 WRZs (see **Figure 2.1**).

**Figure 2.1** Welsh Water Water Resource Zones



The Pembrokeshire WRZ covers the far south west corner of Wales, stretching from Pendine Sands in the east to the Pembrokeshire Coastal National Park in the west, and from the village of Manobier in the south to Fishguard in the north. The trigger levels for applying for a drought order at Crowhill are based on water levels in Llys y Fran 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 Pembrokehire WRZ : Llys y Fran Reservoir Drought Action Zones and Historic Droughts**



## 2.2 DESCRIPTION OF EXISTING ARRANGEMENTS AT CROWHILL

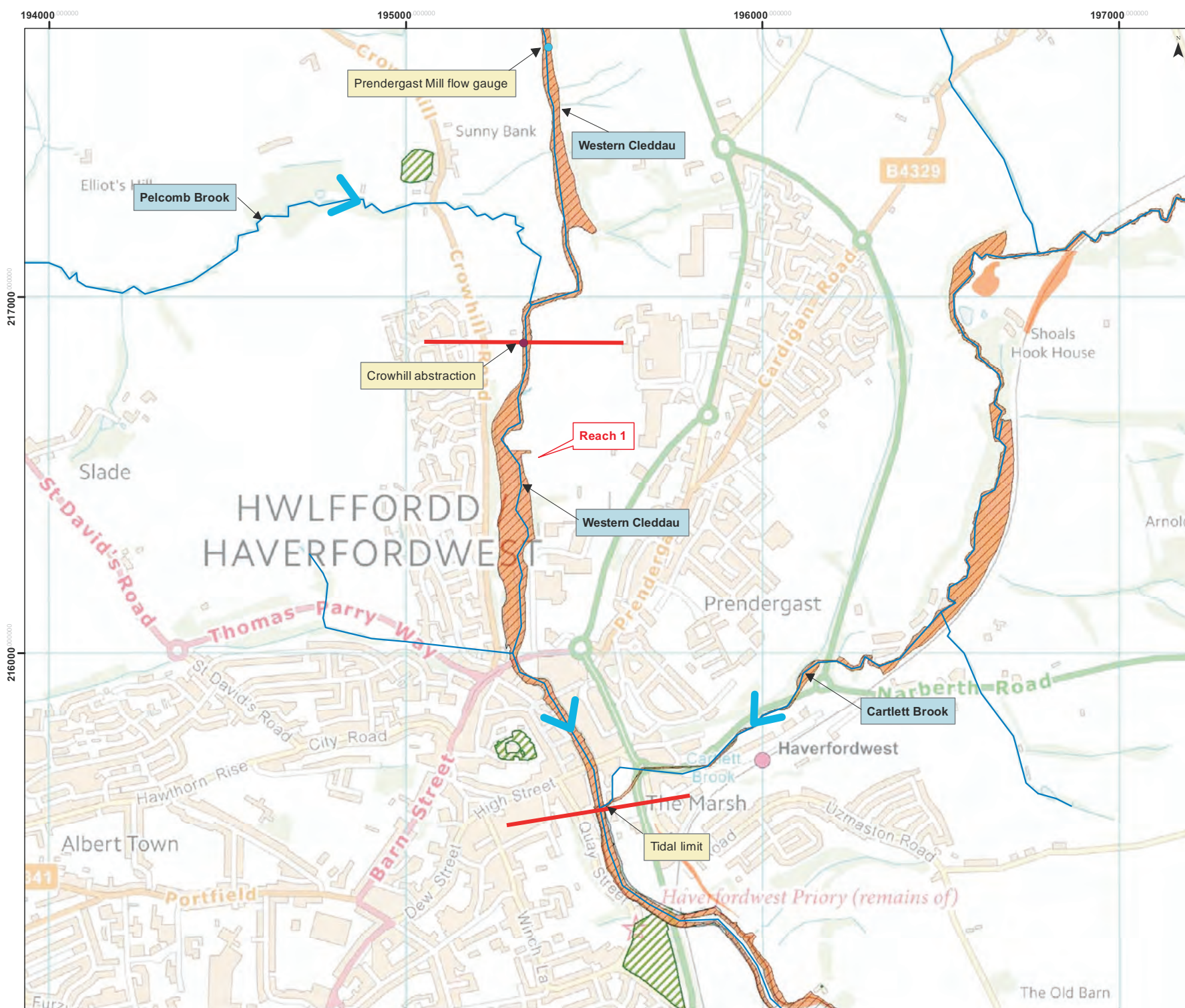
Welsh Water's licence (number: 22/61/3/0001, variation issued on 9 May 2016) to abstract water from the Western Cleddau river at Crowhill includes the following conditions:

- 7,728.2 million litres (Ml) authorised to be abstracted per annum (average daily abstraction of 21.173Ml/d)
- At an abstraction rate not exceeding 21.174Ml/d<sup>3</sup>
- The abstraction may not cause flow in the River Western Cleddau downstream of the Crowhill intake to fall below 37.584Ml/d.
- From April to June (inclusive) and October to December (inclusive), the abstraction rate may not exceed 9.504Ml/d if flow in the River Western Cleddau downstream of the Crowhill intake is less than 89.078Ml/d.

There are no sub-daily abstraction licence limits. The abstraction is made directly from a river intake and pumped to Bolton Hill Water Treatment Works (WTW) from where it is put into the water supply system.



The Crowhill abstraction licence conditions have recently been amended following a review of Welsh Water's abstractions by Natural Resources Wales (NRW) under the environmental requirements of the EU Habitats Directive (under the "Review of Consents" process). The Schedule of Conditions B (as outlined above) take effect from 31 March 2019.

<sup>3</sup> 1 Ml/d is 1 million litres per day.



**Legend**

- Water Courses
- Hydrological Reach
- Direction of Flow
- Abstractions
- Flow Gauge
- Special Area of Conservation
- Site of Special Scientific Interest
- Scheduled Ancient Monuments



1:10,000  
Note: All locations are approximate.  
This drawing incorporates Ordnance Survey information  
© Crown copyright and database rights 2019

Project Title: Welsh Water Drought Plan  
Environmental Assessment

Figure Title: Study area: 8206-1  
Reduce the required prescribed flow  
below the Crowhill Abstraction

Figure Number: Figure 2.3	Date: February 2019
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## **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 Pembrokeshire 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 Western Cleddau. If granted, the drought order involves a change in the abstraction conditions at the Crowhill intake. The prescribed flow requirement of 37.58Ml/d means that at river flows of less than 58.75Ml/d (or 110.25Ml/d from April to June and October to December), the full daily licensed volume cannot be abstracted at the Crowhill intake. The drought order would allow the river abstraction from the Western Cleddau to continue as long as flows do not fall below a lower prescribed flow of 18.79Ml/d, increasing the amount of water that can be abstracted at times of low river flows. The seasonal reduced daily abstraction limit would also be temporarily removed from October to December inclusive, so that the lower prescribed flow of 18.79Ml/d would apply throughout the period of implementation of the drought order.

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



**Table 2.1 Crowhill Existing and Proposed Drought Order Abstraction**

Abstraction Water Source	NGR	Normal Abstraction	Proposed Drought Order Abstraction	Benefit Ml/d
Western Cleddau		<p>Welsh Water's licence (number: 22/61/3/0001, variation issued on 9 May 2016) to abstract water from the Western Cleddau river at Crowhill includes the following conditions:</p> <ul style="list-style-type: none"> <li>• 7,728.2 million litres (Ml) authorised to be abstracted per annum (average daily abstraction of 21.173Ml/d)</li> <li>• At an abstraction rate not exceeding 21.174Ml/d<sup>4</sup></li> <li>• The abstraction may not cause flow in the River Western Cleddau downstream of the Crowhill intake to fall below 37.584Ml/d.</li> </ul> <p>From April to June (inclusive) and October to December (inclusive), the abstraction rate may not exceed 9.504Ml/d if flow in the River Western Cleddau downstream of the Crowhill intake is less than 89.078Ml/d.</p>	<p>The drought order involves a change in the abstraction conditions at the Crowhill intake. The prescribed flow requirement of 37.58Ml/d means that at river flows of less than 58.75Ml/d (or 110.25Ml/d from April to June and October to December), the full daily licensed volume cannot be abstracted at the Crowhill intake. The drought order would allow the river abstraction from the Western Cleddau to continue as long as flows do not fall below a lower prescribed flow of 18.79Ml/d, increasing the amount of water that can be abstracted at times of low river flows. The seasonal reduced daily abstraction limit would also be temporarily removed from October to December inclusive, so that the lower prescribed flow of 18.79Ml/d would apply throughout the period of implementation of the drought order.</p>	3.00 Ml/d

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

## 2.8 DROUGHT ORDER PROGRAMME

The drought order 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 Welsh Water's daily abstraction from the

<sup>4</sup> 1 Ml/d is 1 million litres per day.

Western Cleddau at the Crowhill intake subject to a prescribed flow of 22.3Ml/d. The assessed drought order assumes the continuation of the daily abstraction but with the prescribed flow limit reduced by about 50% to 11.1Ml/d, to enable Welsh Water to potentially increase its abstraction at times when it would otherwise be limited by low river flows.



## **3 APPROACH**

### **3.1 INTRODUCTION**

The DPG states that the environmental report must include:

- i. 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 drought order 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, NRW Drought Plans.
- National Policy Statements for Wastewater and Renewable Energy Infrastructure.

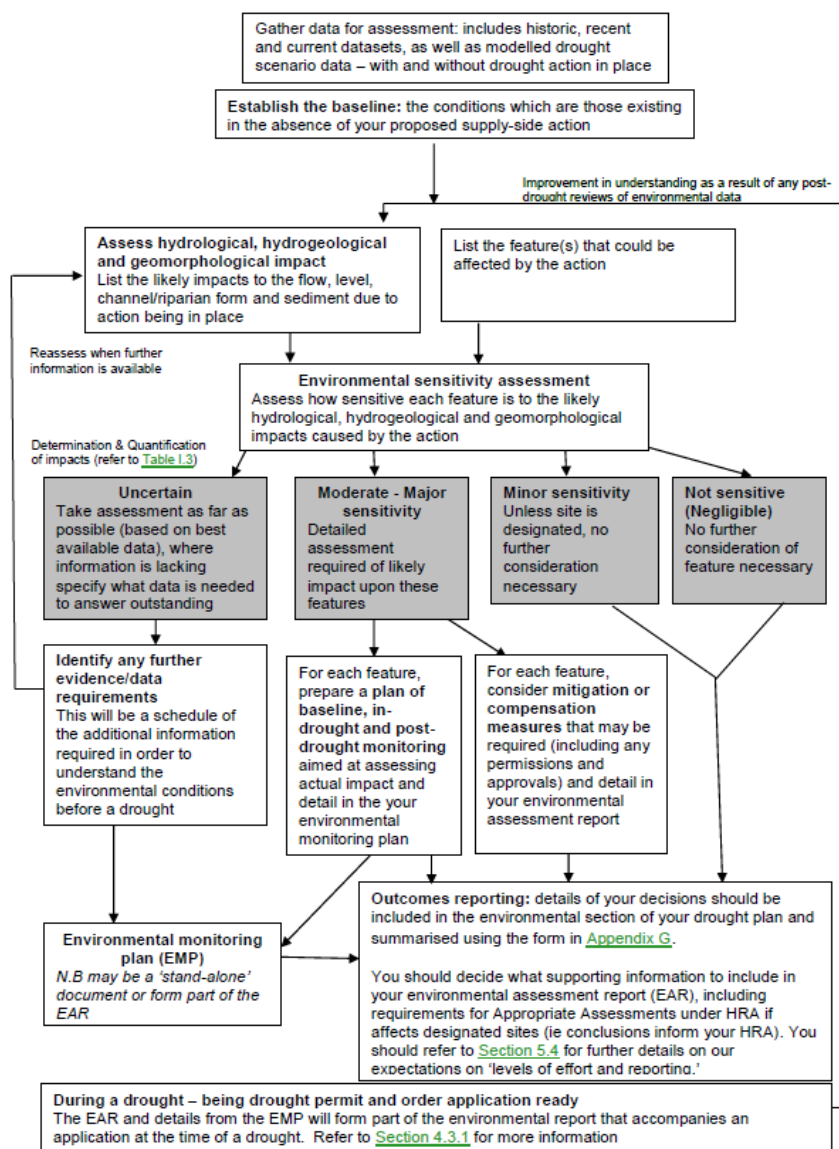
This is discussed further in Section 7.

## 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 Environment Agency 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 Crowhill.**

### ***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 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<sup>5</sup>;
- 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 & archaeology 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 Crowhill drought order

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<sup>5</sup> Under Article 22 of the WFD, the Freshwater Fish Directive (FFD) was repealed on 22 December 2013. Protected waters under the FFD are incorporated within the WFD. Ecological status defined in the WFD sets the same protection to these protected areas for fish. In the case of Salmonid waters, this is assigned a typology in WFD status classification, specifically for dissolved oxygen saturation in rivers and dissolved oxygen concentration in lakes. Salmonid waters are rivers/lakes which, in the Environment Agency's judgement, would support a sustainable fish population dominated by salmonid species; this replaces the system of notices protecting areas through the FFD.

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. DPG Figure 5 categorises four outcomes 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.

For each feature identified, the assessment methodology used in the EAR to identify the magnitude and significance of impact has been defined (see Section 3.3 below).

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.

Consideration of designated sites and SSSIs is undertaken in the screening exercise described in Section 3.2.1 above, and hence the screening process has taken features associated with these sites into consideration, where relevant.

### **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) (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland
- 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
- 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.

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).

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 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<sup>6,7</sup> and the CIEEM study guidelines<sup>8</sup>. 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

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<sup>6</sup> IEMA (2004) Guidelines for Environmental Impact Assessment.

<sup>7</sup> IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK

<sup>8</sup> CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland.



consideration of mitigation and appropriate monitoring triggering mitigation. Appropriate mitigation actions identified are both available and practicable.

A review and update of the existing Welsh Water drought environmental monitoring plan has also been carried out.

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

### **3.4 LIMITATIONS OF THE ASSESSMENT AND UNCERTAINTIES**

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 CROWHILL 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 Crowhill 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:

- a) 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
- b) 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
- c) 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**

#### **4.2.1 List of the Likely Impacts to the Flow / Level Regime due to the Drought Order**

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:

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 Western Cleddau from the Crowhill abstraction intake to the tidal limit.

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 the Crowhill abstraction intake

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 be implemented during the summer period between April and September.

## **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 permit 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**

<b>Issue</b>	<b>Identified Impact</b>
<b>Western Cleddau (Reach 1)</b>	
Flows in the Western Cleddau downstream of Crowhill intake <i>Moderate impacts during the period April to September</i>	<ul style="list-style-type: none"> <li>Reduction of up to about 47% in extreme low flows, with corresponding reductions in wetted width and wetted depth. Duration variable but typically for up to about 10 weeks (e.g. 1976, 1984)</li> </ul>
Water quality in the Western Cleddau <i>Minor risk during the period April to September</i>	<ul style="list-style-type: none"> <li>Impacts to water quality in the Western Cleddau have been assessed as minor for ammonia, dissolved oxygen and soluble reactive phosphorous.</li> </ul>
Consented discharges <i>Negligible risk</i>	<ul style="list-style-type: none"> <li>One small domestic discharge has been identified and is considered to have negligible impact.</li> </ul>

### **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 CROWHILL 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 Crowhill 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)
<b>Cleddau Rivers SAC / Western Cleddau SSSI</b>	Moderate	The Cleddau Rivers SAC / Western Cleddau Rivers SSSI is designated for <i>Ranunculus</i> community habitat and a range of important fish species, which are sensitive to flow and level changes in the Western Cleddau.	Moderate	Yes
<b>Gas Works Lane Section SSSI</b>	Moderate	Site is designated for geological interest and is a key site for studies of lower Silurian stratigraphy and biotas. It is not sensitive to changes in flow and level in the western Cleddau.	Negligible	No
<b>Milford Haven Waterway SSSI</b>	Negligible	The SSSI Milford Haven waterway on its tidal side supports a variety of intertidal marine habitats, muddy gravels, sheltered muds, exposed sands and sheltered rocks. The zone of hydrological influence of the drought order does not extend below the tidal limit of the Western Cleddau,	Negligible	No
<b>Notable Species - Macrophytes –</b>  <i>Ranunculus</i> community	Moderate	These species often develop within specific hydraulic and nutrient conditions, and thus alteration as a result of a drought permit would impact on the species, although the level of impact beyond that of a natural drought is uncertain.	Moderate	Yes
<b>Benthic Macro-invertebrates</b>	Moderate	Freshwater macroinvertebrates species live in niche habitats and their susceptibility to impacts are likely to increase if water levels fall. Although the level of impact beyond that of a natural drought is uncertain this community is likely to be sensitive to changes in flow and level as a result of the drought order implementation.	Moderate	Yes
<b>Notable Species – Invertebrates</b>  Cased caddis <i>Ylodes simulans</i> Freshwater pearl mussel <i>Margaritifera margaritifera</i>	Moderate	These species live in niche habitats and their susceptibility to impacts are likely to increase if water levels fall, although the levels of impact of this beyond that of a natural drought is uncertain.	Moderate	Yes

<b>Site/Feature and designation</b>	<b>Hydrological Impact at Location (Major, Moderate, Minor)</b>	<b>Susceptibility to flow and level impacts</b>	<b>Sensitivity (Uncertain, Moderate, Major, Minor, Negligible)</b>	<b>Further Consideration Required (Yes/No)</b>
<b>Notable Species – Fish</b>  Atlantic salmon <i>Salmo salar</i> Brown trout <i>Salmo trutta</i> Bullhead <i>Cottus gobio</i> Brook lamprey <i>Lampetra planeri</i> River lamprey <i>Lampetra fluviatilis</i> Sea lamprey <i>Petromyzon marinus</i> European eel <i>Anguilla anguilla</i>	Moderate	The availability of riverine habitats for fish may be altered through modification to the velocity, wetted width or depth of water, while lower flows may affect migration activity of various species. Secondary effects of changes to flow regime include reduced water quality (often resulting from reduced dilution of point-source or diffuse pollution) and the potential for increased predation by birds/otter during periods of low flow.	Moderate	Yes
<b>Other Fish Species –</b>  Minnow <i>Phoxinus phoxinus</i> Stoneloach <i>Barbatulla barbatulla</i> Three-spined stickleback	Moderate	Reductions in flow is anticipated to reduce the availability of habitat for fish, and increase the risk of predation. Changes to velocity, depth, and wetted width may restrict fish habitat availability and quality.	Moderate	Yes
<b>Notable Species – Mammals</b>  Otter <i>Lutra lutra</i>	Moderate	Otter are known to be present in the catchment. Implementation of the drought order is considered unlikely to lead to significant adverse effects on habitat or prey availability	Negligible	No
<b>Invasive flora –</b>  Japanese knotweed <i>Fallopia japonica</i> Giant hogweed <i>Heracleum mantegazzianum</i> Himalayan balsam <i>Impatiens glandulifera</i>	Moderate	Japanese knotweed and Himalayan balsam are noted throughout the Western Cleddau. These invasive plant species can use the flow of the watercourse for dispersal but are not reliant on it. Implementation of the drought permit will do nothing to increase this dispersal.	Negligible	No
<b>Recreation</b>	Moderate	Recreational activities along this section of the Western Cleddau include walking and angling, and flow and level changes may impact on the recreational experience. However, water levels will be naturally low in times of drought, and significant impacts are not anticipated.	Negligible	No
<b>Archaeology</b>	Moderate	Two scheduled ancient monument site are located within the study area; Haverfordwest Priory and Haverfordwest Castle. Neither site is anticipated to be impacted by the implementation of the drought order as the sites are not water dependant.	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	W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340)	
Hydrological Impact at Location (Major, Moderate, Minor, Negligible)	Moderate	
Heavily Modified Waterbody (Y/N)	No	No
RBMP Cycle	RBMP2 (2015) <sup>9</sup>	2018 C2 Interim <sup>10</sup>
Overall Biological	Moderate	Moderate
Fish	Good	Moderate
Macrophytes	Good	Good
Phytobenthos	Not Assessed	Good
Macro-invertebrates	High	High
Total P/ Phosphate	Moderate	Good
Ammonia	High	High
Dissolved Oxygen	High	High
pH	High	High
Sensitivity (Uncertain, Moderate/ Major, Minor, Not sensitive)	Moderate	
Further Consideration Required (Y/N)	Yes	

## 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 relevant river reaches for the Crowhill 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

<sup>9</sup> NRW (2017) <https://drive.google.com/file/d/0B2hsDbbdxztZHIitRU9lNkg1YWw/view>

<sup>10</sup> NRW (2018) [https://drive.google.com/file/d/14w17jLo5sNuToVELqMCK\\_yc6DdHU7STb/view](https://drive.google.com/file/d/14w17jLo5sNuToVELqMCK_yc6DdHU7STb/view)



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
<b>Reach 1 – Western Cleddau</b>													
Cleddau Rivers SAC / Western Cleddau SSSI		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Notable Macrophytes – <i>Ranunculus</i> Communities		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Risk to WFD waterbody macrophyte status		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Notable macroinvertebrates – Cased caddis <i>Ylodes simulans</i>		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Brook, river and sea lamprey	Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
	Water Quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N
River lamprey	Downstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Sea lamprey	Migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Atlantic salmon	Juvenile and spawning habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
	Smolt migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Brown / sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
	Juveniles (habitat loss)	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
European eel		N/A	N/A	N/A	N/A	N/A	N/A	N/A		N	N	N	N
Other fish species – minnow, threespined stickleback and stone loach		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N
Risk to WFD waterbody fish status		N/A	N/A	N/A	N/A	N/A	N/A	N/A			N	N	N

#### Key to Environmental Effects:

N	Negligible impacts are considered likely
	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
<b>Reach 1 – Western Cleddau</b>		
Cleddau Rivers SAC / Western Cleddau SSSI	<ul style="list-style-type: none"> <li>The impacts of the drought order on the macrophyte habitats for which the sites are designated have been assessed as minor</li> <li>Impacts on river lamprey, brook lamprey, and sea lamprey, and bullhead (Annex II species for which the SAC has been designated) have been assessed as moderate to major.</li> <li>No adverse effects of the drought order are likely on otter.</li> </ul>	<b>Major</b>

### 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 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.

### **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**.

#### *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
W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) 2009 status: High	<ul style="list-style-type: none"> <li>Impacts of drought order implementation on the macrophyte communities of the impacted reaches have been summarised as minor adverse, short-term, temporary and reversible. Consequently, the macrophyte component of these waterbodies is considered to be at minor risk of short-term deterioration.</li> </ul>	<b>Minor</b>
Feature	Impact	Significance of Impact
<b>Reach 1 – Western Cleddau</b>		
Macrophytes	<ul style="list-style-type: none"> <li>Reduction in growth or condition as a result of impacts on water levels and flows</li> <li>Alteration to community composition as a result of changes in water levels and water quality, including proliferation of filamentous algae</li> </ul>	<b>Minor</b>
Notable Macrophytes – <i>Ranunculus</i> communities	<ul style="list-style-type: none"> <li>Reduction in growth or condition as a result of impacts on water levels and flows</li> <li>Alteration to community composition as a result of changes in water levels and water quality</li> </ul>	<b>Minor</b>

## 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
W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340 2009 status: High	<ul style="list-style-type: none"> <li>The macroinvertebrate component of these waterbodies is considered to be at minor risk of short-term deterioration</li> </ul>	<b>Minor</b>
Feature	Impact	Significance of Impact
<b>Reach 1 – Western Cleddau</b>		
Macroinvertebrates	<ul style="list-style-type: none"> <li>Reduction in species diversity and abundance as a result of reduced recruitment.</li> <li>Reduction in species diversity as a result of the loss of flow-sensitive taxa</li> <li>Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats</li> </ul>	<b>Minor</b>
Notable Species – Cased caddis <i>Ylodes simulans</i>	<ul style="list-style-type: none"> <li>Loss of marginal habitat and exposure of eggs, pupae and larvae.</li> </ul>	<b>Minor</b>

## 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
W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) Current status : Good	There is a minor risk of short-term deterioration in status of the fish component of the waterbody due to the minor to major adverse, short-term, temporary and reversible impacts associated with the drought order.	<b>Minor</b>
Feature	Impact	Significance of Impact
<b>Reach 1 – Western Cleddau</b>		
River lamprey	<ul style="list-style-type: none"> <li>• Migration of juvenile river lamprey and transformer life stages affected or halted by a reduction in flow</li> </ul>	<b>Major</b>
Sea lamprey	<ul style="list-style-type: none"> <li>• Migration of juvenile sea lamprey and transformer life stages affected or halted by a reduction in flow</li> </ul>	<b>Major</b>
Brook, river and sea lamprey	<ul style="list-style-type: none"> <li>• Loss of juvenile habitat as a result of reduced flow related impacts</li> </ul>	<b>Moderate</b>
	<ul style="list-style-type: none"> <li>• Reduced water quality.</li> </ul>	<b>Negligible</b>
Atlantic salmon	<ul style="list-style-type: none"> <li>• Delays and potential cessation of smolt migration due to reduced flows.</li> </ul>	<b>Minor</b>
	<ul style="list-style-type: none"> <li>• Reduced water quality.</li> </ul>	<b>Minor</b>
	<ul style="list-style-type: none"> <li>• Loss of spawning and juvenile habitat as a result of reduced river levels.</li> </ul>	<b>Minor</b>
Bullhead	<ul style="list-style-type: none"> <li>• Reduction in spawning and juvenile survival and an increase in adult mortality due to habitat loss.</li> </ul>	<b>Minor</b>
Brown / sea trout	<ul style="list-style-type: none"> <li>• Delays and potential cessation of adult migration due to reduced flows.</li> </ul>	<b>Minor</b>
	<ul style="list-style-type: none"> <li>• Reduced water quality</li> </ul>	<b>Minor</b>
	<ul style="list-style-type: none"> <li>• Reduction in spawning and juvenile survival due to habitat loss.</li> </ul>	<b>Minor</b>
European eel	<ul style="list-style-type: none"> <li>• Habitat loss and reduced water quality</li> </ul>	<b>Negligible</b>
Other fish species	<ul style="list-style-type: none"> <li>• Habitat loss and reduced water quality</li> </ul>	<b>Minor</b>

## *Phytobenthos*

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

**Table 5.8 Summary of Impacts of Drought Order Implementation on Phytobenthos**

WFD Status/ Community	Impact	Significance of Impact
W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340  Current status: Not Assessed	<ul style="list-style-type: none"> <li>Phy to benthos status not assessed</li> </ul>	-
Feature	Impact	Significance of Impact
<b>Reach 1 – Western Cleddau</b>		
Phy to benthos	<ul style="list-style-type: none"> <li>Changes to community composition due to changes in velocity</li> <li>Changes to community composition and TDI4 scores due to increases in soluble reactive phosphorous</li> </ul>	<b>Minor</b>

### **5.3.5 Supplementary Baseline Monitoring**

Monitoring outside of drought conditions is 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.

### ***Monitoring of Physical Environment and Key Receptors***

A number of gaps have been identified in the baseline information provided whilst undertaking the environmental assessment of this drought order. It is, therefore, recommended that any outstanding and available data are obtained, where possible.

At this stage, it is considered that the following information will need to be obtained as a minimum, although this will be subject to undertaking the work outlined above:

- Fish
  - A suite of electric fishing surveys (three-run quantitative and one-run semi-quantitative) at sites with adequate coverage of Reach 1.
  - Lamprey-specific electric fishing surveys targeting areas of both optimal and sub-optimal habitat identified during a preliminary walkover.

- Habitat mapping of Reach 1 to include salmonid spawning and fry/parr habitat and lamprey spawning and ammocoete habitat and GIS mapping of the data.
- Macroinvertebrates - baseline survey (Reach 1) using standard kick sample method.
- Macrophytes –baseline survey (Reach 1) using standard LEAFPACs method.

## **6 CROWHILL DROUGHT ORDER – MITIGATION**

The environmental assessment has identified significant impacts on fish, including moderate impacts on brook and river lamprey habitat for spawning and juveniles; moderate impacts on migration of river and sea lamprey.

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**

<b>Type of Mitigation</b>	<b>Typical Application</b>
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 <sup>11</sup> 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 Crowhill 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.

<sup>11</sup> 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 2020)
  - 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 hydrological effects of implementing the Crowhill drought order with drought order / permit schemes have been identified. However, this should be

reviewed at time of future application for a drought order.

The Appropriate Assessment of the 8206-1 Crowhill drought order includes consideration of the in-combination effects with the 8206-8 Canaston drought order on the Cleddau Rivers SAC.

### ***Welsh Water WRMP schemes***

No WRMP schemes identified with cumulative impacts.

### ***NRW Drought Plans***

No cumulative impacts of options in Natural Resources Wales or Environment Agency Drought Plans or neighbouring water company drought plans with a drought order at Crowhill are anticipated (see Section B5 in **Appendix B**). 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 CROWHILL 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 Regulation 63 of the Habitats Regulations, the competent authority (in the case of a drought order in Wales this would be 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 potential of the drought order to have a likely 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 having LSEs (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 CROWHILL DROUGHT ORDER**

The objective of this section is to bring together all relevant information to enable a screening exercise to be undertaken of the impacts of the Crowhill 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 Cleddau Rivers SAC and Pembrokeshire Marine SAC designated features and discusses the potential for the drought order at Crowhill to influence their status. For species, impacts on populations, range and supporting habitats and species have been considered.

### **9.2.1 Potential Impacts on Qualifying Features of Cleddau Rivers SAC**

In carrying out the screening process, the assessment has considered the main possible sources of effects on the sites arising from the potential drought permit, 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 Cleddau Rivers 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.

***Brook, River and Sea Lamprey***

The assessment has identified the potential for impacts on lamprey species as a result of a reduction in river levels and wetted width in Reach 1.

A reduction in flow (resulting in delayed or interrupted migration and an increase in siltation and suffocation of eggs) and the related reduction in wetted width (reduction or loss of spawning habitats) could result in an impact on breeding successes and consequently the conservation status of the designated features.

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 brook river and sea lamprey in the Cleddau Rivers SAC.

### ***Bullhead***

Bullhead are likely to be present throughout the predicted zone of impact however, the deep, slow-flowing channel form extant within the potential zone of impact does not constitute optimal bullhead habitat. Spawning and egg incubation takes place from March to May and therefore the most sensitive lifestages are likely to be impacted by a drought order. The species is known to be flow sensitive and reduced flows (and likely reduced water quality) associated with implementation of a drought order may have a limited impact on bullhead populations.

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 the Cleddau Rivers SAC.

### ***Otter***

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

There are not anticipated to be any changes to habitat or prey availability for otter as a result of drought order implementation and the drought order is not anticipated to result in likely significant effects on otter populations.

### ***Water Courses of Plain to Montane Levels with the *Ranunculus fluitantis* and *Callitriche-Batrachion* Vegetation***

The assessment has identified the potential for impacts to affect macrophyte populations as a result of a reduction in flow, flow velocity, wetted width and depth of the river. These all have the potential to expose plants to desiccation which could impact on the conservation status of this habitat type. In addition, any significant reduction in the frequency of higher flows is considered likely to reduce the 'cleansing' functioning of the river, whereby high and moderate flows remove any build-up of filamentous algae and fine sediments on the river substrate; and algae and epiphytes growing on submerged plants. Any reduction in this cleansing function could potentially affect macrophytes, especially slower-growing taxa, and in extreme cases these could be smothered by algae.

The spread of invasive non-native species can be increased during drought, for example where muddy banks are exposed by receding water levels this offers new habitat for growth by species such as Himalayan balsam. As a result, it can be concluded that implementation of a drought order has the potential to result in likely significant effects on the water courses of plain to montane levels with the *Ranunculus fluitantis* and *Callitriche-Batrachion* vegetation feature in the Cleddau Rivers SAC.



### ***Alluvial Forests***

A drought order would have negligible impact on this designated feature. The reductions in flow, flow velocity, wetted width and depth of the river have the potential to temporarily impact the habitat, especially the alluvial ground flora that is an integral feature of this habitat. However, the periods when the drought order would be in place are not prolonged enough to adversely impact this habitat to a degree that it could not recover in the very short term (i.e. the following growing season). There are also no areas of alluvial forest within close proximity of the impacted reach<sup>12</sup>.

As a result, it can be concluded that implementation of a drought order would not result in any likely significant effects on the alluvial forests habitats within the Cleddau Rivers SAC.

### ***Active Raised Bogs***

The feature is not present within Management Unit 1 of the Cleddau Rivers SAC which could be impacted by the drought order. As a result, it can be concluded that implementation of a drought order would not result in any likely significant effects on the active raised bog habitats within the Cleddau Rivers SAC.

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<sup>12</sup> Annex 3 – Map of Alluvial Woodland Locations (Jones, 2004) contained within Core Management Plan (2017).

**Table 9.1 Summary of Likely Significant Effects of Crowhill Drought Order Implementation Against Conservation Objectives for the Cleddau Rivers SAC**

Feature	Attribute (taken directly from Natural Resources Wales Conservation Objectives document)	Site Specific Target range and Measures	Potential Impact of Drought Order	LSE?
<b>Afonydd Cleddau/Cleddau Rivers SAC</b>				
Sea Lamprey	Distribution within catchment	Any silt beds adjacent to or downstream of suitable spawning sites should contain <i>Pertromyzon</i> ammocoetes.	Adverse impacts of drought order implementation on distribution of ammocoetes as a result of reduction in flow and wetted width.	Yes
	Am mocoete density	Am mocoetes should be present in at least four sampling sites each not less than 5km apart.	Adverse impacts of drought order implementation on am mocoete density as a result of reduction in flow and wetted width	Yes
Brook Lamprey and River Lamprey	Age/size structure of am mocoete population	Samples < 50 ammocoetes 2 size classes Samples > 50 ammocoetes at least 3 size classes	Adverse impacts of drought order implementation on the age / size structure of ammocoete as a result of reduction in flow and wetted width	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	Adverse impacts of drought order implementation on distribution of ammocoetes as a result of reduction in flow and wetted width	Yes
	Am mocoete density	Optimal habitat: >10 m <sup>-2</sup> Overall catchment mean: > 5 m <sup>-2</sup>	Adverse impacts of drought order implementation on am mocoete density as a result of reduction in flow and wetted width	Yes
Bullhead	Adult densities	No less than 0.2 m <sup>-2</sup> in sampled reaches	Adverse impacts of drought order implementation on adult bullhead densities as a result of reduction in flow	Yes
	Distribution	Bullheads should be present in all suitable reaches. As a minimum, no decline in distribution from current.	Adverse impacts of drought order implementation on adult bullhead distribution as a result of reduction in flow	Yes
	Reproduction/ age structure	Young-of-year fish should occur at densities at least equal to adults	Adverse impacts of drought order implementation on reproduction / age structure of bullhead as a result of reduction in flow	Yes
European Otter	Distribution	Lower Limit: Otter signs found at 85% of Otter Survey of Wales full survey sites (current level: 97%) within the Eastern and Western Cleddau.	No risk to achievement of conservation objective as extent of habitat and prey availability unlikely to be affected by drought order.	No
	Breeding activity	2 reports (within the catchment) of otter cub/family sightings or 2 reports of cubs, lactating females or	No risk to achievement of conservation objective as extent of habitat and prey availability unlikely to be affected by drought order.	No

		pregnant females from otter road casualties are recorded for at least 1 year in any three year period.		
	Actual and potential breeding sites	There should be no reduction or decline in the number or quality of identified actual or potential breeding sites.	No risk to achievement of conservation objective as extent of habitat and prey availability unlikely to be affected by drought order.	No
	Water quality	To maintain and restore RE1 across catchment with no increase in pollutants potentially toxic to otters	No risk to achievement of conservation objective as extent of habitat and prey availability unlikely to be affected by drought order.	No
	Food availability	Fish biomass stays within expected natural fluctuations	No risk to achievement of conservation objective as extent of habitat and prey availability unlikely to be affected by drought order.	No
	Riparian habitat	No overall permanent decrease and no overall loss in sensitive areas	No risk to achievement of conservation objective as extent of habitat and prey availability unlikely to be affected by drought order.	No
	Anthropogenic mortality	No increase in numbers of recorded Road Deaths	No risk to achievement of conservation objective as extent of habitat and prey availability unlikely to be affected by drought order.	No
	Disturbance	No significant change to bank side usage, no significant development, particularly in sensitive areas.	No risk to achievement of conservation objective as extent of habitat and prey availability unlikely to be affected by drought order.	No
Water courses of plain to montane levels with the <i>Ranuncion fluitantis</i> and <i>Callitricho-Batrachion</i> vegetation	Distribution within catchment	Distribution within site unites 1, 3, 7 & 10	Adverse impacts of drought order implementation on the distribution of this habitat considered likely as a result of reduced flow, flow velocity, wetted width and depth.	Yes
	Typical species (including those listed in the SSSI citation)	Characteristic plant species should dominate the assemblage	Adverse impacts of drought order implementation on the distribution of this habitat considered likely as a result of reduced flow, flow velocity, wetted width and depth	Yes
	Native species	Cover of indicators of eutrophication maintained below threshold over the medium to long term	Potential changes to water quality as a result of the drought order could increase the presence of filamentous algae during the period of implementation.	Yes
	Alien/ introduced species	No impact on native biota from alien or introduced species	Some invasive non-native species can spread during droughts where muddy banks are exposed by receding water levels e.g. Himalayan balsam.	Yes

Alluvial forests with <i>Alnus glutinosa</i> and <i>Fraxinus excelsior</i> ( <i>Alno-Padion</i> , <i>Alnion incanae</i> , <i>Salicion albae</i> )	Extent	No reduction in the total number of sites (72)	Alluvial forests are not located within close proximity of the impacted reach, nor will the drought order significantly affect periodic inundation during flooding events, given the prevailing drought conditions.	No
	Quality	3 out of 4 sample woodlands on each arm of the Cleddau to meet site-specific assessment of good condition alluvial woodland.	Alluvial forests are not located within close proximity of the impacted reach, nor will the drought order significantly affect periodic inundation during flooding events, given the prevailing drought conditions.	No
	Structure and processes	<p>The canopy is dominated by alder <i>Alnus glutinosa</i> or willow <i>Salix</i> spp. In alluvial woods with free draining soils there may be ash or oak in the canopy, but in the wetter alluvial woodlands ash <i>Fraxinus excelsior</i> will be limited to areas of relatively drier ground. 50% - 90% of the canopy forming trees are alder.</p> <p>At least one example of each age component present (sapling if the survey site has a gap or woodland edge, mature, over mature, deadwood)</p> <p>The under-storey covers between 5-30% in at least 80% of survey sites</p> <p>Gaps large enough to cause a noticeable growth response from ground vegetation in &gt;40% of survey sites</p> <p>Dense thickets of bramble cover &lt;10% of individual sites and are confined to drier margins of habitat</p> <p>Deadwood, lying or standing &gt; 20 cm diameter and &gt; 1 m length present at 80% of survey sites</p> <p>No evidence of alder disease</p>	Alluvial forests are not located within close proximity of the impacted reach, nor will the drought order significantly affect periodic inundation during flooding events, given the prevailing drought conditions.	No
	Regeneration	Regeneration occurring and 90% alder and willow	Alluvial forests are not located within close proximity of the impacted reach, nor will the drought order significantly affect periodic inundation during flooding events, given the prevailing drought conditions.	No
	Non-native species	< 5% of the canopy forming trees across the woodland	Alluvial forests are not located within close proximity of the impacted reach, nor will the	No

		are non-native Exotics cover <10% ground	drought order significantly affect periodic inundation during flooding events, given the prevailing drought conditions.	
	Ground flora	60% of the survey sites should support alluvial ground flora including two of the following: meadowsweet <i>Filipendula ulmaria</i> , yellow flag <i>Iris pseudacorus</i> , nettle <i>Urtica dioica</i> , common reed <i>Phragmites australis</i> , greater tussock sedge <i>Carex paniculata</i> , opposite-leaved golden saxifrage <i>Chrysosplenium oppositifolium</i> , rushes <i>Juncus spp</i> , tufted hair-grass <i>Deschampsia cespitosa</i> , hemlock water-dropwort <i>Onanthe crocata</i> , and wild angelica <i>Angelica sylvestris</i> .	Alluvial forests are not located within close proximity of the impacted reach, nor will the drought order significantly affect periodic inundation during flooding events, given the prevailing drought conditions.	No
	Hydrology	Dense thickets of bramble cover <10% of individual sites and are confined to drier margins of habitat (bramble is an indicator that the site may be drying out)	Alluvial forests are not located within close proximity of the impacted reach, nor will the drought order significantly affect periodic inundation during flooding events, given the prevailing drought conditions.	No
	Grazing	No impact on regeneration and ground flora criteria satisfied.	Alluvial forests are not located within close proximity of the impacted reach, nor will the drought order significantly affect periodic inundation during flooding events, given the prevailing drought conditions.	No
Active raised bogs	Extent	No reduction in extent	The qualifying feature is not present within the impacted reach.	No
	Habitat composition	Area of mire (2.3 ha) to be made up of the following communities: M2a at least 0.1 ha 10% of M17-M18 in I & L M18 at least 1.0 ha and, M17 upper limit 1.3 ha.  Area of lagg fen (10.4 ha) to be made up of the		

		<p>following communities:</p> <p>M6: c. 1.0 ha</p> <p>M23: 1.8 ha</p> <p>M25: 7.1 ha</p> <p>M27: 0.3 ha</p> <p>S4: 0.1 ha</p> <p>W4: 0.1 ha</p>		
	Indicators of negative change – non-woody vascular plant species	No more than 1% cover of the following on the bog surface: <i>Phragmites australis</i> , <i>Phalaris arundinacea</i> , <i>Glyceria maxima</i> , <i>Epilobium hirsutum</i> , <i>Urtica dioica</i> , <i>Pteridium aquilinum</i> , <i>Rubus fruticosus</i> , <i>Juncus effusus</i> , <i>Deschampsia cespitosa</i> , <i>Cirsium</i> spp.		
	Development of shrub	<p>On the mire expanse, trees and shrubs (Betula, Salix, Rhododendron, Pinus species, other gymnosperms) no more than rare and &lt; 5% cover</p> <p>On the bog margin (rand) woody species &lt; 10% cover</p>		
	Drainage	<p>Water table depths should not exceed 20 cm below ground level in an average summer.</p> <p>Flooding should be confined to natural hollows only and result from rainfall and not overbank flooding.</p>		
	Atmospheric deposition	Upper limit: 10 kg N/ha/yr		No

### 9.2.2 Potential Impacts on Qualifying Features of Pembrokeshire Marine SAC

Pembrokeshire Marine SAC is designated for the following qualifying features:

The Annex I habitats for which the SAC has been designated are:

- Estuaries
- Large shallow inlets and bays
- Reefs

The Annex I habitats which are notified as a qualifying feature, but not a primary reason for site selection:

- Sandbanks which are slightly covered by sea water all the time
- Mudflats and sandflats not covered by seawater at low tide
- Coastal lagoons (Priority feature)
- Atlantic salt meadows (*Glauco-Puccinellietalia maritima*)
- Submerged or partially submerged sea caves

The Annex II species for which the SAC has been designated are:

- Grey seal *Halichoerus grypus*
- Shore dock *Rumex rupestris*

The Annex II which are notified as a qualifying feature, but not a primary reason for site selection:

- Sea lamprey *Petromyzon marinus*
- River lamprey *Lampetra fluviatilis*
- Allis shad *Alosa alosa*
- Twait shad *Alosa fallax*
- Otter *Lutra lutra*

A Core Management Plan is not available for the site, instead an advice package for the European Marine Site as a whole has been produced<sup>13</sup>. Specific attributes and targets are not available for each feature, rather overarching conservation objectives as follows.

#### ***Conservation objectives for the habitat features to achieve favourable condition:***

- **Range:** the overall distribution and extent of the habitat features within the site,

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<sup>13</sup> Natural Resources Wales (undated) Pembrokeshire Marine/ Sir Benfro Forol SAC European Marine Site Advice provided by Natural Resources Wales in fulfilment of Regulation 37 of the Conservation of Habitats and Species Regulations 2017.

and each of their main component parts is stable or increasing.

For the inlets and bays feature these include;

- The embayment of St. Brides Bay
- The ria of Milford Haven
- Peripheral embayments and inlets

For the coastal lagoons feature this is subject to the requirements for maintenance of the artificial impoundment structure and maintenance of the lagoons for the original purpose or subsequent purpose that pre-dates classification of the site.

- **Structure and function:** the physical biological and chemical structure and functions necessary for the long-term maintenance and quality of the habitat are not degraded. Important elements include;
  - geology,
  - sedimentology,
  - geomorphology,
  - hydrography and meteorology,
  - water and sediment chemistry,
  - biological interactions.

This includes a need for nutrient levels in the water column and sediments to be:

- at or below existing statutory guideline concentrations
- within ranges that are not potentially detrimental to the long term maintenance of the features species populations, their abundance and range.

Contaminant levels in the water column and sediments derived from human activity to be:

- at or below existing statutory guideline concentrations
- below levels that would potentially result in increase in contaminant concentrations within sediments or biota
- below levels potentially detrimental to the long-term maintenance of the feature species populations, their abundance or range.



- **Typical Species:** The presence, abundance, condition and diversity of typical species is such that habitat quality is not degraded. Important elements include:
  - species richness
  - population structure and dynamics,
  - physiological health,
  - reproductive capacity
  - recruitment,
  - mobility
  - range

As part of this objective it should be noted that:

- populations of typical species subject to existing commercial fisheries need to be at an abundance equal to or greater than that required to achieve maximum sustainable yield and secure in the long term
- the management and control of activities or operations likely to adversely affect the habitat feature is appropriate for maintaining it in favourable condition and is secure in the long term.

### **Restoration and recovery**

For the inlets and bays features this includes the need for some restoration of the populations of several typical species which are severely depleted with respect to historical levels as a consequence primarily of human exploitation.

In the Milford Haven waterways complex inputs of nutrients and contaminants to the water column and sediments derived from human activity must remain at or below levels at the time the site became a candidate SAC.

### ***Conservation objectives for the species features to achieve favourable condition:***

- **Populations:** the population is maintaining itself on a long-term basis as a viable component of its natural habitat. Important elements include:
  - population size
  - structure, production

- condition of the species within the site.

As part of this objective it should be noted that for otter and grey seal;

- Contaminant burdens derived from human activity are below levels that may cause physiological damage, or immune or reproductive suppression

For grey seal and otter, populations should not be reduced as a consequence of human activity.

- **Range:** The species population within the site is such that the natural range of the population is not being reduced or likely to be reduced for the foreseeable future.

As part of this objective it should be noted that for otter and grey seal:

- Their range within the SAC and adjacent inter-connected areas is not constrained or hindered.
- There are appropriate and sufficient food resources within the SAC and beyond.
- The sites and amount of supporting habitat used by these species are accessible and their extent and quality is stable or increasing.
- **Supporting habitats and species:** The presence, abundance, condition and diversity of habitats and species required to support this species is such that the distribution, abundance and populations dynamics of the species within the site and population beyond the site is stable or increasing. Important considerations include;
  - distribution
  - extent
  - structure
  - function and quality of habitat
  - prey availability and quality.

As part of this objective it should be noted that;

- The abundance of prey species subject to existing commercial fisheries needs to be equal to or greater than that required to achieve maximum sustainable yield and secure in the long term.
- The management and control of activities or operations likely to adversely affect the species feature is appropriate for maintaining it in favourable

condition and is secure in the long term.

- Contamination of potential prey species should be below concentrations potentially harmful to their physiological health.
- Disturbance by human activity is below levels that suppress reproductive success, physiological health or long-term behaviour
- For otter there are sufficient sources within the SAC and beyond of high quality freshwater for drinking and bathing.

### **Restoration and recovery**

In the Milford Haven waterways complex inputs of nutrients and contaminants to the water column and sediments derived from human activity must remain at or below levels at the time the site became a candidate SAC.

As part of this objective it should be noted that for the otter, populations should be increasing.

Using the Pembrokeshire Marine features map, priority habitat mapping available on Magic, Google Earth aerial imagery, the underlying SSSI citation and considering the relative sensitivity to freshwater inputs the following features have been screened out; large shallow inlets and bays, reefs, grey seal, coastal lagoons, submerged or partially submerged sea caves, sandbanks which are slightly covered by sea water all the time, and shore dock as they are unlikely to be found within the upper estuary of the Western Cleddau. Otter can be screened out as habitat and prey availability would not be affected, given their extensive range.

Further consideration has been given to likely significant effects on the following features; estuaries, mudflats and sandflats not covered by seawater at low tide, Atlantic salt meadows, sea lamprey, river lamprey, allis shad and twaite shad.

The upper part of mean low water channel is not designated as part of the Pembrokeshire Marine SAC from the railway bridge downstream to the confluence with Merlin's Brook, which provides an additional freshwater source to the estuary. Smaller streams contribute to the freshwater input downstream at Hop Gardens and Hanton Bridge, although not likely to be significant volumes during a drought. Large areas of saltmarsh are present above the high water level, however given the effects of the drought order will be constrained to Q<sub>99</sub> flows in August and September only, and not affecting the remainder of the year, LSEs are considered unlikely. Similarly, areas of mudflat are only present downstream of the Merlin's Brook confluence, which will provide some freshwater to ameliorate the effects of the drought order. As such, no

LSEs to the mudflat habitat are anticipated either.

Given the very short section of SAC between the Merlin's Brook confluence and the Cleddau Rivers SAC, and the designation of the habitats above the high water level only, impacts to the fish species are considered unlikely. Allis and twaite shad are not qualifying features of the Cleddau Rivers SAC, and were not recorded in surveys completed by NRW in 2017 in the reach (between Crowhill abstraction and tidal limit) and therefore are unlikely to be present. The Review of Consents<sup>14</sup> for the existing Crowhill abstraction concluded that impacts from that were confined to the first 150m of the downstream reach given the hydraulic influences of town weir. Effects further downstream at the Pembrokeshire Marine SAC (~1km) are therefore considered unlikely, and as such impacts to the migration of sea and river lamprey, and use of suitable habitat, are not anticipated.

### **9.3 SUMMARY**

In summary, no likely significant effects to the qualifying features of the Pembrokeshire Marine SAC have been identified. Likely significant effects have been identified for the sea, brook and river lamprey populations, bullhead populations and *Ranunculus* vegetation communities within the Cleddau Rivers SAC as a result of the implementation of the drought order.

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

### **9.4 IN-COMBINATION EFFECTS**

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.

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<sup>14</sup> Environment Agency Wales (2005). *Afonydd Cleddau Habitats Directive Review of Consents Stage 3a Licence Review Document*. November 2005.

## **10 ENVIRONMENTAL MONITORING PLAN (EMP)**

### **10.1 INTRODUCTION**

The overall scope of the EMP for the Crowhill 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 order. 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. Monitoring recommendations are set out in Section 10.3.

### **10.2 BASIS OF THE EMP**

#### **10.2.1 EMP Guidance**

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.
- 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.
- The level of monitoring needed should be risk-based. Not all sites will require in-drought and post-drought monitoring.
- 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 (in relation to any proposals that may affect any SACs, SPAs, NNRs, SSSIs or RAMSAR sites) 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 Baseline, Pre, Onset, During and Post Drought Monitoring and Mitigation Recommendations**

Feature reach and	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		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 <b>Reach 1</b>	<ul style="list-style-type: none"> <li>Reduction in abundance and distribution of taxa sensitive to nutrient enrichment (SRP)</li> <li>Reduction in growth or condition as a result of impacts on water levels and flows</li> <li>Changes to community composition due to changes to flow velocities and habitat loss due to reduction in wetted width and depth.</li> <li>Increase in detrimental smothering by</li> </ul>	<p>Macrophyte surveys were undertaken on behalf of Welsh Water in 2017 in the impacted reaches<sup>15</sup>. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites are located at:</p> <ul style="list-style-type: none"> <li>SM9532316543</li> </ul>	<p>Survey to be undertaken and macrophytes identified (if drought order likely to be implemented in plant growing season). Follow LEAFPACS2 standard methodology<sup>16</sup>.</p> <p>Walkover survey to identify any key sources of nutrient loading.</p> <p>Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.</p>	<p>Walkover of key sections known to be susceptible to lower flows, informed by pre-drought survey.</p> <p>If drought order implementation occurs in plant growing season, carry out macrophyte surveys at baseline sites. Follow LEAFPACS2 standard methodology for assessing macrophyte communities.</p> <p>Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.</p>	<p>Mitigating impacts to the macrophyte community as a result of lowered flow and water level is not feasible during drought order implementation.</p> <p>Mitigating this impact should be triggered by post drought macrophyte community assessments to implement post drought mitigation measures.</p> <p>Consider measures to address identified point sources of nutrient loading.</p> <p>Consider scope for addressing any identified sources of nutrient loading from walkover survey, if this would help address water quality risks.</p>	<p>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.</p> <p>Significant alteration to macrophyte community composition (as informed by expert judgement, based on baseline data and multivariate statistical analyses) triggers post drought mitigation actions:</p> <p>If existing macrophyte community has significantly deteriorated, consider reseeded /replanting where possible to promote recovery. Replanting of macrophyte</p>	Welsh Water

<sup>15</sup> Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018: Crowhill, July 2018

<sup>16</sup> Environment Agency (2011). Surveying freshwater macrophytes in rivers. Operational instruction 131\_07. (Unpublished procedures manual)

Feature reach	Potential Impact identified in EAR	Pre-drought baseline monitoring Key Locations	On-set of environmental drought Monitoring and trigger setting	During Drought Permit Implementation Period Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Post Drought Permit Monitoring and post-drought mitigation (where applicable)	Responsibility
	filamentous algae levels increasing due to an increase in nutrients, increases in water temperature and decreased velocity					community composition to be informed by pre-drought community.	
Macroinvertebrates  <b>Reach 1</b>	<ul style="list-style-type: none"> <li>Reduction in species diversity and abundance as a result of reduced recruitment.</li> <li>Reduction in species diversity as a result of the loss of flow-sensitive taxa</li> <li>Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats</li> <li>Alteration to community composition as a result of water quality deterioration.</li> </ul>	<p>Macroinvertebrate surveys were undertaken on behalf of Welsh Water in 2017 in the impacted reaches<sup>17</sup>. Limited older data outside the impacted reach is also available from NRW.</p> <p>Two sites per impacted reach. To complement any existing NRW monitoring, in discussion with NRW. Monitoring sites are located at the following Welsh Water &amp; NRW sites:</p> <ul style="list-style-type: none"> <li>US Control – NRW Site: Prendergast Gauging Station</li> <li>Welsh Water Site: SM9531215995</li> <li>Welsh Water Site: SM9532916837</li> </ul>	<p>Seasonal monitoring of macroinvertebrates at the baseline survey sites (spring and autumn). Samples to be collected and identified to species level.</p> <p>Carry out water quality surveys at same time.</p> <p>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.</p>	<p>Seasonal monitoring of macroinvertebrates at the baseline survey sites (spring and autumn). Samples to be collected and identified to species level.</p> <p>Carry out water quality surveys at same time.</p> <p>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.</p>	<p>Mitigating impacts to the macroinvertebrate community as a result of lowered flow and water level is not feasible during drought order implementation.</p> <p>Mitigating this impact should be triggered by post drought macroinvertebrate community assessments to implement post drought mitigation measures.</p> <p>Consider possible in-stream measures or adjustments to improve habitat conditions.</p> <p>Consider the removal of fine silt by manual raking of small areas.</p>	<p>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.</p> <p>Significant alteration to macroinvertebrate community composition (as informed by expert judgement and based on baseline data) triggers post drought mitigation actions:</p> <p>Targeted habitat alteration/improvements can enhance natural recovery. Habitat restoration techniques can be utilised to improve habitat quality, and flush sediment from benthic substrate.</p> <p>If sedimentation is deemed to be a risk to the</p>	Welsh Water

<sup>17</sup> Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018: Crowhill, July 2018

Feature reach	Potential Impact identified in EAR	Pre-drought baseline monitoring Key Locations	On-set of environmental drought Monitoring and trigger setting	During Drought Permit Implementation Period		Post Drought Permit Monitoring and post-drought mitigation (where applicable)	Responsibility
				Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring		
						community, consider the removal of fine silt by manual raking of any accessible shallow marginal areas.	
<p>Fish (including brown / sea trout, river, brook and sea lamprey, Atlantic salmon, bullhead and European eel)</p> <p><b>Reach 1</b></p>	<ul style="list-style-type: none"> <li>• Migration of juvenile river &amp; sea lamprey and transformer life stages affected or halted by a reduction in flow</li> <li>• Loss of juvenile fish habitat as a result of reduced flow related impacts</li> <li>• Increased mortality (density dependant) as a result of increased predation and competition</li> <li>• Delays and potential cessation of adult salmonid migration due to reduced flows</li> </ul>	<p>The fish community in the impacted reach is reasonably well understood as a result of monitoring carried out by Welsh Water<sup>18</sup> and NRW. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites are located at:</p> <ul style="list-style-type: none"> <li>• NRW Site: Control site – WC 20</li> <li>• Welsh Water Site: SM9532816839</li> <li>• Lamprey specific monitoring at site W1 (SM 9527216207)</li> </ul>	<p>Electric-fishing surveys to monitor fish populations at three sites in the impacted reach (including lamprey-specific surveys).</p> <p>In severe drought conditions, no fish population surveys are advised during drought as this may cause further stress.</p> <p>Walkover of impacted Reach 1:</p> <ul style="list-style-type: none"> <li>• Identification of key structures which may provide a barrier at lower flows.</li> <li>• Identification of key habitats which are at risk of low flow impacts, particularly juvenile lamprey habitat.</li> </ul> <p>Measure dissolved oxygen, conductivity and temperature in the field using calibrated handheld equipment.</p> <p>Appropriate trigger values would be set for level and flow for spawning habitats based on local circumstances, timing, seasonality and expert opinion.</p>	<p>No fish population surveys are advised during drought as this may cause further stress.</p> <p>Additional walkovers, if situation is expected to deteriorate in stream sections known to contain high fish densities, nursery and cover habitats. Record extent of exposed marginal habitats, bed substrates and estimates of overlying silt cover.</p> <p>Frequency of walkovers 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.</p> <p>Targeted fish passage assessment of barriers/obstructions to fish passage and any associated fish passes should be undertaken to</p>	<p>Targeted installation of woody debris features to provide fish with the habitat required to support feeding and development (growth).</p> <p>If the results of the walkovers deem spawning gravels to be at risk to siltation, the following mitigation action/s may be undertaken:</p> <ul style="list-style-type: none"> <li>• Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)<sup>19</sup></li> <li>• 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)</li> </ul>	<p>Two years of annual post-drought fish population surveys (including lamprey specific surveys) at baseline monitoring sites (corresponding with a control and impact site/s) to determine any changes in population dynamics both temporally and spatially.</p> <p>The results of the fish population surveys should help inform mitigation, targeting habitat restoration where deemed to be appropriate to support and enhance affected populations.</p> <p>Walkover of key fish habitat locations recording the number of juvenile lamprey habitat potentially affected. Record extent of exposed marginal habitats, and composition of the bed substrate and estimates of overlying silt cover.</p> <p>If the results of the</p>	Welsh Water

<sup>18</sup> Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018: Crowhill, July 2018

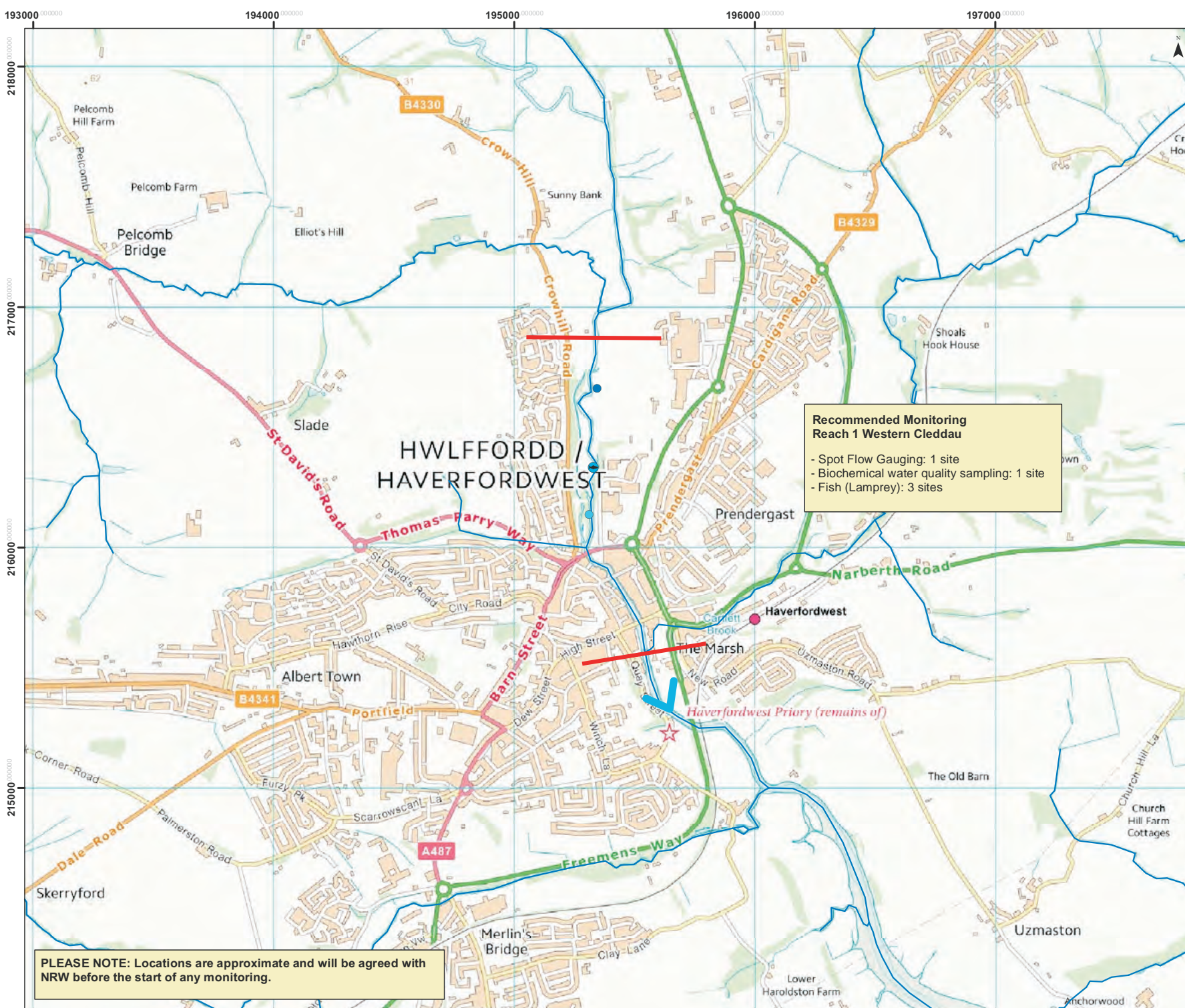
<sup>19</sup> Wild Trout Trust Habitat Management Sheet – Gravel Cleaning [http://www.wildtrout.org/sites/default/files/library/Gravel\\_Cleaning\\_Apr2012\\_WEB.pdf](http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf)

Feature reach	Potential Impact identified in EAR	Pre-drought baseline monitoring Key locations	On-set of environmental drought Monitoring and trigger setting	During Drought Permit Implementation Period Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Post Drought Permit Monitoring and post-drought mitigation (where applicable)	Responsibility
	<ul style="list-style-type: none"> <li>Changes in flows and water levels may delay or prevent passage over barriers to migration</li> <li>Alteration to species distribution and abundance as a result of water quality deterioration.</li> <li>Mortality as a result of water quality deterioration (e.g. oxygen stress)</li> </ul>			<p>ascertain if they pose an increased risk to the free movement of fish during key migration periods, i.e. during adult salmonid and juvenile lamprey migration (late summer/autumn).</p> <p>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.</p> <p>Measure dissolved oxygen, conductivity and temperature in the field using calibrated handheld equipment.</p> <p>Deployment of automated water quality equipment that continuously monitors for dissolved oxygen.</p>	<p>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:</p> <ul style="list-style-type: none"> <li>Deployment of aeration equipment in key reaches that have standing or slow flowing water with low oxygen levels.</li> <li>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.</li> </ul> <p>Consider provision of physical deterrents to deter piscivorous birds at significant locations (e.g. scare crows) in consultation with NRW.</p> <p>In extreme cases (where environmental parameters such as dissolved oxygen and temperature allow), consider removal of</p>	<p>walkovers deem important habitats to be at risk to exposure/reduction (in extent), the following mitigation action/s may be undertaken:</p> <ul style="list-style-type: none"> <li>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 juvenile lamprey migration (late summer/autumn).</li> <li>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).</li> </ul>	

Feature reach and	Potential Impact identified in EAR	Pre-drought baseline	On-set of environmental drought	During Drought Permit Implementation		Post Drought Permit	Responsibility
		monitoring Key locations	Monitoring and trigger setting	Period Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
					<p>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 Regulations 2014.</p> <p>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).</p> <p>Consider 'Trap &amp; 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).</p>		

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)	
Cleddau Rivers SAC / Western Cleddau SSSI	<ul style="list-style-type: none"> <li>Impacts on river lamprey, brook lamprey, and sea lamprey, and bullhead (Annex II species for which the SAC has been designated) have been assessed as moderate to major.</li> </ul>	Macrophyte and Fish monitoring to be undertaken at the sites identified for the relevant sections above.					
Phytobenthos Reach 1	<ul style="list-style-type: none"> <li>Decrease in flow affecting phytobenthos community composition.</li> <li>Low risk of deterioration to SRP affecting phytobenthos community composition and TDI score.</li> <li>Increases in filamentous algae smothering the substrate.</li> </ul>	<p>Data is absent for the impacted reach. Sampling according to DARLEQ2 protocol is recommended at one site in Reach 2 (control) and one site in Reach 1. Sampling to be undertaken in at least 1 year, ideally 2-year baseline, ideally encompassing 1 x "normal" flow year and 1 x "dry" flow year, 2 x sampling per year, in spring and autumn.</p> <p>Identify survey sites during walkover as outlined above.</p>	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





- Legend**
- Water Courses
  - Hydrological Reach
  - Direction of Flow
  - Fish Survey Sites
  - Spot Flow Survey Site
  - Water Quality Survey Site



1:14,816  
Note: All locations are approximate  
This drawing incorporates Ordnance Survey Information  
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Project Title: Welsh Water Drought Plan  
Environmental Assessment

Figure Title: Environmental Monitoring: 8206-1  
Reduce the required prescribed  
below the Crowhill Abstraction

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 Crowhill drought order. If granted and implemented, the drought order would allow river abstraction by Welsh Water from the Western Cleddau to continue subject to a revised daily prescribed flow of 11.1Ml/d, enabling more water to be abstracted in drought conditions.

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 hydrological / hydrogeological impact assessment is identified as **moderate** impact on the Western Cleddau during the period April to September due to the risk of reduction in extreme low flows as a result of the drought order.

An environmental assessment was therefore required and included for features where screening has identified a major or moderate impact. Screening identified WFD Status and Community Assessment / Environment (Wales) Act Section 7 Species and the Cleddau Rivers SAC and the Western Cleddau SSSI as environmental features for which an environmental assessment was required. The assessment has concluded that there are **moderate** impacts on fish (lamprey), and **minor** impacts on other fish species, macroinvertebrates, macrophytes and phytobenthos.

The HRA Screening concluded that implementation of a drought order has the potential to result in likely significant effects on the populations of brook, river and sea lamprey in the Cleddau Rivers SAC.

No cumulative effects of implementing the drought order with 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 Crowhill.

The environmental assessment has identified significant impacts of implementation of a drought order at Crowhill. Consequently, in line with the Welsh Ministers / Defra / NRW / Environment Agency Guidance for drought order assessments, 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 Crowhill, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **moderate**.



# **APPENDIX A**

## **HYDROLOGY AND HYDROGEOLOGY**

### **METHODOLOGY**

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

Consideration is required (by the DPG<sup>1</sup>) 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<sup>2</sup> 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<sup>3</sup>. Where possible, the hydrological assessments presented in previous EMPs and EARs of the drought options have been used to

<sup>1</sup> Welsh Government / Defra / NRW / Environment Agency (2011). Water Company Drought Plan Guideline. June 2011.

<sup>2</sup> Hydrological impact approach used in previous drought plan environmental assessments for water companies including Thames Water, Yorkshire Water and United Utilities

<sup>3</sup> 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)**

% reduction in flow		Summer Q99		
		<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)**

% reduction in flow		Summer Q99		
		<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<sub>95</sub>, summer<sup>4</sup>) and very high sensitivity to changes in extreme low flow (represented by Q<sub>99</sub>, 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<sub>95</sub>), but similarly sensitive to reductions in extreme summer low flows (summer Q<sub>99</sub>).

**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 (Q<sub>95</sub>) and year round median flow (Q<sub>50</sub>).

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

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

<sup>4</sup> Flow statistics indicate the proportion of days a flow is equalled or exceeded. Therefore Q<sub>95</sub> 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)**

	% reduction in flow	Year round Q95		
		<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 Western Cleddau River during the period of implementation of the Crowhill drought order.

For the purposes of this assessment, the “without drought order” baseline includes the continuation of Welsh Water’s daily abstraction from the Western Cleddau river at the Crowhill intake, subject to the abstraction not reducing river flows downstream of the intake below a prescribed flow of 37.58Ml/d, and also subject to a daily maximum abstraction of 9.5Ml/d during specified months if downstream river flow is below 89Ml/d. The assessed drought order assumes the continuation of the daily abstraction but with the prescribed flow requirements reduced by 18.79Ml/d to enable Welsh Water to increase its abstraction at times when it would otherwise be prohibited due to low river flows. The reduction is exactly 50% of the overall prescribed flow, and the seasonal reductions in abstraction would also be relaxed from October onwards so that the reduced prescribed flow requirement of 18.79Ml/d would be applicable throughout the period of implementation of the drought order.

### B.1.1 Welsh Water’s Existing Operations

Welsh Water’s licence (number: 22/61/3/0001, variation issued on 9 May 2016) to abstract water from the Western Cleddau river at Crowhill (see **Figure B1.1**) includes the following conditions:

- 7,728.2 million litres (Ml) authorised to be abstracted per annum (average daily abstraction of 21.173Ml/d)
- At an abstraction rate not exceeding 21.174Ml/d<sup>1</sup>
- The abstraction may not cause flow in the River Western Cleddau downstream of the Crowhill intake to fall below 37.584Ml/d.
- From April to June (inclusive) and October to December (inclusive), the abstraction rate may not exceed 9.504Ml/d if flow in the River Western Cleddau downstream of the Crowhill intake is less than 89.078Ml/d.

There are no sub-daily abstraction licence limits. The abstraction is made directly from a river intake and pumped to Bolton Hill Water Treatment Works (WTW) from where it is put into the water supply system.

The Crowhill abstraction licence conditions have recently been amended following a review of Welsh Water’s abstractions by Natural Resources Wales (NRW) under the environmental requirements of the EU Habitats Directive (under the “Review of Consents” process). The

<sup>1</sup> 1 Ml/d is 1 million litres per day.



Schedule of Conditions B (as outlined above) take effect from 31 March 2019.

### B.1.2 Welsh Water's Proposed Drought Order Operations

The drought order involves a change in the abstraction conditions at the Crowhill intake. The prescribed flow requirement of 37.58Ml/d means that at river flows of less than 58.75Ml/d (or 110.25Ml/d from April to June and October to December), the full daily licensed volume cannot be abstracted at the Crowhill intake. The drought order would allow the river abstraction from the Western Cleddau to continue as long as flows do not fall below a lower prescribed flow of 18.79Ml/d, increasing the amount of water that can be abstracted at times of low river flows. The seasonal reduced daily abstraction limit would also be temporarily removed from October to December inclusive, so that the lower prescribed flow of 18.79Ml/d would apply throughout the period of implementation of the drought order.

The drought order is most likely to be implemented during the summer and autumn period from August to November inclusive. This has been confirmed by water resources modelling carried out by Welsh Water. The assessment includes the Western Cleddau downstream of the Crowhill intake for 1.27 km to the tidal limit. 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 key objectives:

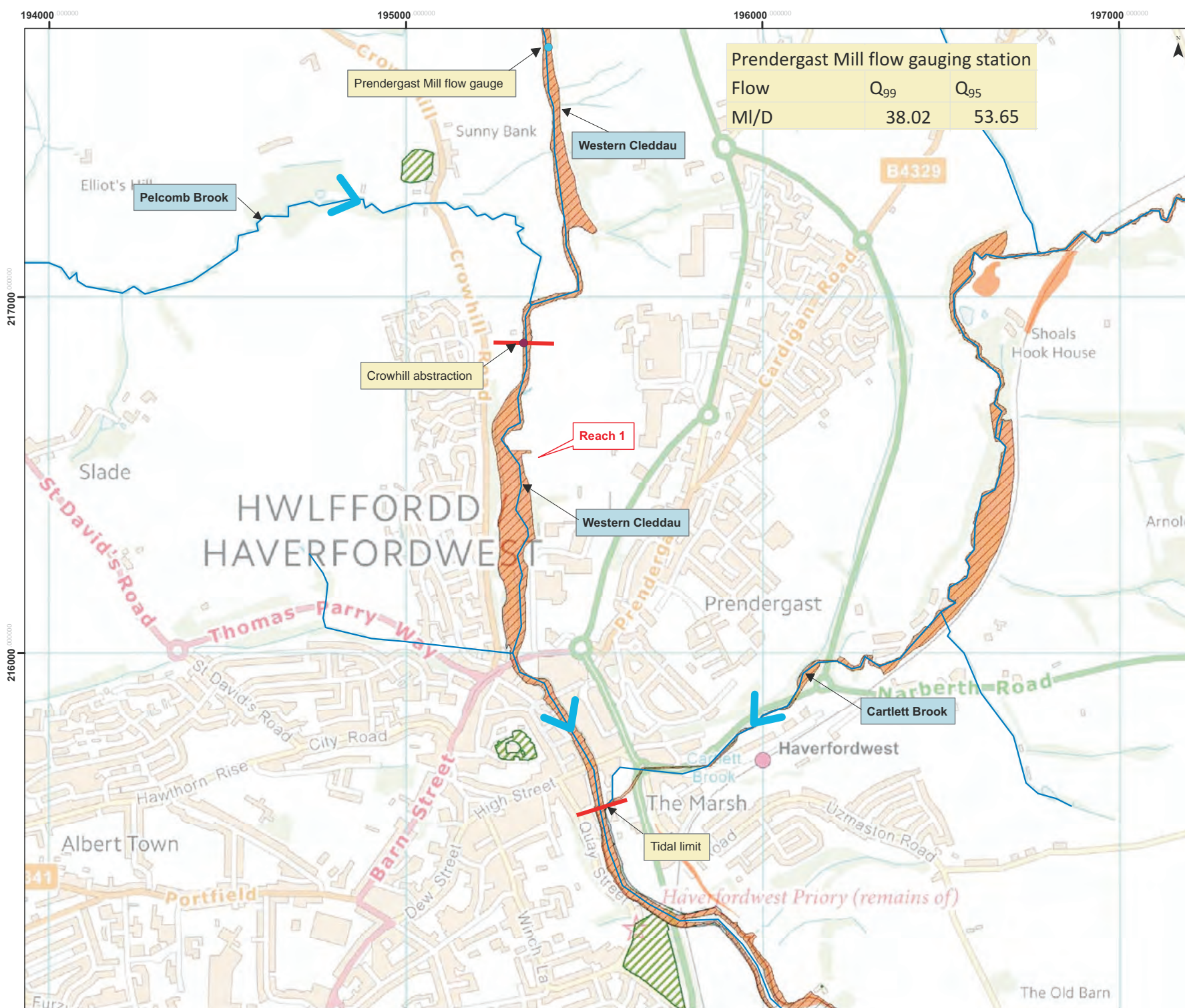
1. To “list the likely impacts to the flow, level, channel/riparian form and sediment due to action being in place” as required by the DPG<sup>2</sup> and set out in Figure 2 of the DPG.
2. It is used to support the screening and assessment of sensitive features (including ecological features and designated 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.

This appendix is set out in the following sections:

- Section B.2 Hydrological Impact
- Section B.3 Physical Environment Assessment
- Section B.4 Physical Environment Impact Summary
- Section B.5 Cumulative Impacts.

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<sup>2</sup> 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.



Prendergast Mill flow gauging station		
Flow	Q <sub>99</sub>	Q <sub>95</sub>
MI/D	38.02	53.65



### Legend

- Hydrological Reach
- Water Courses
- Direction of Flow
- Abstractions
- Flow Gauge
- Special Area of Conservation
- Site of Special Scientific Interest
- Scheduled Ancient Monuments



1:10,000  
 Note: All locations are approximate  
 This drawing incorporates Ordnance Survey Information  
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Project Title: Welsh Water Drought Plan  
 Environmental Assessment

Figure Title: Study area: 8206-1  
 Reduce required prescribed flow  
 below the Crowhill Abstraction

Figure Number: Figure B1.1  
 Date: February 2019

## B2 HYDROLOGICAL IMPACT

### B.2.1 Reference Conditions

#### B.2.1.1 Catchment Overview

The Western Cleddau is a steep, fast-flowing, shallow river in its upper reaches which becomes slower, deeper and more meandering towards the tidal limit. This small river catchment (217 km<sup>2</sup> total drainage area of the entire river catchment to the tidal limit) is located in the county of Pembrokeshire. The area is largely of a lowland nature, although it includes part of the Preseli Hills. The land is sparsely populated, with the exception of the town of Haverfordwest. The catchment is characterised by intensive agriculture, mainly dairy farming, although sheep rearing and early potato growing are locally important.

#### Baseline Data Availability

Continuous monitoring of river flow was previously undertaken by NRW at the Prendergast Mill flow gauge, the lowest flow gauge on the River Western Cleddau, located 0.8 km upstream of the Crowhill intake. However, the data quality is poor for the period from 2004 onwards. This gauge has therefore been replaced by a new gauge at Treffgarne on the Western Cleddau, located approximately 9 km upstream of the Crowhill intake, and data from the new gauge has been used to extend the flow record for the purposes of this assessment. Welsh Water monitors the daily abstraction flows from the Crowhill intake.

Data are available for:

- Prendergast Mill flow gauge: daily and sub-daily river flow. Flow data have been merged with those from the nearby NRW Redhill flow gauge to produce a continuous record from 1965 to 2015 (data in this record for the period 1974-1990 were measured at Redhill). However data from 2004 onwards have been excluded from the assessment following advice from NRW.
- Treffgarne flow gauge: daily river flow from 2014 to date.
- Crowhill abstraction intake: daily abstraction volumes from 1993 to date.

Prendergast Mill flow gauge was previously used in the operational control of the Welsh Water abstraction at the Crowhill intake. However, under the new licence conditions, provision of the prescribed flow at the weir at the Crowhill intake is determined by Welsh Water by equating the specified values with measured flows at the Treffgarne flow gauge.

Around 40 river cross-sections have been surveyed for flooding impact studies 35m upstream and 112m downstream of the Crowhill intake. Data on water levels and velocities at several hydro-ecologically representative sites in the lower River Western Cleddau is available from the Afonydd Cleddau Habitats Directive Review of Consents study reports.

A summary of recorded flow in the Western Cleddau river is presented in **Table B2.1** and

Table B2.2.

Table B2.1 Summary of Recorded Mean, Maximum and Minimum Daily Flow in the Western Cleddau River at Prendergast Mill Flow Gauging Station (1965 – 2003)

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	3776	3776	4234	2704	1659	4389	1296	3257	1892	5668	3966	5028	5668
10% (high flow)	1523	1305	968	693	519	445	254	334	399	1074	1445	1538	1045
50%	744	552	465	337	232	158	111	106	116	276	604	749	321
80%	444	351	299	201	152	102	77	64	66	121	308	443	124
90%	354	294	249	168	124	86	63	50	51	78	210	346	85
95% (low flow)	247	248	215	149	108	75	50	41	44	59	161	281	65
99% (extreme low flow)	169	179	156	119	88	62	39	31	33	48	70	221	42
Minimum flow	139	138	135	109	80	55	36	27	26	42	56	159	26

The low flow statistics at Prendergast Mill for the summer period (1st April to 30th September inclusive) are: Summer  $Q_{95}$  = 53.7 Ml/d; Summer  $Q_{99}$  = 38.0 Ml/d.

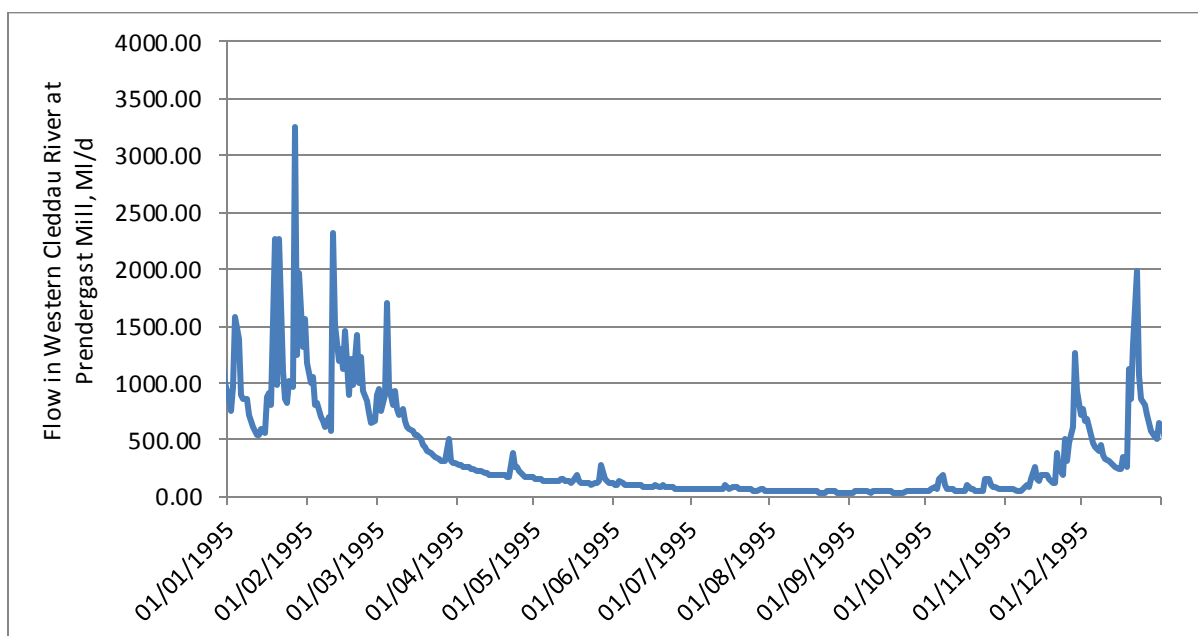
Table B2.2 Summary of Recorded Mean, Maximum and Minimum Daily Flow in the Western Cleddau River at Treffgarne Flow Gauging Station (2014 – 2018)

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	2169	2143	1365	1192	582	594	338	846	723	1071	4303	3076	4303
10% (high flow)	1344	1123	624	451	222	240	138	258	328	344	1350	1199	787
50%	674	467	335	224	128	95	81	85	145	192	512	530	239
80%	429	315	280	175	107	81	58	65	66	126	307	362	102
90%	283	267	260	152	101	77	52	57	43	111	262	304	76
95% (low flow)	245	248	230	143	95	72	49	53	41	108	188	280	60
99% (extreme low flow)	204	228	212	129	89	61	47	50	39	54	123	255	44
Minimum flow	190	221	206	125	87	59	44	46	39	43	119	252	39

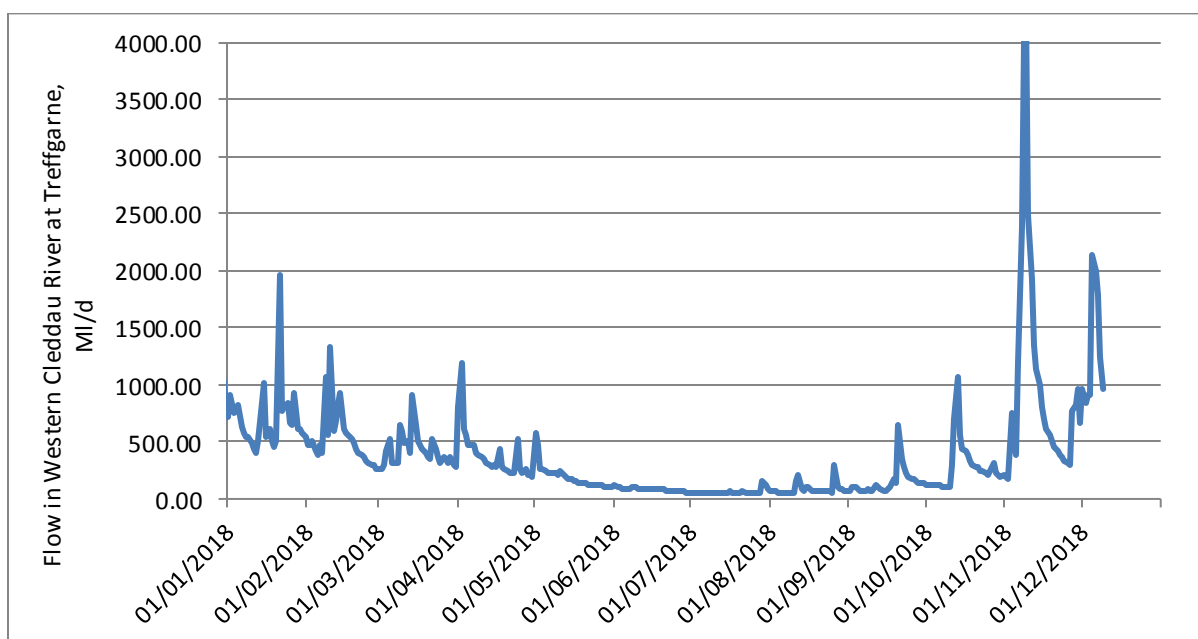
The low flow statistics at Treffgarne for the summer period (1st April to 30th September inclusive) are: Summer  $Q_{95}$  = 50.8 Ml/d; Summer  $Q_{99}$  = 41.5 Ml/d. These are broadly similar to the summer flow statistics for the Prendergast Mill gauge, however it should be noted that the flow records do not cover the same period and also the catchment area is around 36% smaller at the upstream Treffgarne gauge.

Hydrographs for typical dry years at the two gauging locations are shown in **Figure B2.1** and **B2.2**. The hydrograph for Treffgarne illustrates the recent low flow period of May to September 2018.

**Figure B2.1 Flows in the Western Cleddau River at Prendergast Mill, 1995**



**Figure B2.2 Flows in the Western Cleddau River at Treffgarne, 2018**



### B.2.1.2 Hydrology

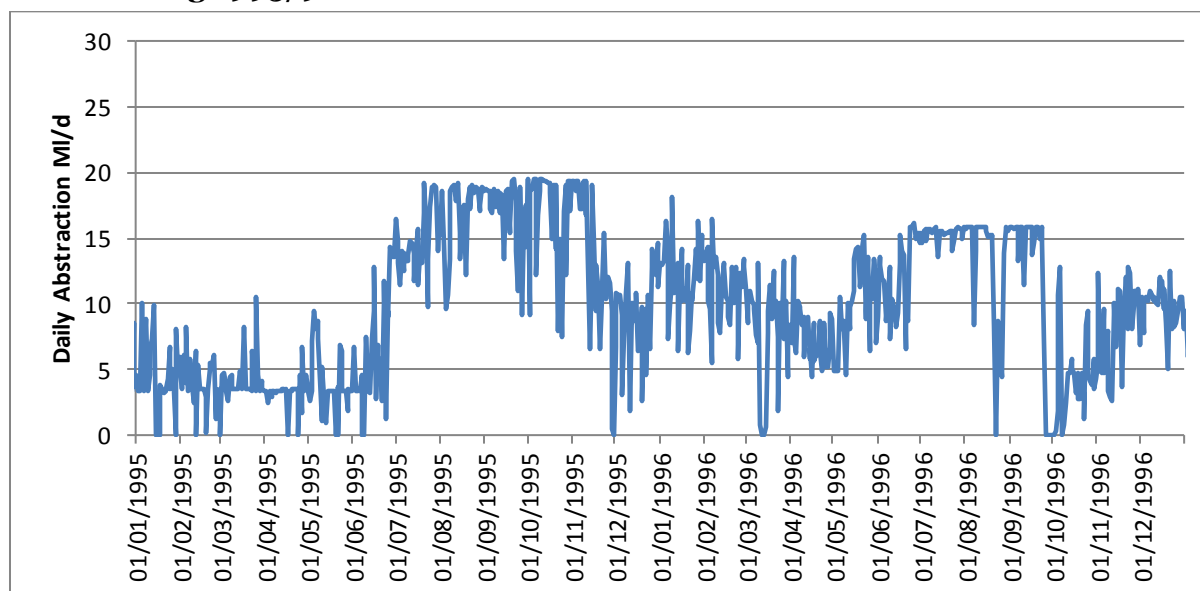
#### Western Cleddau River, Crowhill Intake to tidal limit (Reach 1)

The lower Western Cleddau (Reach 1) is a lowland river meandering through a wide floodplain (typically 300 m wide) of glacial sand / gravel and alluvial deposits. In Reach 1, the river is typically constrained within vertical, or undercut, natural earth banks or a re-sectioned

channel typically less than 10 m in width. Surrounding land use is a predominantly urbanised area. River flow is smooth over a mostly gravel and pebble substrate.

Welsh Water abstracts water on a daily basis from Crowhill intake on the Western Cleddau river. Abstraction volumes are typically in the range 0.5Ml/d to 20Ml/d. Inspection of the historical data record indicates that abstraction tends to be lower during the winter months when supply from Llys y Fran Reservoir is maximised, and higher in summer to conserve reservoir storage during periods of drawdown; this is particularly noticeable in dry years. **Figure B2.3** illustrates this pattern for the representative dry period of 1995/96.

**Figure B2.3 Measured Abstraction from Crowhill Intake on Western Cleddau River during 1995/96**



## B.2.2 Hydrological Impact

### B.2.2.1 Hydrological Zone of Influence

A review of the flows and physical habitat characteristics of the river network downstream of the Crowhill intake has identified the areas where the proposed drought order impacts upon hydrology. The study area includes the Western Cleddau from immediately downstream of the Welsh Water abstraction intake to the tidal limit; it comprises one distinct hydrological reach as listed in **Table B2.9** and **Table B2.10** and identified on **Figure B1.1**.

The potential hydrological impact of the drought order has been reviewed for this single hydrological reach and is discussed below.

### B.2.2.2 Hydrological Impact Assessment

The estimated percentage reduction in river flow statistics as presented in **Table B2.9** have been compared against the summer hydrological assessment matrix for lowland locations (**Figure A.2** in **Appendix A**) to determine the significance of the hydrological impacts.



**Table B2.10** presents the equivalent percentage reductions in the year round river flow statistics, assessed against the year round/winter hydrological assessment matrix for lowland locations (**Figure A.4** in **Appendix A**).

In order to estimate the potential impact on flows downstream of the Crowhill abstraction intake, theoretical daily abstractions have been calculated both for the baseline and “with drought order” scenarios.

It is assumed that daily abstraction from Crowhill intake would be maximised during drought conditions, in order to conserve storage in Preseli and Llys y Fran Reservoirs as far as possible. Theoretical abstraction volumes have been calculated based on the maximum daily licensed volume of 21.174Ml/d, subject to the prescribed flow constraint of 37.58Ml/d (baseline) or 18.79Ml/d (with drought order). Abstractions during the periods April to June and October to December inclusive are limited to 9.5Ml/d if a higher rate of abstraction would reduce downstream river flow to below the additional seasonal flow constraint of 89.08Ml/d (baseline scenario) or 70.29Ml/d (with drought order, during the period April to June only).

Daily flows in the Western Cleddau downstream of the Crowhill intake have been calculated by subtracting the modelled daily abstractions from the measured flow at Prendergast Mill gauging station, for the period 1965 to 2003. The period from 2004 to 2013 is excluded from the analysis due to concerns over the data quality for this period.

For the period from 2014 to date, data is available from the Treffgarne gauge but this does not directly equate to flows immediately upstream of the Crowhill intake. Catchment areas were compared for the two gauges, and a simple linear regression was also carried out using the period of overlapping data (2014 – 2015), to determine an appropriate scaling ratio to apply to the Treffgarne record in order to combine it with the Prendergast Mill record for modelling purposes. The relative flow values stated in the abstraction licence, for determining the prescribed flow values at Prendergast Mill based on gauged flows at Treffgarne, were also used to calculate the ratio.

**Table B2.3** presents the relative flow ratios calculated from the approaches outlined above. As a precautionary approach, and since the low flows at which the prescribed flow conditions may limit abstraction are of most relevance to the effects of the drought option, the lowest scaling factor of 1.3 based on the stated relative flow values in the licence has been applied to the Treffgarne flows.

**Table B2.3 Treffgarne to Prendergast Mill estimated flow ratios**

Method	Data sources	Estimated flow ratio
Linear Regression	Daily gauged data, 2014 - 2015	1.7
Relative catchment areas	National River Flow Archive (Prendergast Mill) and Flood Estimation Handbook (Treffgarne)	1.6
Relative flow values applicable to determine stated flow conditions from Treffgarne gauged flow	Abstraction licence	1.3

The resulting modelled flow records (for baseline and “with drought order”) have then been analysed to determine the low flow and extreme low flow statistics for the summer period of April to September inclusive (1965 to 2018, excluding the period from 2004 to 2013 inclusive). **Table B2.4** presents a summary of key summer flow statistics for this modelled flow of the Western Cleddau river downstream of Welsh Water’s Crowhill intake. These have been used to assess the impact of the drought order during the months of implementation of August and September, which fall within the hydrological summer of April to September inclusive.

**Table B2.4 Summary of Modelled Mean, Maximum and Minimum Daily Flow in the Western Cleddau Downstream of Crowhill Intake (1965 – 2003 and 2014 - 2018) with Licensed Abstraction Maximised: April to September inclusive**

Percentage of time river flow equalled or exceeded	Daily flow Ml/d, April to September 1965 – 2003 and 2014 - 2018		
	Baseline (prescribed flow =37.58Ml/d)	With Drought Order (prescribed flow =18.79Ml/d)	Change (%)
Maximum flow	4367.9	4367.9	0.0%
10% (high flow)	447.1	447.1	0.0%
50%	143.0	143.0	0.0%
80%	72.1	72.1	0.0%
90%	48.8	48.8	0.0%
95% (low flow)	37.6	37.6	0.0%
99% (extreme low flow)	37.6	18.8	50.0%
Minimum flow	26.3	18.8	28.5%

The results indicate that the drought order does not cause any change in the high, median or low summer flow statistics downstream of the Crowhill intake. The Q<sub>95</sub> flow is unchanged at 37.6Ml/d. The extreme low flow statistic, Q<sub>99</sub>, is reduced under the drought order from 37.6Ml/d to 18.8Ml/d; this is a 50% reduction (in line with the reduction applied to the prescribed flow value). Inspection of the modelled data indicates that the most significant impacts on downstream flows occur within the dry years of 1976, 1984, 1990 and 1995.

**Table B2.5** presents a summary of key year round flow statistics for the modelled flow of the



Western Cleddau river downstream of Welsh Water's Crowhill intake, used to assess the hydrological impact of the drought order during the winter implementation months of October and November.

**Table B2.5 Summary of Modelled Mean, Maximum and Minimum Daily Flow in the Western Cleddau Downstream of Crowhill Intake (1965 – 2003 and 2014 - 2018) with Licensed Abstraction Maximised: Year round flow statistics**

Percentage of time river flow equalled or exceeded	Daily flow Ml/d, 1965 – 2003 and 2014 - 2018		
	Baseline (prescribed flow =37.58Ml/d)	With Drought Order (prescribed flow =18.79Ml/d)	Change (%)
Maximum flow	5646.7	5646.7	0.0%
10% (high flow)	1024.3	1024.3	0.0%
50%	298.9	298.9	0.0%
80%	104.1	104.1	0.0%
90%	68.7	67.4	1.8%
95% (low flow)	47.0	45.6	2.9%
99% (extreme low flow)	37.6	23.6	37.3%
Minimum flow	26.3	18.8	28.5%

The results indicate that there is no impact on high or moderate year round flows due to the drought order; the change in the year round median flow ( $Q_{50}$ ) is zero. There is a small reduction of 2.9% in the year round low flow statistic ( $Q_{95}$ ).

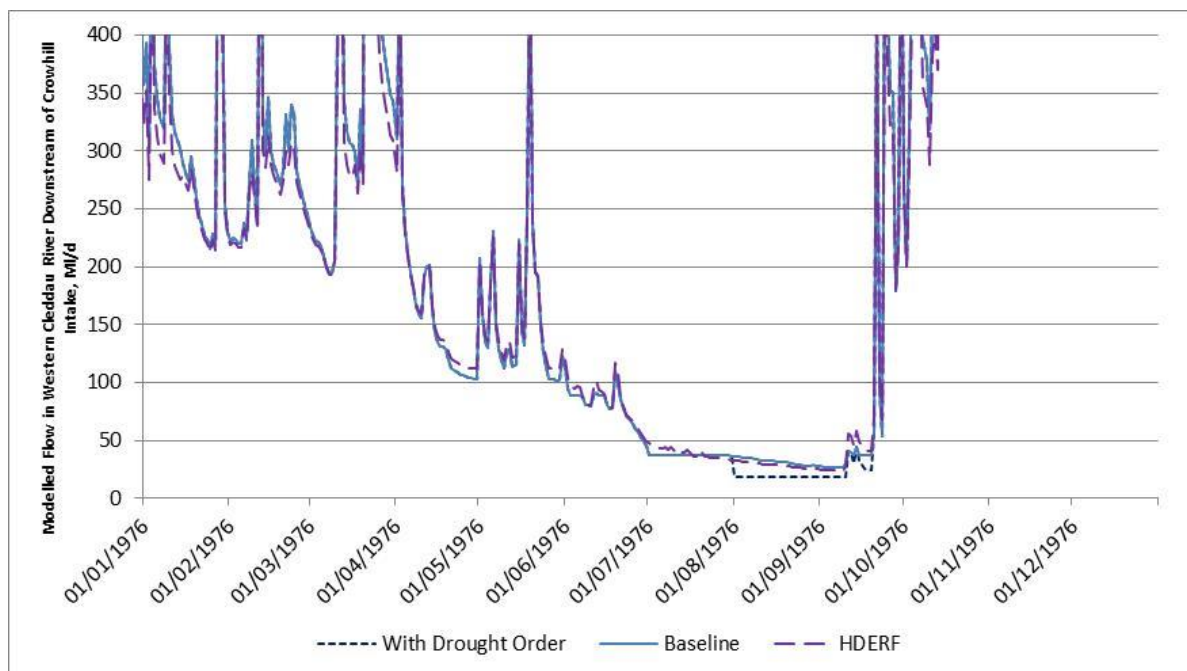
Generic flow indicators can also be considered and these include the Habitats Directive Ecological River Flow (HDERF) which is defined in the Afonydd Cleddau Review of Consents Stage 4 Site Action Plan as follows:

- At flows above  $Q_{50}$  the maximum reduction in natural flows is 15%
- Up to 10% reduction in natural flows between  $Q_{50}$  and  $Q_{95}$
- Up to 10% reduction in natural flows below  $Q_{95}$

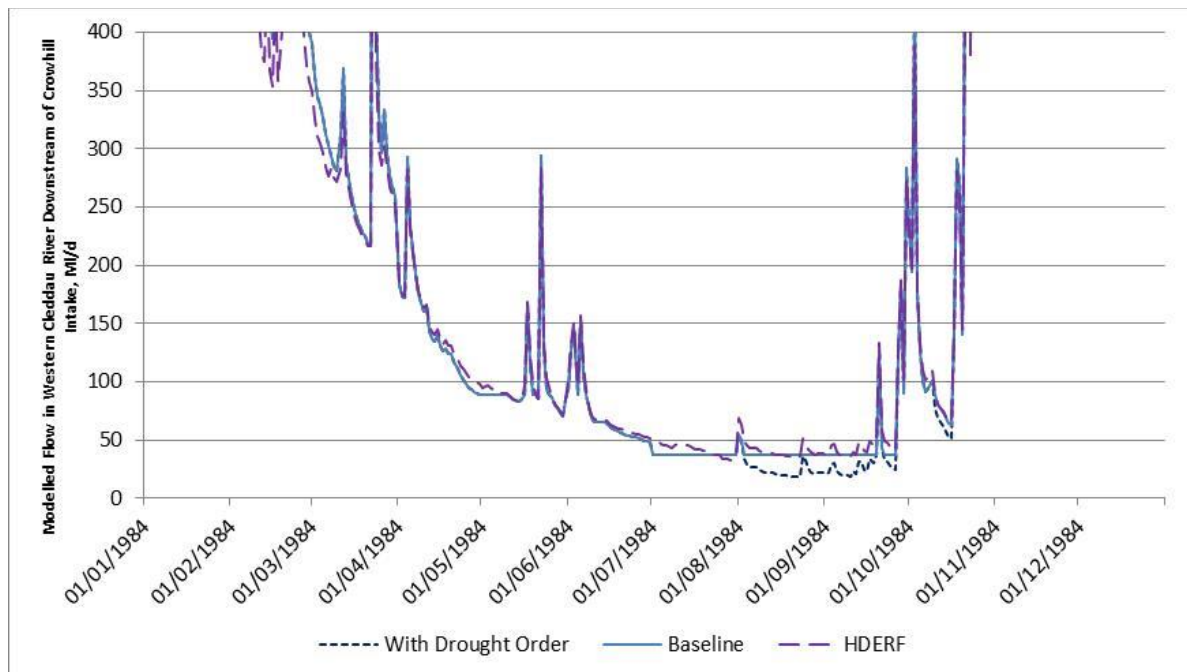
The gauged flow record of the river Western Cleddau at Prendergast Mill, extended by scaling the gauged flows at Treffgarne from 2014 to 2018, was used to determine a HDERF flow series for the river reach downstream of Prendergast Mill (in which the Crowhill intake is located). Daily HDERF flow values 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.

**Figure B2.4 to B2.7** below illustrates the change in flow downstream of Crowhill intake due to the drought order in a number of representative dry years (1976, 1984, 1990 and 1995). Note that the vertical scale is limited to 400Ml/d in order to highlight the changes in the low flow regime, so higher flows above 400Ml/d are not shown. The HDERF flow series for the Western Cleddau at Crowhill, as outlined above, is also shown on each hydrograph.

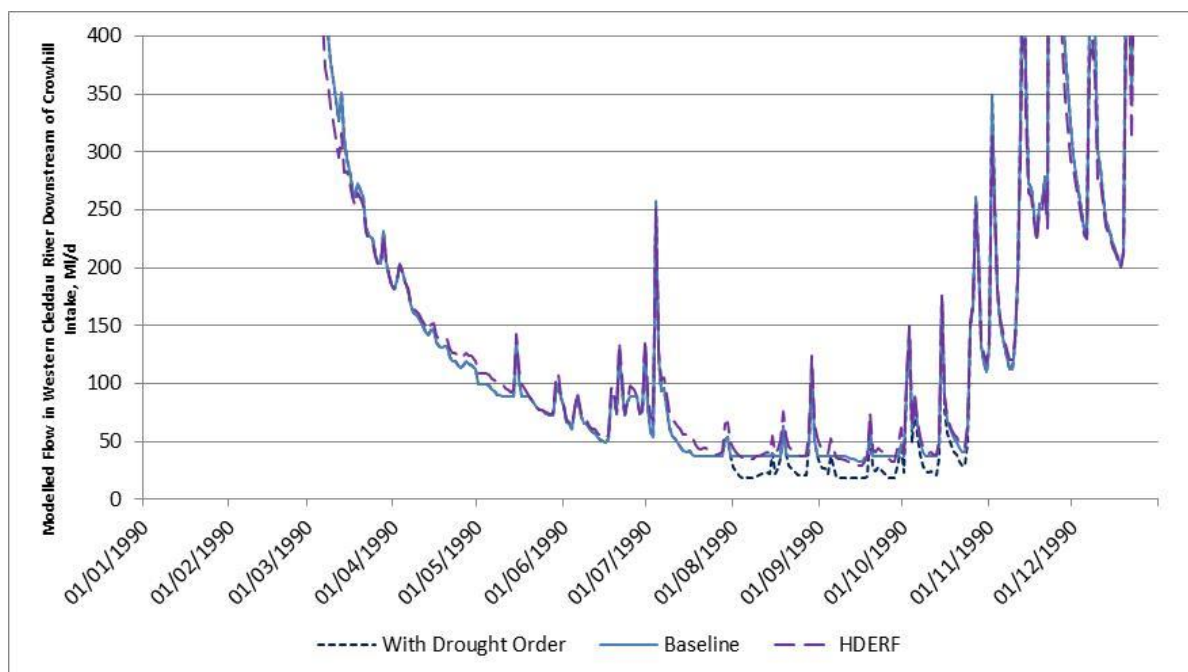
**Figure B2.4 Modelled Mean Daily Flow in the Western Cleddau River downstream of Crowhill Intake, Baseline and With Drought Order (1976)**



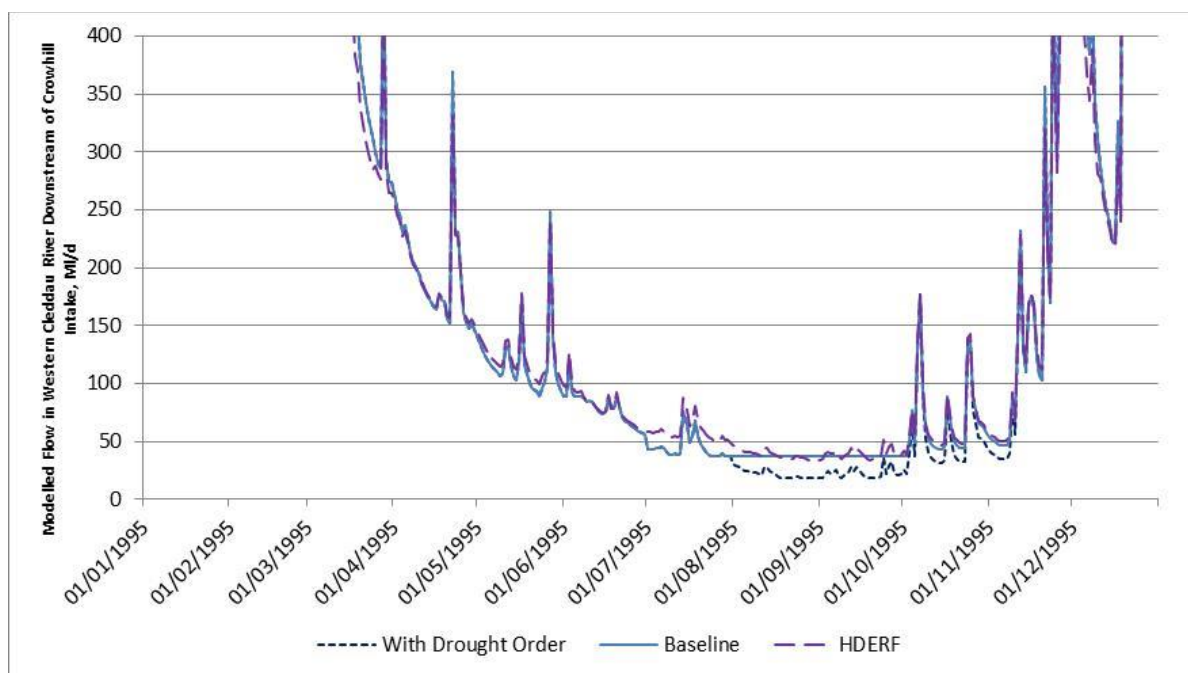
**Figure B2.5 Modelled Mean Daily Flow in the Western Cleddau River downstream of Crowhill Intake, Baseline and With Drought Order (1984)**



**Figure B2.6 Modelled Mean Daily Flow in the Western Cleddau River downstream of Crowhill Intake, Baseline and With Drought Order (1990)**



**Figure B2.7 Modelled Mean Daily Flow in the Western Cleddau River downstream of Crowhill Intake, Baseline and With Drought Order (1995)**



### Reach 1 – Western Cleddau River, Crowhill Intake to tidal limit

The drought order involves a reduction in the prescribed flow condition at the Crowhill intake, from 37.58Ml/d to 18.79Ml/d. The analysis above indicates that this reduces the summer  $Q_{95}$  low flow statistic downstream of the intake by 9%, and the summer  $Q_{99}$  extreme low flow statistic by 50%. As this is a lowland location, the hydrological impact of the drought order in this reach is therefore assessed as **moderate** during the period April to September based on

the standard hydrological assessment matrix.

The drought order does not cause any reduction in the year round median flow statistic ( $Q_{50}$ ), however it does cause a small reduction of 2.9% in the year round low flow statistic ( $Q_{95}$ ). The hydrological impact of the drought order is therefore assessed as **negligible** during the period October to March based on the year round (winter) hydrological assessment matrix.

The Stage 4 Site Action Plan for the Afonydd Cleddau states that a flow of  $0.4\text{m}^3/\text{s}$  ( $34.56\text{Ml/d}$ ) is required to maintain an acceptable flow and water depth through the Town Weir fish pass. Under the proposed drought option, Welsh Water's abstraction would not cause this condition to be breached during the key fish migration periods of April to June inclusive, due to the seasonal river flow condition remaining above this flow (at  $70.29\text{Ml/d}$ ). However during the key fish migration period of October to December inclusive, the reduced prescribed flow condition of  $18.79\text{Ml/d}$  means that the flow of  $34.56\text{Ml/d}$  could in theory be breached under the drought order. Inspection of the modelled data indicates that this would have occurred on 10 days in each of October 1990 and October 1995 had this drought order been in force in those years, but no breach would have occurred in the drought years of 1976 and 1984.

Information is available on hydraulic parameters for four representative cross-sections downstream of the Crowhill intake. These cross-sections (referenced as 0210, 0301, 0302 and 0302.5) were surveyed by the Environment Agency and reported on in the Afonydd Cleddau Habitats Directive Review of Consents Stage 3b Licence Review Document (October 2007). For each cross-section, values of velocity and maximum water depth corresponding to selected low flow values are provided, together with the relative reduction per unit flow value ( $\text{m}^3/\text{s}$ ). This data has been used to estimate velocity and maximum water depth by interpolation for the baseline and "with drought option" modelled extreme low flow values ( $Q_{99}$ ), in order to estimate the percentage change in these parameters.

The results of this analysis, presented in **Tables B2.6** and **B2.7** below, should be treated with a degree of caution due to the interpolation method used to estimate parameter values corresponding to the modelled flow values in this assessment. However, the analysis gives an indication that water velocities and depths downstream of the abstraction may reduce by up to 60% and 34% respectively, as a result of implementing the drought option.

**Table B2.6 Impact of drought option on estimated flow velocities downstream of Crowhill intake**

Modelled flow statistic		Velocity (m/s) in each cross-section			
		0210	0301	0302	0302.5

	Gauged Flow (m <sup>3</sup> /s)				
Summer Q <sub>99</sub> baseline	0.435	0.020	0.030	0.179	0.570
Summer Q <sub>99</sub> with drought option	0.218	0.008	0.017	0.129	0.599
Change	0.218	0.012	0.013	0.050	-0.029
<b>Change %</b>	<b>50%</b>	<b>60%</b>	<b>43%</b>	<b>28%</b>	<b>-5%</b>

**Table B2.7 Impact of drought option on estimated maximum water depths downstream of Crowhill intake**

Modelled flow statistic	Gauged Flow (m <sup>3</sup> /s)	Maximum Water Depth at each Cross Section (m)			
		0210	0301	0302	0302.5
Summer Q <sub>99</sub> baseline	0.435	1.720	1.350	0.300	0.169
Summer Q <sub>99</sub> with drought option	0.218	1.677	1.307	0.257	0.111
Change	0.218	0.042	0.042	0.043	0.058
<b>Change %</b>	<b>50%</b>	<b>2%</b>	<b>3%</b>	<b>14%</b>	<b>34%</b>

**Figures B2.4 to B2.7** indicate that the drought option leads to a significant reduction below the HDERF flows; this reduction could continue for a number of months in the driest years depending on the duration of implementation and of low flow conditions.

Analysis of the modelled flows downstream of Crowhill indicates that for the baseline case the HDERF daily flows are met on around 65% of the data record (covering 1965 – 2003 and 2014-2018); however this is based on a theoretical maximum daily abstraction rather than actual historic values, and does not account for a small increase in flow between the gauging station and abstraction intake from a tributary, Pelcomb Brook. With the drought option in place, the HDERF flows are met on 64% of the days in the record, a reduction of just 1% of the days overall. However, this masks the fact that the additional days with flow below the HDERF values occur mainly in the four driest years of the record, as summarised in **Table B2.8**. The 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 2 – 6 weeks.

**Table B2.8 Impact of drought option on no. of days HDERF is met in dry years**

Year	No. of days in year that HDERF is met, selected dry years in data record 1965 – 2003 and 2014 - 2018
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	Baseline (prescribed flow =37.58Ml/d)	With Drought Order (prescribed flow =18.79Ml/d)	Change (days)
1976	263	222	-41
1984	200	183	-17
1990	177	150	-27
1995	176	147	-29

### B.2.2.3 Hydrological Impact Summary

One river reach has been considered for which the assessed hydrological impacts have been determined as **moderate** during the summer implementation months of August – September inclusive, and **negligible** during the winter implementation months of October to November inclusive. The impacted reach is shown in **Table B2.9** and **Table B2.10** and establishes the full in-channel zone of influence of the drought order for environmental sensitivity screening (see **Figure B1.1**).]

**Table B2.9 Hydrological and Monitoring Reaches Identified in the Study Area – Summer Impact (August – September)**

Hydrological Reach	Reach boundary		Reach length (km)	% flow reduction		Hydrological Impact - Summer
	Upstream	Downstream		Summer Q <sub>95</sub>	Summer Q <sub>99</sub>	
1 Western Cleddau River	Crowhill Abstraction Intake	Tidal limit	1.27km	0%	50%	<b>Moderate</b>

**Table B2.10 Hydrological and Monitoring Reaches Identified in the Study Area – Winter Impact (October – November)**

Hydrological Reach	Reach boundary		Reach length (km)	% flow reduction		Hydrological Impact - Winter
	Upstream	Downstream		Year round Q <sub>50</sub>	Year round Q <sub>95</sub>	
1 Western Cleddau River	Crowhill Abstraction Intake	Tidal limit	1.27km	0%	2.9%	<b>Negligible</b>

## **B3 PHYSICAL ENVIRONMENT ASSESSMENT**

### **B.3.1 Geomorphology**

Geomorphology information for the lower River Western Cleddau has been obtained as a result of a walkover survey undertaken for Welsh Water during summer 2017 as part of an effort to identify the extent and location of flow sensitive habitats in the Crowhill reach and ensure characteristics of the watercourse are fully understood. The walkover survey, at one location in the only reach, followed a Drought 'Plus' River Habitat Survey (RHS+)<sup>3</sup> approach.

The study area is in the lower River Western Cleddau where the river meanders through a wide floodplain (typically 300m wide) of quaternary glacial sand / gravel and alluvial deposits. In the uppermost 250m of the survey section the in-stream channel substrate was dominated by gravel and silt, at 36% and 23% respectively, with some coarser pebbles and cobbles. In the lower 250m, 70% of the section was not visible and the remaining material was comprised of silt, sand and gravel. The flow type was predominantly smooth with some rippled flow and upwelling present in the uppermost sections where coarser substrate was present.

The channel bank substrate was composed entirely of earth and the bank profile was mostly classified as steep, with some instances of moderate sloping sections further downstream and bank erosion throughout the entire section. Close to 40% of the banks were recorded to have tree cover and this was particularly prevalent in the upper half of the survey section, where overhanging trees were also widespread.

There are no NRW River Habitat Survey (RHS) sites within the study area, however, there are two sites in the vicinity of the Prendergast Mill flow gauge, one upstream (4010) and one downstream (15553), which are indicative of the river in the study area. Data for these sites have been reviewed. The river reach is typically constrained through an urbanised area and the lower RHS site (15553) reflects this, classified as obviously modified (HMS score of 855) with re-sectioned bank and artificial embankments.

At the monitored sites, in-stream bed surface was recorded as 90-100 % gravel-pebble and the remaining proportion as not visible. The flow type in the reach was smooth or rippled, with a riffle or run present at the monitored sites. Channel bankfull width and depth were documented as 8.5-18m (narrower where re-sectioned) and 1.25m, respectively. The natural bank profile is vertical or undercut, composed of earth where not modified.

#### **B.3.1.1 Anthropogenic Features**

Using observations from extant aerial imagery and Ordnance Survey (OS) map data, in-channel structures and bridges were identified in the hydrological reach.

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<sup>3</sup> RHS+, also termed 'Catchment Hydrology and Ecology Walkover' (CHEW), is an in-house geomorphological assessment created by Cascade (now part of Ricardo). RHS+ has a greater emphasis on ecology than a normal RHS and has a slightly different method of approach.

The study reach of the Western Cleddau consists in total of eight bridges and one broad crested weir. The weir at the tidal limit of the Western Cleddau in Haverfordwest, known as Town Weir was made passable to the range of fish species present in 2003 with the installation of a super-active bottom baffle fish pass.

### ***B.3.1.2 Conclusions***

A potential reduction of up to 50% in summer extreme low flows has been identified as a result of the drought order. This would lead to corresponding reductions in wetted width and wetted depth of the river cross-section downstream of the Crowhill intake to the tidal limit for the duration of the drought order. Potential reductions in flow velocities and maximum water depths of up to 60% and 34% respectively have been estimated as a result of the drought order. At very low flows, there is a risk of increased sedimentation downstream of the abstraction intake due to the drought order but there is only a small distance to the tidal limit where this impact will arise.



### 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 WwTWs), 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 WFD classification, the Environment Agency has set out<sup>4</sup>, following UKTAG evidence<sup>5</sup>, 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. Values at the limit of detection were halved in line with standard Environment Agency practice.

Ten years of NRW routine monitoring data were reviewed to provide an overview of water quality in the zone of impact). On the Western Cleddau River within the extent of influence of the drought order (Reach 1), there are two NRW water quality sampling sites (**Table B3.1** and **Figure B1.1**). Data are available for these sites (2006 to 2015) and include measurements of a suite of parameters.

<sup>4</sup> Environment Agency (2011) Method statement for the classification of surface water bodies v2.0 (external release) Monitoring Strategy v2.0 July 2011 Table 2

<sup>5</sup> UK Technical Advisory Group on the Water Framework Directive (2008) Recommendations on Surface Water Classification Schemes for the purposes of the Water Framework Directive December 2007 (alien species list updated – Oct 2008 and Nov 2008). Appendix 1

**Table B3.1 Details of NRW Sampling Points on the Western Cleddau**

Reach	Site Name	NRW Site Code	Grid reference	Location
1	Western Cleddau at Source	120000	SM9533016909	Western Cleddau D/S of confluence with Pelcombe Brook
	New Bridge, Haverfordwest, Dyf	32804	SM9552615704	Western Cleddau U/S of confluence with Cartlett Brook

### Reach 1 (Western Cleddau, Crowhill Intake to tidal limit)

Water quality data are available for two NRW monitoring points on Reach 1 (moderate hydrological impact). Data are available for Western Cleddau at Source (site 120000) and New Bridge, Haverfordwest, Dyf (site 32804).

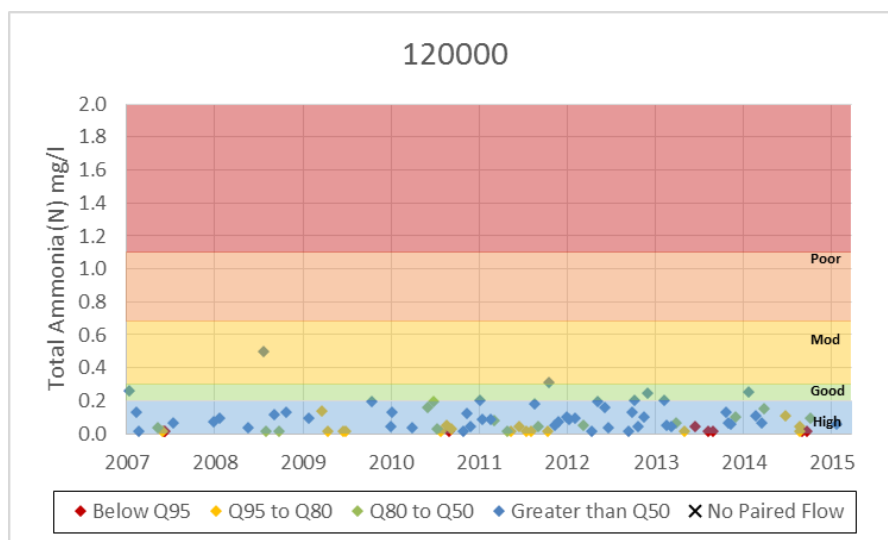
The monitoring site on the Western Cleddau at Source represents the upstream section of Reach 1 whilst New Bridge represents the downstream section of Reach 1. The average pH at Source over the ten year review period was 7.5 and the maximum water temperature was 18°C. The average pH at New Bridge, Haverfordwest, Dyf over the ten year review period was 7.5 and the maximum water temperature was 19.8°C.

### **Total ammonia concentration**

Total ammonia concentration for monitoring site 120000 on the Western Cleddau at Source was reviewed and data are presented in **Figure B3.1** against the relevant WFD standards for an upland low alkalinity river<sup>6</sup>.

### **Figure B3.1 Total Ammonia in the Western Cleddau Source, Incorporating Appropriate WFD Status Bands**

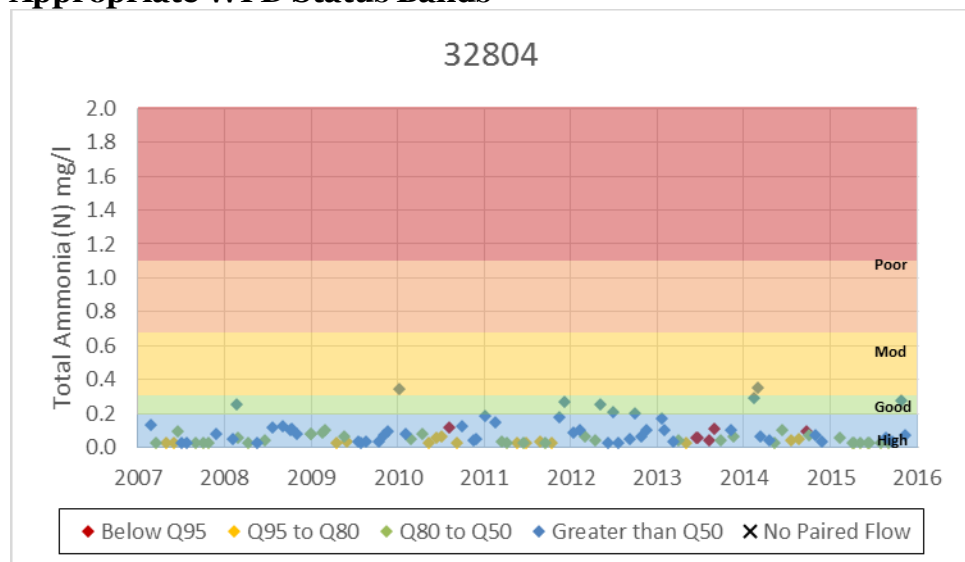
<sup>6</sup> The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.



Total ammonia concentrations at the Western Cleddau Source (see **Figure B3.1**) were predominantly consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). Multiple instances of good WFD status are noted in addition to an isolated incident of moderate WFD status observed on 30/07/2008 with 0.5 mg/l.

Total ammonia concentrations on the Western Cleddau at New Bridge, Haverfordwest, Dyf were reviewed and data presented in **Figure B3.2** against the relevant WFD standards for an upland low alkalinity river<sup>7</sup>.

**Figure B3.2 Total Ammonia at New Bridge, Haverfordwest, Dyf, Incorporating Appropriate WFD Status Bands**



Total ammonia concentrations on the Western Cleddau at New Bridge, Haverfordwest, Dyf (see **Figure B3.2**) were predominantly consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). Two instances of moderate WFD status were

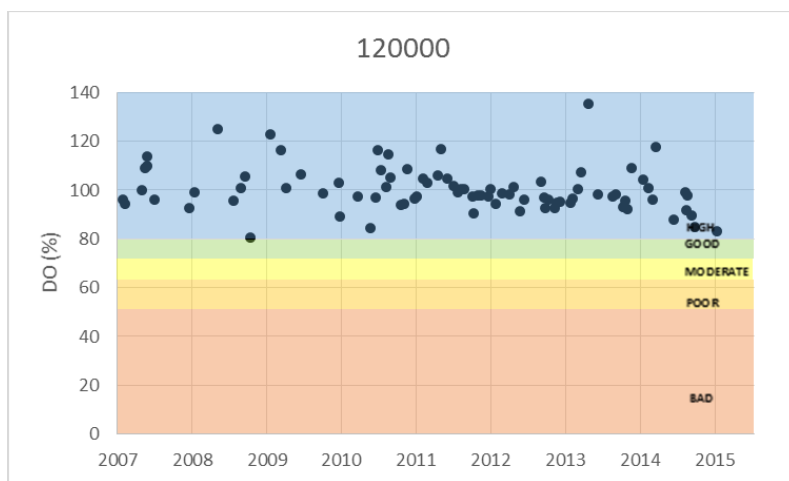
<sup>7</sup> The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

noted on 14/01/2010 and 06/03/2014 with both measuring 0.34 mg/l respectively.

### Dissolved oxygen saturation

Dissolved oxygen saturation at the Western Cleddau Source was reviewed and data are presented in **Figure B3.3** against the relevant WFD standards for an upland low alkalinity river<sup>8</sup>.

**Figure B3.3 Dissolved Oxygen Concentrations on the Western Cleddau Source, Incorporating Appropriate WFD Status Bands**

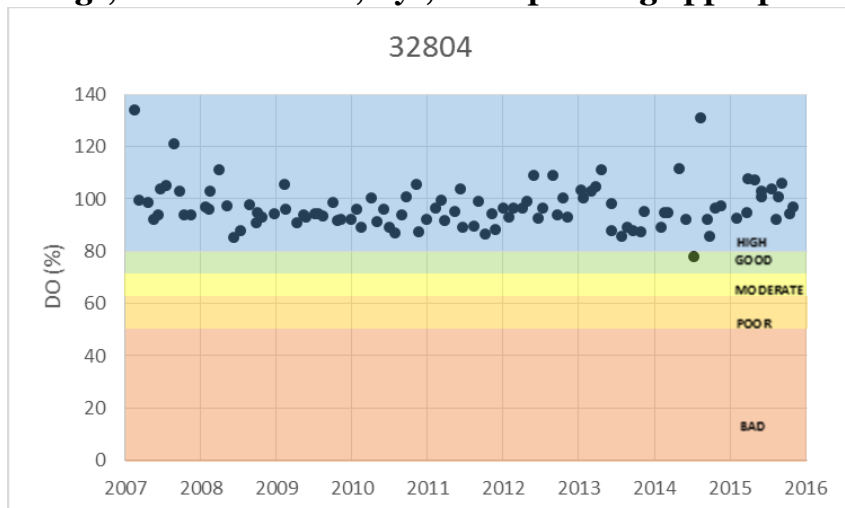


Dissolved oxygen saturation measurements at the Western Cleddau Source (see **Figure B3.3**) were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Dissolved oxygen saturation at the Western Cleddau at New Bridge, Haverfordwest, Dyf was reviewed and data are presented in **Figure B3.4** against the relevant WFD standards for an upland low alkalinity river.

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

**Figure B3.4 Dissolved Oxygen Concentrations on the Western Cleddau at New Bridge, Haverfordwest, Dyf, Incorporating Appropriate WFD Status Bands**

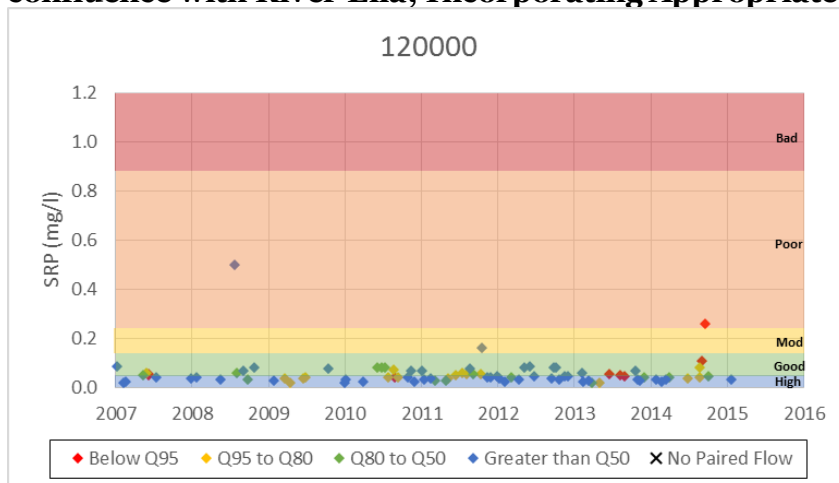


Dissolved oxygen saturation measurements at the Western Cleddau at New Bridge, Haverfordwest, Dyf (see **Figure B3.4**) were consistent with the WFD standard to support high status for fish and invertebrates (80%). One instance of good status is observed on 24/07/2014 with 78%.

### ***Soluble Reactive Phosphorus Concentration***

Soluble reactive phosphorus (SRP) concentration at the Western Cleddau at Source was reviewed and data are presented in **Figure B3.5** against the relevant site specific WFD standard<sup>9</sup>.

**Figure B3.5 Soluble Reactive Phosphorus at the Western Cleddau at Source at confluence with River Llia, Incorporating Appropriate WFD Status Bands**



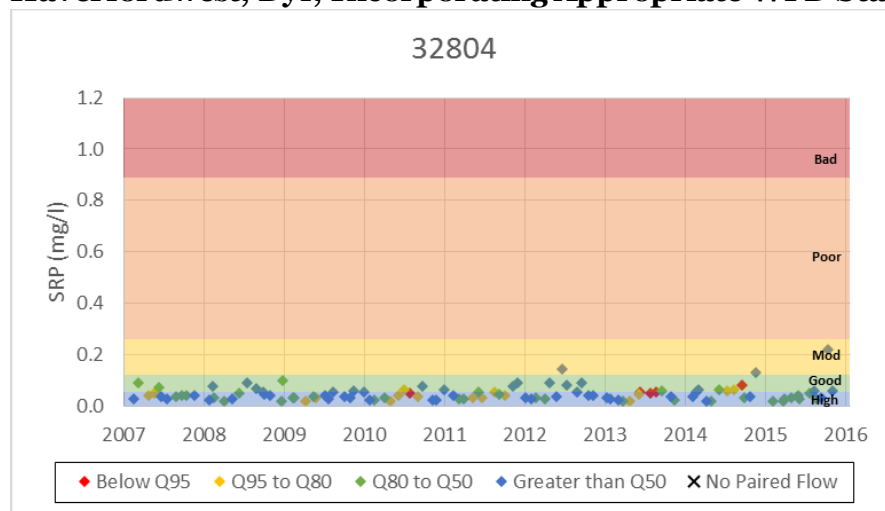
SRP concentrations at Western Cleddau Source (see **Figure B3.5**) were mostly consistent with the WFD standard to support good status for diatoms and macrophytes (0.02mgP/l).

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

Moderate WFD status is noted in once instance on 24/10/2011 with 0.16mgP/l while poor status is noted twice on 30/07/2008 and 24/09/2014 with 0.50mgP/l and 0.26mgP/l respectively.

SRP concentration at New Bridge, Haverfordwest, Dyf was reviewed and data are presented in **Figure B3.6** against the relevant site specific WFD standard.

**Figure B3.6 Soluble Reactive Phosphorus at Western Cleddau at New Bridge, Haverfordwest, Dyf, Incorporating Appropriate WFD Status Bands**



SRP concentrations at New Bridge, Haverfordwest, Dyf (see **Figure B3.5**) were mostly consistent with the WFD standard to support good status for diatoms and macrophytes (0.02mgP/l). Moderate status is also noted 04/07/2012, 04/12/2014 and 30/10/2015 with 0.14mgP/l, 0.13mgP/l and 0.22mgP/l respectively.

### Water Quality Summary

Assessment of risk to water quality as a result of the Crowhill drought order is limited by the spatial and temporal extent of the data available.

Total ammonia concentrations were mostly consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Crowhill drought order. Seasonal variability in total ammonia concentration was low. The risk of the drought order to total ammonia concentration levels within the zone of influence is therefore **minor** in Reach 1 of the Crowhill drought order.

Dissolved oxygen saturation values were mostly consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Crowhill drought order. The risk of the drought order to dissolved oxygen saturation levels within the zone of influence is therefore **minor** in Reach 1 of the Crowhill drought order.

SRP concentrations were mostly consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Crowhill drought order. The risk of

the drought order to dissolved oxygen saturation levels within the zone of influence is therefore **minor** in Reach 1 of the Crowhill drought order.

### B.3.3 Environmental Pressures

#### B.3.3.1 Flow Pressures

No significant abstractions other than the Welsh Water abstraction at Crowhill (22/61/3/1/4) are located within the zone of influence.

#### B.3.3.2 Water Quality Pressures

One consented discharge has been identified as having a negligible or higher water quality pressure. A summary of these impacts is identified in **Table B3.2**.

**Table B3.2 Summary of Water Quality Pressures**

Discharge Name	Permit Number	Flow: Daily total (Ml/day)	Flow: DWF (Ml/day)	BOD: 5 Day ATU (mg/l)	Ammoniacal Nitrogen as N (mg/l)	Suspended Solids at 105 C (mg/l)	Water Quality Pressure
Rising Sun Inn	BP0267101	0.01	Not specified	Not specified	Not specified	Not specified	Negligible

## B4 PHYSICAL ENVIRONMENT IMPACT SUMMARY

Potential impacts on the physical environment associated with the drought order at Crowhill abstraction intake on the Western Cleddau River are summarised in **Table B4.1**.

**Table B4.1 Summary of Potential Changes to the Physical Environment of the Impacted Reach from Implementation of Crowhill Abstraction Drought Order**

<b>Western Cleddau (Reach 1)</b>	
Flows in the River Western Cleddau downstream of Crowhill intake <i>Moderate impacts during the period August to September; Negligible impacts during the period October – November.</i>	<ul style="list-style-type: none"> <li>Reduction of up to about 50% in extreme low flows (August – September), with corresponding reductions in wetted width and wetted depth. Estimated reduction of up to 60% in flow velocities and up to 34% in maximum water depth. Duration variable but typically for up to about 10 weeks (e.g. 1976, 1984).</li> </ul>
Water quality in the River Western Cleddau <i>Minor risk during the period April to September</i>	<ul style="list-style-type: none"> <li>Impacts to water quality in the Western Cleddau have been assessed as minor for ammonia, dissolved oxygen and soluble reactive phosphorous.</li> </ul>
Consented discharges <i>Negligible risk</i>	<ul style="list-style-type: none"> <li>One small domestic discharge has been identified and is considered to have negligible impact.</li> </ul>



## B5 CUMULATIVE IMPACTS

The focus of this EAR is the Crowhill drought order. The assessment, as described in previous sections, has considered how the proposed drought order 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 Crowhill Drought Order with other Drought Options**

Organisation	Potential In-combination Impacts	Further Consideration Required (Yes/No)
Welsh Water - other drought options in the Pembrokeshire WRZ	<b>8206-7 (Llys-y-Fran use of freshet bank)</b> – the impact of the Llys-y-Fran freshet bank drought order has been assessed as negligible on all reaches of the Afon Syfynwy and downstream Eastern Cleddau and would not have any impact on flows in the Western Cleddau catchment. Therefore no further, cumulative effects are anticipated as a result of these two drought orders being implemented together.	No
	<b>8206-8 (Reduced Hands-Off Flow at Canaston)</b> – This option results in a flow reduction of up to 34Ml/d from the Llys-y-Fran Reservoir outflow to the Afon Syfynwy and on the downstream River Eastern Cleddau. However, as there are no flow reductions on the Western Cleddau catchment, there are no in-combination impacts anticipated. However while there are no cumulative hydrological effects both options impact the same European designated site.	Yes
	<b>8206-2 (Preseli)</b> - the hydrological influence of the Preseli drought order has been assessed as being restricted to a reach of the Afon Syfynwy from the Rosebush Reservoir to Llys-y-Fran Reservoir, and as such no in combination effects are anticipated.	No
Welsh Water - other drought options in the Western Cleddau catchment	No other potential drought permit / order options within the Western Cleddau catchment.	N/A
Natural Resources Wales - Drought options in the Eastern Cleddau catchment	No previous drought order applications have been made in the South West Wales region.	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)<sup>1</sup>.

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 <sup>a</sup>	<0.2mgN/l	Minor	Moderate
	≥0.2mgN/l	Moderate	Major

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

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

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

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 <sup>c</sup>	<1mg/l	Minor	Minor
	1-3mg/l	Minor	Moderate
	≥3mg/l	Moderate	Major

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

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

<sup>d</sup> Standards are WFD high/good threshold for BOD of 4mg/l and good/moderate threshold of 5mg/l for lowland high

<sup>1</sup> 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.

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

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

<sup>4</sup> 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<sup>5</sup>.

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.

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

<sup>e</sup> 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<sup>6</sup>.

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

<sup>f</sup> 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<sup>8</sup>.

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

<sup>g</sup> 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<sup>9</sup>.

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).

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

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

<sup>7</sup> Note that "Lowland low alkalinity" is a category that only exists for SRP standards, and not for total ammonia or BOD.

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

<sup>9</sup> 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**

<b>Potential Effects</b>
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 <i>High</i> or <i>Good</i> , the potential impact is to be investigated. This investigation is specific to the risk of deterioration below the <i>Good</i> status band to the <i>Moderate</i> status band, as advised by NRW / Environment Agency.
<b>Definition of Impacts</b>
<p>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.</p> <ul style="list-style-type: none"> <li>• <b>Major:</b> 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.</li> <li>• <b>Moderate:</b> 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.</li> <li>• <b>Minor:</b> 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.</li> <li>• <b>Negligible:</b> A negligible impact is one where the predicted impact will not result in a detectable change in the fish population.</li> </ul>
<b>Data Requirements</b>
<p>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:</p> <ul style="list-style-type: none"> <li>• Relevant study area (as identified in the screening report)</li> <li>• 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</li> <li>• Meteorology (where flow data insufficient) from available NRW / Environment Agency rain gauges</li> <li>• Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys</li> <li>• Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.</li> </ul>

### **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 be 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<sup>10</sup>. 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**

<b>Ecological Value</b>	<b>Example</b>
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

<sup>10</sup> 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**

<b>Habitat Preferences</b>		<b>Unfavourable Habitat</b>	<b>Potential Impacts</b>
<b>Type/ Age Class</b>	<b>Description</b>		
<b>Atlantic salmon <i>Salmo salar</i> and Brown/Sea trout <i>Salmo trutta</i></b>			
Spawning	<ul style="list-style-type: none"> <li>Clean and unconsolidated gravels typically in the transitional area between pools and riffles where the flow is accelerating and depth is decreasing</li> </ul>	-	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)	<ul style="list-style-type: none"> <li>Shallow areas with a low water velocity and pebble substrate, often at the margins of riffles</li> </ul>	<ul style="list-style-type: none"> <li>Deep and/or high velocity habitats.</li> </ul>	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: <ul style="list-style-type: none"> <li>submerged structures</li> <li>undercut banks</li> <li>overhanging vegetation &lt;50cm above the water surface</li> <li>water surface turbulence causing a broken surface</li> <li>Deep pools downstream of obstacles and sufficient water quantity through structures to enable passage across obstacles.</li> </ul>	<ul style="list-style-type: none"> <li>Open and shallow habitats, but will use these during migration to reach spawning gravels.</li> <li>Habitats upstream of significant obstructions.</li> </ul>	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
<b>Brook lamprey <i>Lampetra planeri</i></b>			
Spawning	<ul style="list-style-type: none"> <li>Clean, unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.</li> </ul>	-	Deposition of silt Reduction in velocity, depth or wetted width resulting in exposure of river bed Increased water velocity and depth
Nursery	<ul style="list-style-type: none"> <li>Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary.</li> <li>Variation in depth between 2cm and 30cm (&gt;15cm is optimal) with a relatively high organic content.</li> </ul>	-	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		
Adults	<ul style="list-style-type: none"><li>Cover (stones and vegetation) in the vicinity of spawning gravels.</li></ul>		Deterioration in water quality
			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 <i>Lampetra fluviatilis</i>			
Spawning	<ul style="list-style-type: none"><li>Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.</li></ul>	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	<ul style="list-style-type: none"><li>Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (&gt;15cm is optimal) with a relatively high organic content.</li></ul>	-	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	<ul style="list-style-type: none"><li>Suitable estuarine conditions, that is free from pollution and with suitable prey species available.</li><li>Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.</li></ul>	<ul style="list-style-type: none"><li>Areas with significant pollution or limited prey availability.</li><li>Habitats upstream of significant obstructions.</li></ul>	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, <i>Petromyzon marinus</i>			
Spawning	<ul style="list-style-type: none"><li>Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.</li></ul>	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	<ul style="list-style-type: none"><li>Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (&gt;15cm is optimal) with a relatively high organic content.</li></ul>	-	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	<ul style="list-style-type: none"><li>Suitable estuarine conditions, that is free from pollution and with suitable prey species available.</li><li>Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.</li></ul>	<ul style="list-style-type: none"><li>Areas with significant pollution or limited prey availability.</li><li>Habitats upstream of significant obstructions.</li></ul>	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, <i>Cottus gobio</i>			
Spawning	<ul style="list-style-type: none"><li>Coarse, hard substrate of gravel and stones.</li></ul>	<ul style="list-style-type: none"><li>Deep, silty watercourses with high flow velocities and little or no cover.</li></ul>	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	<ul style="list-style-type: none"><li>Shallow, stony riffles</li></ul>		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
Adult	<ul style="list-style-type: none"><li>Sheltered sections created by woody debris, tree roots, leaf litter, macrophyte cover or larger stones.</li></ul>		Deterioration in water quality
			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, <i>Anguilla anguilla</i>			
Juvenile (<30cm)	<ul style="list-style-type: none"><li>Wetland habitats within 30km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.</li></ul>	<ul style="list-style-type: none"><li>Low productivity watercourses with dominance of coarse substrates and low macrophyte cover and diversity.</li><li>Habitats upstream of significant obstructions.</li></ul>	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
			Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
Adult (>30cm, female >45cm)	<ul style="list-style-type: none"><li>Deep, slow flowing watercourses and wetland habitats within 80km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.</li></ul>		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 <i>Barbus barbus</i>			
Spawning	<ul style="list-style-type: none"><li>Run/glide flow</li><li>Less than 50cm deep</li><li>Velocities greater than 0.5m/s</li><li>Substrate composed of clean and uncompacted gravel</li></ul>	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	<ul style="list-style-type: none"><li>Marginal shallow bays set back from or within margins of main channel</li><li>Depths between 1cm and 30cm</li><li>No discernible to minimal flow</li><li>Substrate composed of &gt;30% gravel and sand with low silt content</li><li>Lack of or very little riparian shading</li></ul>		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	<ul style="list-style-type: none"><li>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.</li><li>The species also occupies deep water habitats at the foot of weirs,</li></ul>		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
<b>Fine-lined pea mussel, <i>Pisidium tenuilineatum</i> and depressed river mussel <i>Pseudanodonta complanata</i></b>			
All life stages	<ul style="list-style-type: none"> <li>Fine sediments of lowland rivers and canals,</li> </ul>	<ul style="list-style-type: none"> <li>High velocity watercourses with coarse substrates.</li> </ul>	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
<b>White-clawed crayfish <i>Austropotamobius pallipes</i></b>			
All life stages	<ul style="list-style-type: none"> <li>Slow-flowing sections of stony rivers</li> <li>Boulder riffles in chalk or clay streams</li> <li>Submerged tree roots</li> <li>Debris dams</li> <li>Crevices in old or damaged submerged brickwork, stonework, cracked concrete or rotten wooden structures</li> <li>Un-mortared stone revetting which protects banks from erosion</li> <li>Stands of submerged and emergent aquatic plants</li> <li>Old gravel workings and chalk pits</li> <li>Good water quality</li> </ul>	<ul style="list-style-type: none"> <li>Uniform clay channels</li> <li>Areas of deep or soft silt</li> <li>Dense filamentous algae</li> <li>Narrow fast-flowing channels</li> <li>Areas of sand and gravel, or bedrock, which are lacking in cobble or boulder (though they may feed in or commute through these areas)</li> <li>Pebble or cobble shingle regularly exposed by changing river levels</li> <li>Areas of armoured bed where the substrate is compacted by the river flow</li> <li>Acidic streams or ochreous drainage</li> <li>Poor water quality or salinity</li> </ul>	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 Crowhill 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 EAR and 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 the text in Section 5 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 presented in full in **Appendix B**.

The ecological assessment has been undertaken recognising the Institute of Environmental Management and Assessment (IEMA)<sup>1</sup> and the Chartered Institute of Ecology and Environmental Management (CIEEM) study guidelines<sup>3</sup>. 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 reach for the Crowhill 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:

Section D.2 Designated Sites

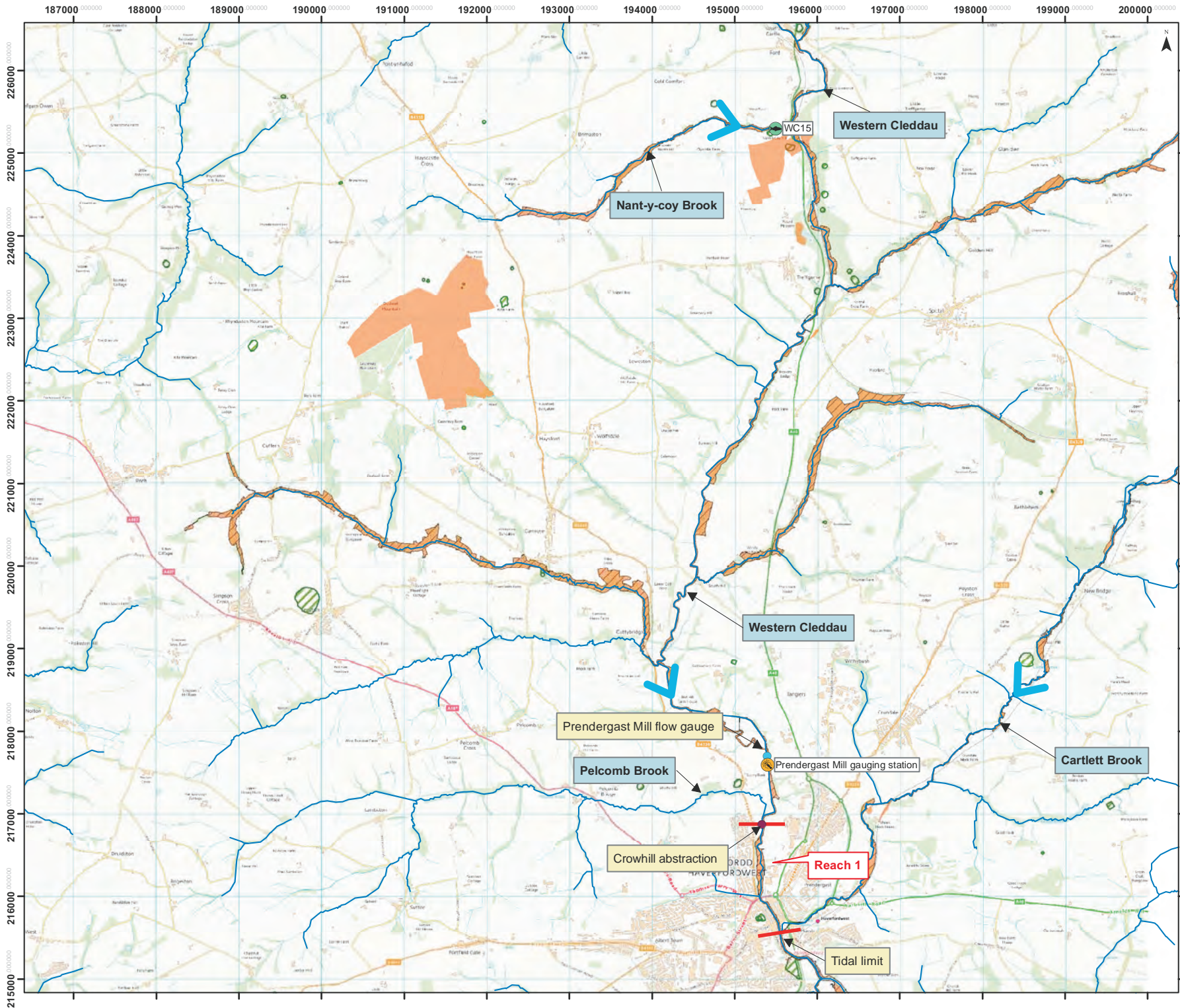
Section D.3 WFD Status and Community Assessment / Notable Species

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<sup>1</sup> IEMA (2004) Guidelines for Environmental Impact Assessment.

<sup>2</sup> IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK

<sup>3</sup> CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland.



- Legend**
- Water Courses
  - Hydrological Reach
  - Direction of Flow
  - Abstractions
  - Flow Gauge
  - Fish
  - Macroinvertebrates
  - Special Area of Conservation
  - Site of Special Scientific Interest
  - Scheduled Ancient Monuments



1:42,723  
Note: All locations are approximate  
This drawing incorporates Ordnance Survey Information  
© Crown copyright and database rights 2019

Project Title: Welsh Water Drought Plan  
Environmental Assessment

Figure Title: Study area: 8206-1  
Reduce the required prescribed flow  
below the Crowhill Abstraction

Figure Number: Figure D1.1  
Date: February 2019

## **D2 DESIGNATED SITES**

### **D.2.1 Afonydd Cleddau / Cleddau Rivers SAC / Western Cleddau River SSSI**

#### **Baseline**

The Western Cleddau is designated as part of the Cleddau Rivers SAC and SSSI. The Annex I habitats for which the SAC has been designated are:

- Watercourses of plain to montane levels with the *Ranunculus fluitantis* and *Callitriche-Batrachium* vegetation
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)
- Active raised bogs.

The Annex II species for which the SAC has been designated are:

- River lamprey *Lampetra fluviatilis*
- Brook lamprey *Lampetra planeri*
- Sea lamprey *Petromyzon marinus*
- Bullhead *Cottus gobio*
- Otter *Lutra lutra*.

The Countryside Council for Wales (CCW; now part of Natural Resources Wales, NRW) assessed the condition status of the first two Annex I habitats as ‘unfavourable; unclassified’, and the active raised bogs feature as ‘unfavourable; declining’. All Annex II species have been assessed as ‘unfavourable: unclassified’, with the exception of otter, which has been assessed as ‘favourable; maintained’<sup>4</sup>.

The Crowhill drought order hydrologically impacted reach only affects management unit 1 of the SAC which contains the following features: brook lamprey, river lamprey, sea lamprey, bullhead, otter, and *Ranunculus* habitat which is a key habitat within unit 1. Bullhead are reported to be present in particularly high numbers upstream of Haverfordwest within the impacted reach.

A number of other environmentally sensitive or notable species are listed in the Western Cleddau River SSSI citation. Additional fish species present, but which are not designated include: sea trout *Salmo trutta*, non-migratory brown trout *Salmo trutta*, European eel *Anguilla Anguilla*, 3-spined stickleback *Gasterosteus aculeatus*, minnow *Phoxinus phoxinus* and stone loach *Barbatula barbatula*.

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<sup>4</sup> Countryside Council for Wales (2008) *Core Management Plan Including Conservation Objectives*, Cleddau Rivers SAC. 14 April 2008.

The rare invertebrate cased caddis *Ylodes simulans* and an aging population of the nationally scarce European protected species freshwater pearl mussel *Margaritifera margaritifera* have been recorded in the Western Cleddau River SSSI, however these are not designated features of the SSSI<sup>5</sup>.

### **D.2.2 Assessment**

The hydrological assessment has identified a potential reduction of up to 50% in extreme low flows has been identified as a result of the drought order. This would lead to corresponding reductions in wetted width and wetted depth of the river cross-section downstream of the Crowhill intake to the tidal limit for the duration of the drought order. Potential reductions in flow velocities and maximum water depths of up to 60% and 34% respectively have been estimated as a result of the drought order. At very low flows, there is a risk of increased sedimentation downstream of the abstraction intake due to the drought order but there is only a small distance to the tidal limit where this impact will arise. The hydrological impact in this reach will be **moderate**. In addition, there would be **minor** risks of impacts to water quality with regard to soluble reactive phosphorus, ammonia, and dissolved oxygen (see **Appendix B**).

The Annex 1 habitat ‘watercourses of plain to montane levels with the *Ranunculus fluitantis* and *Callitriche-Batrachion* vegetation’ is present within the impacted reach and is considered to be at **minor** risk of short-term deterioration as a result of the Crowhill drought order. The impacts on the macrophyte community present within the impacted reach is discussed in Section D.3.1.

The fish community present within the impacted reach includes river lamprey, brook lamprey, sea lamprey and bullhead (the Annex II species for which the SAC has been designated), along with brown/sea trout, European eel and other species of fish, and are considered to be at **minor** to **major** risk of short-term deterioration as a result of the Crowhill drought order. The impacts on the fish community are identified in Section D.3.3. Therefore, based on the implementation of the drought order assessed as posing up to a major adverse impact on the species for which the site is designated, the overall impact on the Cleddau Rivers SAC/Western Cleddau SSSI is assessed as **major adverse**.

Otter are reported to be present within the impacted reach. Due to the limited length of the reach (1.27km) compared to the large size of its available habitat and home range, and considering that there would be no anticipated material change to prey availability, the risk of impact on otter is considered to be **negligible**.

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<sup>5</sup> Countryside Council for Wales (2003) Site of Special Scientific Interest Citation: Western Cleddau River.

## Summary

The potential impacts of the Crowhill drought order on designated sites are summarised in **Table D2.1**. 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 designated sites. The impacts presented in **Table D2.1** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

**Table D2.1 Summary of Impacts on Designated Sites**

Feature	Impact	Significance of Impact
<b>Reach 1 – Western Cleddau</b>		
Cleddau Rivers SAC / Western Cleddau SSSI	<ul style="list-style-type: none"> <li>The impacts of the drought order on the macrophyte habitats for which the sites are designated have been assessed as minor.</li> <li>Impacts on river lamprey, brook lamprey, and sea lamprey, and bullhead (Annex II species for which the SAC has been designated) have been assessed as moderate to major.</li> <li>No adverse effects of the drought order are likely on otter.</li> </ul>	<b>Major</b>

## **D3 WFD STATUS AND COMMUNITY ASSESSMENT / NOTABLE SPECIES**

### **D.3.1 Macrophytes**

#### **Baseline**

No baseline macrophyte monitoring information was received from NRW within the reaches subject to hydrological impact. Baseline macrophyte surveys were undertaken for Welsh Water in August 2017 consisting of the collection of macrophyte data from a 100 metre stretch. Survey locations and results are provided in **Table D3.1**.

Macrophyte results were provided using the standard LEAFACS2 methodology<sup>6</sup> 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 LEAFACS2 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
- (iv) Percentage cover of all green filamentous algal taxa over the whole of the surveyed river sections (ALG).

**Table D3.1 Macrophyte survey results for the Crowhill Drought Order, 2017**

Site details		Indices				Environmental Variables	
Reach	Site Location (NGR, downstream extent)	RMNI	NTAXA	NFG	ALG	Total % Cover of Macrophytes	Total % cover of filamentous algae
1	SM9532316543	6.29	5.0	4.0	0.0	10	0

<sup>6</sup> WFD-UKTAG (2014) UKTAG river assessment method – macrophytes and phytobenthos (River LEAFACS2).



**Table D3.1** provides a summary of RMNI, NTAXA, NFG and ALG 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. 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.

The RMNI score recorded in Reach 1 of the Western Cleddau measured 6.29 and indicative of mesotrophic to eutrophic conditions, which is to be expected for a lowland reach of river towards the downstream end of the catchment. Macrophyte diversity was low, with 5 taxa recorded. Whilst macrophyte cover was fairly low (10%), filamentous algae was absent from the site.

#### Notable Macrophyte Communities

The Cleddau Rivers SAC core management plan<sup>7</sup> identified that *Ranunculon fluitantis* and *Callitricho-Batrachion* vegetation is present within management unit 1 which is impacted by the Crowhill drought order. As a precautionary approach it is assumed that this habitat is present within the impacted reach.

The Western Cleddau contains the CB4 'smaller meso-eutrophic rivers *Ranunculus* community'. The dominant species typically associated with this community type are water crowfoot species *Ranunculus penicillatus* ssp. *pseudofluitans* and the bryophytes *Fontinalis antipyretica* and *Rhynchostegium riparioides*. Other species frequently present include starworts *Callitriche hamulata*, *C. platycarpa*, and *C. stagnalis*, and water milfoil *Myriophyllum alterniflorum*. However, this community is very variable in its nature and is susceptible to impacts due to eutrophication<sup>8</sup>.

Macrophytes in the Western Cleddau catchment have been surveyed at two sites on the Western Cleddau below the Spittal Brook confluence and at one site on the Cartlett Brook<sup>9</sup>. The closest site to Crowhill on the Western Cleddau was at its confluence with the Camrose Brook (NGR SM941188), where nine CB4 and nine CB5 macrophyte species were recorded, both above the thresholds of four and five species respectively for CB4 and CB5 habitat types proposed by Hatton-Ellis and Grieve (2003). The site surveyed on the Cartlett Brook (NGR SM981180) recorded similar species diversity per habitat type, with eight CB4 and nine CB5 species found in 2001-02.

<sup>7</sup> Countryside Council for Wales (2008) *Core Management Plan Including Conservation Objectives*, Cleddau Rivers SAC. 14 April 2008.

<sup>8</sup> Hatton-Ellis TW & Grieve N (2003). *Ecology of Watercourses Characterised by Ranunculon fluitantis and Callitricho-Batrachion Vegetation*. Conserving Natura 2000 Rivers Ecology Series No. 11. English Nature, Peterborough.

<sup>9</sup> Grieve, N., Clarke, S., Caswell, B. and Newman, J.R. (2003). *Macrophyte surveys of the Cleddau rivers and selected tributaries*. Rothamsted Research Centre for Aquatic Plant Management report to Countryside Council for Wales, CCW Contract Science Report No. 578



Important stands of the habitat have been identified in the lower reaches of the Western Cleddau main river below Welsh Hook, at Wolf's Castle and at Pont Llangwarren.

## **Assessment**

Assessment is based on a worst-case scenario of a sensitive *Ranunculon fluitantis* and *Callitricho-Batrachian* community being present within the impacted reach.

*Callitricho-Batrachian* communities are characteristic of flowing water conditions and are commonly associated with riffles and stable gravel and/or pebble substrates. The effects of flow are of great importance to macrophyte communities and will determine which plants occupy specific locations within the river channel, since different plants are morphologically adaptable to specific flow types by characteristics such as anchoring strength<sup>10</sup>. Reduction in extreme low flows could reduce the overall extent of habitat favoured by lotic species present within the study area and favour those species more adapted to lentic and marginal / riparian conditions. The reduction in extreme low flows may also favour the proliferation of filamentous or epiphytic algae species due to changes in velocity and water temperature. A reduction in wetted width as a result of the drought order could result in a loss of flow sensitive species and an increase in cover by marginal species.

The minor risk to water quality deterioration (notably the temporary increase in soluble reactive phosphorous concentration) associated with the impacted reach could encourage macrophyte growth and increase the occurrence of more opportunistic taxa, epiphytes and filamentous algae. In turn, this could reduce species diversity if slower growing species or those that prefer lower nutrient conditions are outcompeted.

The drought order could be implemented from August to November, which coincides with the latter months of the macrophyte growing season and could therefore result in a decline in the condition of sensitive slow growing species such as *Ranunculon* communities, resulting in a short term deterioration of the macrophyte community.

Although the proposed drought option would exacerbate the low flow impacts for the duration of its implementation (4 months), this would be temporary, impacting one growing season, with normal flows and velocities being restored thereafter. Hydrological impacts are assessed as moderate during August and September and negligible during October and November. The overall significance of impacts on the macrophyte community as a result of the Crowhill drought order has been assessed as **minor** adverse during August and September. Impacts outside the growing season are assessed as **negligible**.

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<sup>10</sup> Environment Agency Wales (2007). Afonydd Cleddau Habitats Directive Review of Consents Stage 3B Licence Review Document. October 2007.

## Summary

The potential impacts of the Crowhill drought order on the macrophyte community are summarised in **Table D3.2**. 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 D3.2** represent the worst case impacts of implementing the drought order, over and above the impacts potentially caused by a natural drought.

**Table D3.2 Summary of Impacts on Macrophyte Community**

Feature	Impact	Significance of Impact
<b>Reach 1 – Western Cleddau</b>		
Macrophytes	<ul style="list-style-type: none"> <li>• Reduction in growth or condition as a result of impacts on water levels and flows</li> <li>• Reduction in abundance and distribution of taxa sensitive to nutrient enrichment (SRP)</li> <li>• Alteration to community composition as a result of changes in water levels and water quality, including proliferation of filamentous algae</li> </ul>	<b>Minor</b> (August-September only)
<i>Ranunculus fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation	<ul style="list-style-type: none"> <li>• Reduction in growth or condition as a result of impacts on water levels and flows</li> <li>• Alteration to community composition as a result of changes in water levels and water quality</li> <li>• Sedimentation of riffle/cobble habitat</li> </ul>	<b>Minor</b> (August-September only)

The macrophyte element of the W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) WFD waterbody is currently classified as Good in the interim 2018 cycle 2. There is a risk of short-term deterioration in status of the macrophyte component of the W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) waterbody due to the drought order. Impacts of drought order implementation on the macrophyte communities of the impacted reaches have been summarised as minor adverse, short-term, temporary and reversible. Consequently, the macrophyte component of these waterbodies is considered to be at **minor** risk of short-term deterioration.

## **D.3.2 Macroinvertebrates**

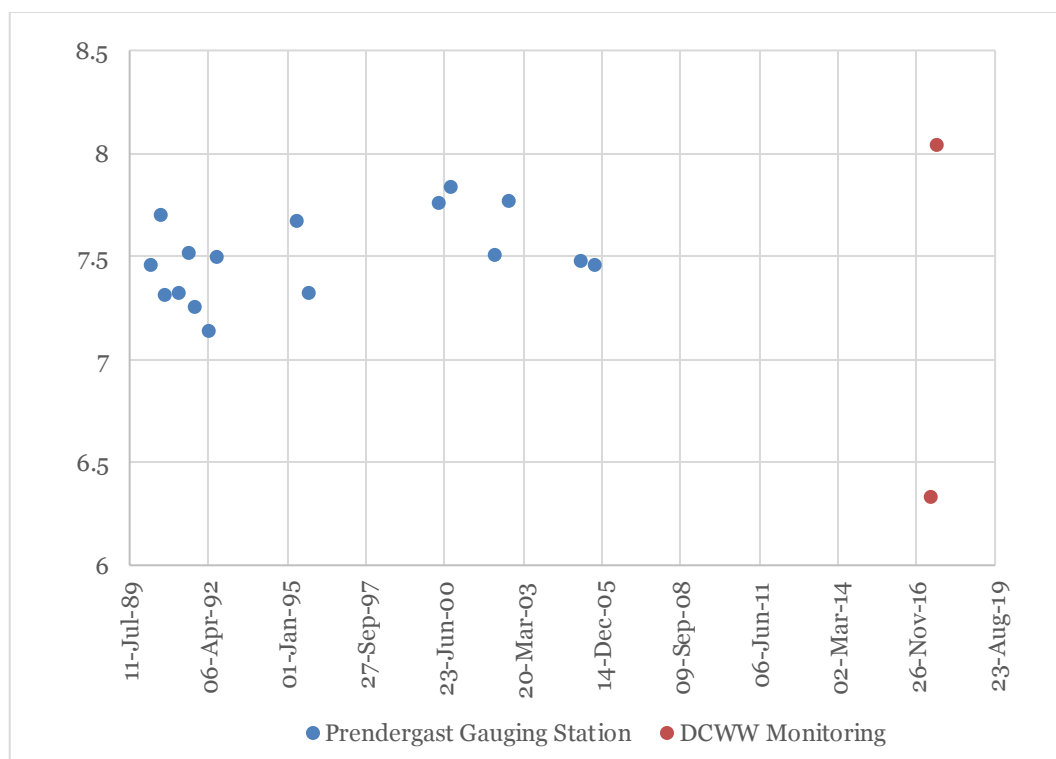
### **D.3.2.1 Baseline**

Baseline macroinvertebrate data for Reach 1 was limited to two DCWW sites sampled on two occasions in 2017 (spring - 30/05/2017 and autumn - 19/09/2017). The spring survey was located in the lower reaches of the Western Cleddau, near the A487 road crossing (NGR: SM9531215995). The autumn survey site was located near the Crowhill abstraction intake weir (NGR: SM9532916837). Historic data was limited to a single monitoring site approximately 1km upstream of the impacted reach at the Prendergast Gauging station (see **Figure D1.1**).

Samples were collected in spring (March to May), summer (June to August) and autumn (September to November) in various years between 1990 and 2005 by Environment Agency Wales (now part of NRW) as part of the biological component of their General Quality Assessments and WFD assessments.

The BMWP, ASPT and LIFE scores recorded at the Prendergast Gauging site and the 2017 monitoring sites are presented in **Figures D3.1-3.3**.

**Figure D3.1 LIFE Scores for the survey sites associated with the Crowhill drought order**

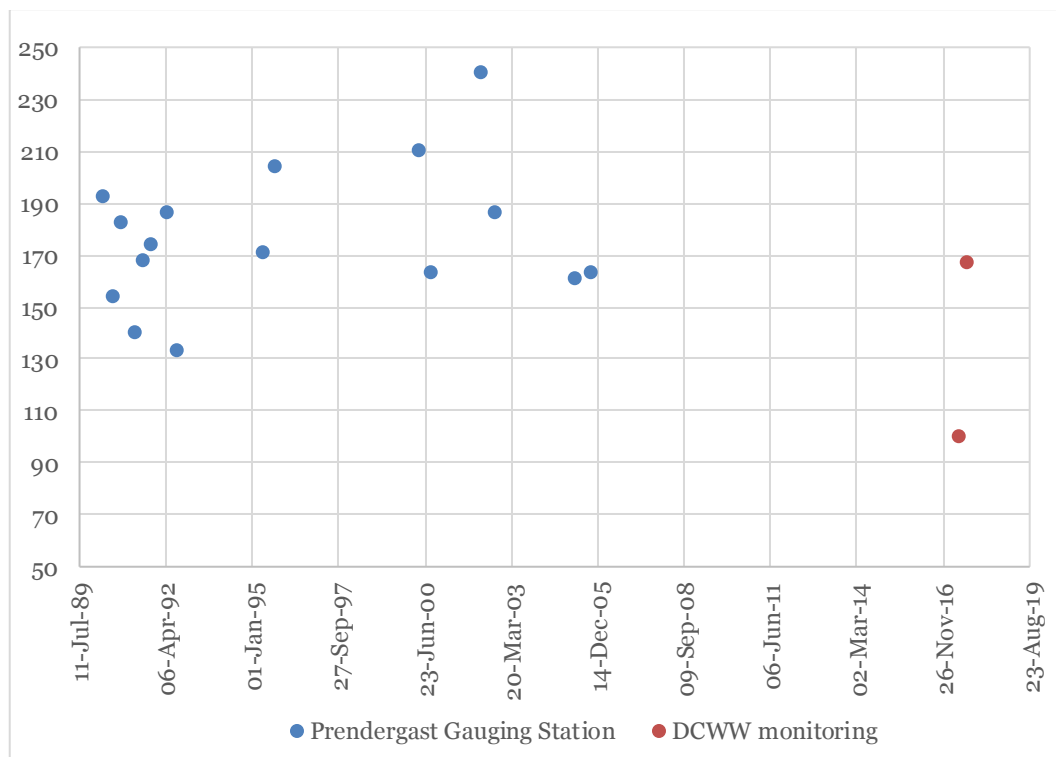


The 2017 surveys were undertaken in two different locations within Reach 1, potentially highlighting spatial and/or temporal variation between the spring and autumn surveys. The spring survey was undertaken in the lower reaches of the river where the Town Weir (NGR: SM 95541 15577) potentially impounds flow, resulting in a community indicative of slower flowing conditions compared to the autumn survey undertaken approximately 1km upstream where flow impoundment effects are believed to be reduced. During the spring survey, the community was numerically dominated by pollution tolerant taxa, such as non-biting midges (Chironomidae), aquatic worms (Oligochaeta) and the invasive New Zealand mud snail (*Potamopyrgus antipodarum*). Many of the species within the most numerically abundant groups have a preference for slow flows or standing water, although species with preferences for moderate to fast flows were also present. The autumn survey site was located

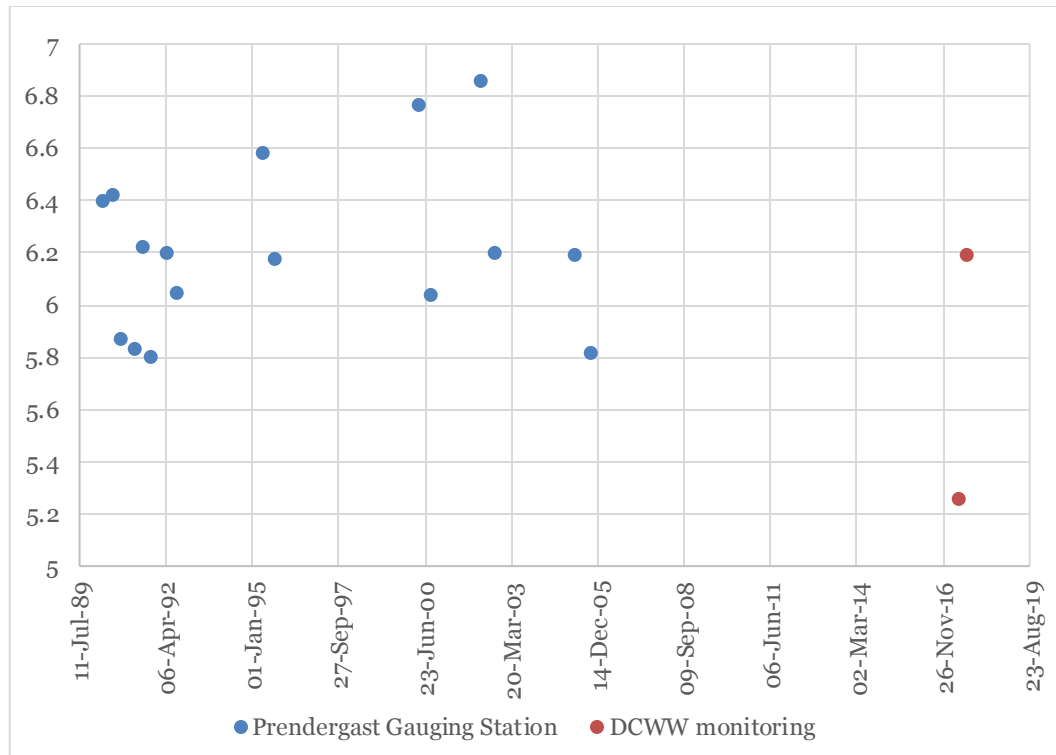
approximately 1km upstream of the spring sample and contained a diverse species assemblage including mayflies (Ephemeroptera), adult riffle-beetles (Elmidae) and freshwater shrimp (*Gammarus* sp.), indicative of a community associated with moderate to fast flows.

LIFE scores calculated from the data collected upstream of Reach 1 at Prendergast Gauging Station range from 7.14 to 7.84, with an average score of 7.5. The average LIFE scores observed at the Prendergast Gauging station indicate the presence of invertebrate families that favour relatively high velocity habitats. Although the data from the Prendergast gauging station can provide an indication of the communities likely to be present within the impacted reach, the most recent sample data available for this site are ten years old making any conclusions less reliable.

**Figure D3.2 BMWP Scores for the survey sites associated with the Crowhill drought order**



**Figure D3.3 ASPT for the survey sites associated with the Crowhill drought order**



BMWP and ASPT scores in Reach 1 in 2017 ranged from 100 to 167 and 5.26 to 6.19 respectively. These scores are indicative of a community associated with good water quality.

The BMWP scores calculated from samples collected upstream of Reach 1 at the Prendergast gauging station range from 133 to 240 which indicates a community associated with very good water quality. The ASPT scores range from 5.8 to 6.9 which are indicative of moderate to good water quality. The BMWP and ASPT scores indicate the presence of invertebrate families that favour clean water with high oxygen levels. The composition and abundance of the macroinvertebrate communities at the sampling locations are indicative of high diversity with a peak count of 35 families recorded in 2002. Although the data from the Prendergast gauging station can provide an indication of the communities likely to be present within the impacted reach, the data available from this site are ten years old making any conclusions less reliable.

Overall, the results indicate that the macroinvertebrate community is indicative of a community associated with good to high water quality with a high abundance of pollution sensitive taxa present. As such, adverse impacts on water quality as a result of a drought order would be likely to have an adverse impact on the macroinvertebrate community.

#### Notable Benthic Macroinvertebrates

The Western Cleddau River SSSI citation identified two notable invertebrates: the cased caddis *Ylodes simulans*, and the nationally scarce European protected species freshwater pearl

mussel *Margaritifera margaritifera*<sup>11</sup>. *Ylodes simulans* is classed as rare under the Red List pre-1994 IUCN guidelines. This category applies to taxa with small populations that are not at present Endangered or Vulnerable, but are at risk (in the UK, this was interpreted as species which exist in fifteen or fewer 10km squares). This species is included in LIFE flow group two and as such is associated with slow flows. No data is available on the distribution of the species within the Western Cleddau SSSI, as a precautionary approach it is assumed to be present within the impacted reach.

Although freshwater pearl mussel are identified as being present within the catchment by the SSSI citation, an NRW assessment on conservation status for freshwater pearl mussel in the period 2007 to 2012<sup>12</sup> states that on the Western Cleddau all mussels were taken from the river and placed into captivity in 2006, so this population is effectively extinct. As a result this species is not been considered further for assessment.

The macroinvertebrate data available for this site were only available to family level and as a result no other notable species were identified.

#### **D.3.2.2 Assessment**

For Reach 1, operation of the drought order is predicted to result in a 50% reduction of the summer (August to September) Q<sub>99</sub> flow, resulting in a moderate hydrological impact. Flow impacts correspond to an estimated reduction of up to 60% in flow velocities and up to 34% in maximum water depth. Hydrological impacts are assessed as negligible during October-November.

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 autumnal months of the drought order 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. Baseline data from Reach 1 describes a macroinvertebrate community with a mixed sensitivity to reduced flows, potentially dependent on spatial distribution within the reach as determined by the effect on flow caused by the Town Weir.

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

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<sup>11</sup> Countryside Council for Wales (2003) Site of Special Scientific Interest Citation: Western Cleddau River.

<sup>12</sup> Natural Resources Wales (2013) Supporting documentation for the Third Report by the United Kingdom under Article 17 on the implementation of the European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) from January 2007 to December 2012: Conservation status assessment for S1029 - Freshwater pearl mussel. (*Margaritifera margaritifera*)

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.

Typically, invertebrate communities can recover rapidly from short term flow impacts as a result of immigration from upstream habitats, such as those recorded shortly upstream at the Prendergast Gauging Station survey site. 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.

The water quality assessment has identified a minor risk of deterioration to the ammonia concentration, dissolved oxygen saturation, and soluble reactive phosphorus in Reach 1. This may manifest as a small reduction in pollution sensitive taxa in this reach over the short term.

Overall, the impact on the macroinvertebrate community in Reach 1 is assessed as **minor adverse** during September, due to a temporary loss of habitat under extreme low flows, and **negligible** during the period October-November.

No delay to recovery of flows have been identified at the cessation of the drought order and consequently the risk of continued impact beyond the drought order period on macroinvertebrates is considered to be negligible.

#### Notable Benthic Macroinvertebrates

*Ylodes simulans* may be impacted by a reduction in extreme low flows due to changes in velocity and loss of marginal habitat, potentially exposing eggs, pupae and larvae. No impacts to adults are anticipated as they are terrestrial during this stage. The LIFE flow group assigned to the species indicates that larvae have a preference for slow flows as such will not be sensitive to reductions in flow rates. The impacts are not considered significant against the background of a natural drought which will have already reduced available habitat and flows. The impacts of *Ylodes simulans* are therefore assessed as **minor**.

#### Summary

The potential impacts of the Crowhill drought order on the macroinvertebrate community are summarised in **Table D3.3**. 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 D3.3** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

#### **Table D3.3 Summary of Impacts on Macroinvertebrate Community**

Feature	Impact	Significance of Impact
<b>Reach 1 – Western Cleddau</b>		
Macroinvertebrates	<ul style="list-style-type: none"> <li>Reduction in species diversity and abundance as a result of reduced recruitment.</li> <li>Reduction in species diversity as a result of the loss of flow-sensitive taxa</li> <li>Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats</li> </ul>	<b>Minor</b> (August-September only)
Notable Species: Cased caddis <i>Ylodes simulans</i>	<ul style="list-style-type: none"> <li>Loss of marginal habitat and exposure of eggs, pupae and larvae.</li> </ul>	<b>Minor</b> (August-September only)

The macroinvertebrate element of the W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) WFD waterbody is currently classified as High in the interim 2018 cycle 2. There is a risk of short-term deterioration in status of the macroinvertebrate element of the W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) waterbody due to the drought order.

Impacts of drought order implementation on the macroinvertebrate communities of the impacted reaches have been summarised as minor adverse, short-term, temporary and reversible. Consequently, the macroinvertebrate component of these waterbodies is considered to be at **minor** risk of short-term deterioration.

### **D.3.3 Fish**

#### **D.3.3.1 Baseline**

The Western Cleddau River within the potential hydrological zone of influence is located within the Cleddau Rivers SAC. The Annex II fish species that are a primary reason for selection of this site are brook lamprey *Lampetra planeri*, river lamprey *Lampetra fluviatilis* and bullhead *Cottus gobio*. Sea lamprey *Petromyzon marinus* are also included in the citation as an Annex II species present as a qualifying feature, but not a primary reason for site selection.

The predicted hydrological zone of influence is limited in extent (1.27km), however, it is located immediately upstream of the tidal limit with potential implications in terms of the migration of diadromous species including the Annex II species already mentioned as well as, for example, Atlantic salmon *Salmo salar* and sea trout *Salmo trutta*.

Information regarding fish populations within the 1.27km hydrological zone of influence on the Western Cleddau is limited due to its short length and the practicalities of monitoring a channel of this size. Following the recommendation of further fisheries monitoring in the hydrological impact zone of the Western Cleddau, Welsh Water commissioned APEM to



undertake a number of surveys in 2017<sup>13</sup>. Surveys consisted of a single semi-quantitative electric fishing surveys on the Western Cleddau in the uppermost reaches of Reach 1 and two lamprey specific surveys (each survey targeted optimal and sub-optimal habitats). Due to the excessive width and depth of the channel in Reach 1, the full width of the river could not be fished effectively, therefore surveys were timed (catch per unit effort methodology). In addition to the data collected in 2017, data is available from surveys carried out further upstream in the catchment (above Reach 1) providing an additional insight into the likely species assemblage within Reach 1.

No NRW data from routine fisheries monitoring are available for the short reach of hydrological impact. Data up to 2018 from three sites, WC20, WC21 and WC22<sup>14</sup>, were provided by NRW as part of a data request for this study. These monitoring sites are located upstream of the hydrological zone of influence, but provide a useful insight into the likely species assemblage in addition to the 2017 APEM survey data.

Lamprey-specific monitoring undertaken as part of the SAC condition assessment process was undertaken in 2014 and 2015 with one site within the hydrological zone of influence.

Condition assessment of the River Cleddau SAC features carried out in 2008 by CCW<sup>15</sup> revealed that all listed fish species were in unfavourable condition: unclassified (i.e. not enough survey data available to undertake an accurate assessment).

‘Principal’ salmon rivers (numbering 64 in England and Wales) are assessed annually with the most recent report<sup>16</sup> published in 2016. The Rivers Eastern and Western Cleddau are classified as a (combined) 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 Eastern and Western Cleddau are classified as currently ‘At risk’ (<5% probability of

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<sup>13</sup> Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2017 – Crowhill - July 2018

<sup>14</sup> River Western Cleddau at: WC20 (Site ID 31084) located at SM9539917711 (immediately upstream of the Crowhill intake); WC21 (Site ID 61103) located at SM9594723019 (~4km upstream); and WC22 (Site ID 61123) located at SM9451719829 (~10km upstream).

<sup>15</sup> CCW (2008). Core Management Plan Including Conservation Objectives for Afonydd Cleddau / Cleddau Rivers SAC (Special Area of Conservation). Version: 8 (Minor map edit, August 2012). Date: 14 April 2008

<sup>16</sup> Cefas, 2017. Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2015. Preliminary assessment prepared for ICES, April 2018.

meeting the management objective) with a predicted classification of 'At risk' in 2022. The Eastern and Western Cleddau rivers in 2017 attained only 48% of their CL. Whilst this is the highest level achieved since 2012, it remains below the MT for the watercourses.

These classifications are significant for this assessment as they highlight the current and ongoing vulnerability of the Atlantic salmon population in the Cleddau rivers catchment. Maintaining migratory corridors and spawning and nursery areas for Atlantic salmon is recognised as particularly important.

The weir at the tidal limit of the Western Cleddau (SM 95543 15575) in Haverfordwest, known as Town Weir, was made passable to the range of fish species present in 2003 with the installation of a super-active bottom baffle fish pass. The efficiency and operational flow range of this fish pass is unknown and it is therefore assumed that it functions effectively for the full range of migratory species present between  $Q_{90}$  and  $Q_{10}$  in line with requirements of the Environment Agency Fish Pass Manual. The pass is unlikely to function efficiently at extreme low flows (e.g. below  $Q_{95}$ ) as there is unlikely to be enough flow running through the pass for it to work effectively.

The 'W. Cleddau - Anghof conf to Cartlett Brook conf' waterbody (GB110061031340) was assessed as being at Good status for fish in 2009 and 2015. The 2018 cycle 2 interim classification assessed the fish element for the waterbody as Moderate<sup>17</sup>.

The available data are sufficient to provide a general understanding of the likely fish assemblage in the hydrological zone of influence. Due to the difficulties surrounding the effective monitoring of fish population dynamics in the hydrological impact zone, a certain level of caution is applied to the assessment of the impact of the drought order over and above a natural drought. This was highlighted in the drought order Environmental Monitoring Plan (EMP) for River Western Cleddau at Crowhill (SW3)<sup>18</sup>. The following baseline summary is a based on available data along with expert judgment.

### Species Composition

Fish survey data specific to the hydrological zone of influence is limited to one semi-quantitative timed run survey in 2016 (NGR location: SM 95328 16839) and a number of lamprey-specific surveys carried out intermittently between 2004 and 2017.

The surveys carried out in Reach 1 in 2017 contained Atlantic salmon (fry life stage only), brown trout, minnow, flounder *Platichthys flesus*, juvenile sea lamprey and brook/river lamprey (unable to identify the difference between the two species at the ammocoete life stage).

<sup>17</sup> Interim cycle 2 2018 status - Based on Natural Resources Wales 2018 Cycle 2 Interim Classification Data - [https://drive.google.com/file/d/14w17jLo5sNuToV ELqMCK\\_y c6 DdHU7 STb/v iew](https://drive.google.com/file/d/14w17jLo5sNuToV ELqMCK_y c6 DdHU7 STb/v iew)

<sup>18</sup> Cascade (2007). DCWW. Provision of an Environmental Monitoring Plan. Environmental Monitoring Plan for River Western Cleddau at Crowhill (SW3). Final. 13th June 2007. Produced for DCWW by Cascade in association with APEM.

In addition to the data collected in Reach 1 in 2017, other species which are considered likely to be present based on survey data collected upstream of Reach 1 include bullhead, European eel *Anguilla anguilla*, three-spined stickleback *Gasterosteus aculeatus* and stone loach *Barbatula barbatula*.

Due to the lack of previous fish population survey data collected in Reach 1, an accurate indication of temporal trends in any of these populations in Reach 1 cannot be made, except for lamprey which are discussed below along with a brief summary of the available data.

### Lamprey Species

**Table D3.4** summarises the lamprey data resulting from lamprey-specific monitoring at site W1 (SM 95272 16207) and Site C1-1 (SM 95328 16839) in 2017 within the hydrological zone of influence. Monitoring was undertaken by APEM in 2004<sup>19,20</sup> and NRW in 2012, 2014 and 2015. For perspective, the mean density threshold to denote favourable condition status in SAC lamprey populations for river and brook lamprey ammocoetes is >10 per m<sup>2</sup> <sup>21</sup>. This threshold was exceeded on all sampling occasions between 2004 and 2015 (density measurement was unavailable for the 2017 APEM surveys) including sub-optimal habitat with the exception of 2015. A wide size range was also recorded suggesting successful recruitment over a number of years.

**Table D3.4 Summary lamprey density estimates (fish per m<sup>2</sup>) from monitoring undertaken at site W1 within Reach 1, 2004-2015 only**

Year	Optimal (OP) or sub-optimal (SO) habitat	Density (N <sup>o</sup> /m <sup>2</sup> )	Size range (mm)
2004	N/A	16	Unknown
2012	OP	48	43 - 130
	SO	19	79 - 116
2014	N/A	10	35 - 130
2015	OP	17	42 - 120
	SO	5	18 - 120

The most recent survey in 2017 recorded a total of three sea lamprey (ammocoete and transformer life stages) in the sub-optimal habitat only. Brook/river lamprey were also recorded in both optimal and sub-optimal habitats. This is the only recorded presence of sea lamprey in fish surveys in the Western Cleddau. This is of particular significance, as the Afonydd Cleddau SAC Condition Assessment<sup>22</sup> states there are ‘no records of adult migrating sea lamprey’ in the Western Cleddau. This record clearly highlights the importance of the

<sup>19</sup> Cascade (2007). Provision of an Environmental Monitoring Plan. Environmental Monitoring Plan for River Western Cleddau at Crowhill (SW3). Final. 13th June 2007. Produced for DCWW by Cascade in association with APEM.

<sup>20</sup> APEM (2005). Lamprey Survey on the Rivers Tywi, Teifi and Cleddau. Review of Consents Report No. 7.

<sup>21</sup> 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.

<sup>22</sup> NRW (2013) Second Reporting Cycle Condition Assessments – Afonydd Cleddau.

habitats present within the hydrological zone of impact to the spawning and development of sea lamprey.

The 2007 EMP reported that brook and river lamprey ammocoetes '*were evenly distributed across most of the [Western Cleddau] catchment where suitable habitat was available*' which is supported by the results of the 2017 surveys recording brook/river lamprey ammocoetes in Reach 1. Brook and river lamprey spawning grounds tend to be located further upstream than sea lamprey but spawning in the lower reaches of rivers is known to occur amongst all three species. The presence of these juvenile life stages indicates the two species are indeed likely to spawn within the hydrological zone of impact.

### Bullhead

Bullhead were not recorded in Reach 1 in 2017, however, due to the difficulty in sampling the deeper areas of the river channel, it cannot be assumed they are completely absent from Reach 1. The species were recorded at NRW site WC21 located approximately 4km upstream of the hydrological zone of influence, highlighting their presence in the watercourse. The 2007 EMP reported that bullhead were well-distributed throughout the Western Cleddau catchment.

### Atlantic Salmon

The 2015 NRW Cleddau Rivers salmon and sea trout report<sup>23</sup> states juvenile salmon abundance in 2015 achieved Grade D (Fair – in the bottom 40% for a fishery of this type) (site WC17 located ~15km upstream of Reach 1). The 2007 EMP stated that juvenile Atlantic salmon (fry and parr) densities were generally low across the catchment (generally Grade D or E<sup>24</sup>), although good densities were recorded at isolated sites. HABSCORE results suggested that juvenile Atlantic salmon habitat was limited across the catchment. It is assumed that the hydrological zone of influence provides an essential migratory corridor but that spawning and development of juveniles is likely to occur further upstream of Reach 1 due to the generally deep, slow flowing nature of the short, impacted reach not being particularly suitable for these life stages of salmonids. This rationale is supported by the low number of salmon recorded in 2017 in Reach 1 (a single salmon fry recorded) and 2015 at NRW site WC20 (located immediately above the hydrological zone of influence) and the higher densities recorded upstream at sites WC21 and WC22 (~5km and ~10km upstream of Reach 1 respectively).

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<sup>23</sup> Natural Resources Wales, 2015. Know Your River – Cleddau Rivers Salmon and Sea Trout Catchment Summary

<sup>24</sup> 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).

### Brown / Sea Trout

The 2015 NRW Cleddau Rivers salmon and sea trout report<sup>25</sup> states juvenile trout abundance in 2015 achieved Grade C (Fair – in the middle 20% for a fishery of this type) (site WC17 located ~15km upstream of Reach 1). The 2007 EMP states that juvenile brown/sea trout densities showed significant variation across the catchment, with NFC Grades from A to F (high to absent). HABSCORE results suggested that juvenile brown / sea trout habitat was limited across the catchment<sup>4</sup>. Similar to Atlantic salmon (outlined above), it is assumed that the hydrological zone of influence provides an essential migratory corridor but that spawning and development of juveniles is likely to occur further upstream of Reach 1 due to the generally deep, slow flowing nature of the impacted reach not being particularly suitable for these life stages of the salmonids. This rationale is supported by the low number and proportion of juvenile brown/sea trout (a single brown trout parr recorded) compared to the adult life stages (three adult brown trout recorded) recorded in Reach 1 in 2017.

### Other Species

Low densities of flounder and minnow were recorded in 2017 in Reach 1. Due to the difficulty in effectively fishing the deep channel associated with Reach 1, the distribution of species recorded upstream of Reach 1, including European eel and the other minor species is unknown, however, all are likely to be present in low densities.

### Data Limitations

Due to the difficulty in effectively sampling the deep channel of the Western Cleddau in its lower reaches at Haverfordwest, there is some uncertainty surrounding the status of the fish population in Reach 1, particularly those which favour the deeper areas of the river.

The precautionary principle has therefore been used in the following assessment which is based on a conservative approach assuming that in addition to the species recorded in Reach 1 in 2017, the species recorded upstream of the hydrological zone of impact are likely to be present during certain periods of the year.

### Ecological Value of Fisheries Receptors

Brook, river and sea lamprey and bullhead are Annex II species that are a primary reason for selection of the Cleddau Rivers SAC and are considered to be of international importance. Atlantic salmon are an Environment Act (Wales) Section 7 Species and Habitats Directive Annex II species and are considered to be of national importance. Brown / sea trout (Environment Act (Wales) Section 7 Species) and European eel (Environment Act (Wales) Section 7 and IUCN Red List ‘Critically Endangered’ species) are also considered to be of

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<sup>25</sup> Natural Resources Wales, 2015. Know Your River – Cleddau Rivers Salmon and Sea Trout Catchment Summary

National importance. Minnow, flounder, three-spined stickleback and stone loach are considered to be of site only importance.

#### **D.3.3.2 Assessment**

For Reach 1, operation of the drought order is predicted to result in a 50% reduction of the summer (August to September)  $Q_{99}$  flow, resulting in a moderate hydrological impact. Flow impacts correspond to an estimated reduction of up to 60% in flow velocities and up to 34% in maximum water depth. Hydrological impacts are assessed as negligible during October-November.

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 watercourse reduces the wetted area and volume with the potential for subsequent impacts on fish populations. Such impacts can result in increased competition for optimal habitat and food<sup>26,27</sup>, reduced reproductive success, growth and condition<sup>28</sup>. There is also the potential for significant impacts on the migrations of diadromous fish species, particularly those where flow is a primary migratory cue.

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. migration and juvenile life stages) most susceptible during the likely summer impact period (August to November).

#### **Brook, River and Sea Lamprey**

##### *Migration of River and Sea Lamprey*

Mature river lamprey migrate upstream into freshwater in the autumn (from October to December<sup>29</sup>); outside of the drought order impact period. River lamprey ammocoetes metamorphose after three to five years in freshwater and then descend to estuarine and marine environments between July and September in smaller rivers<sup>Error! Bookmark not defined.</sup>, coinciding with the drought order implementation period. Upstream migration requires a reasonable flow of water to aid passage past natural and non-natural in-channel barriers. Low flows may hinder downstream passage, leaving this life stage exposed to higher risks of predation and ultimately a reduction in recruitment. Under extreme low flows ( $\leq Q_{99}$ ) there is

<sup>26</sup> 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

<sup>27</sup> 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.

<sup>28</sup> 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.

<sup>29</sup> Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. *Conserving Natura 2000 Rivers Ecology Series No.5*. English Nature, Peterborough

the potential for more severe impacts on migration, particularly at Town Weir which, under these conditions, is likely to constitute a barrier to downstream migration. This would result in delayed and/or reduced migration to sea, thereby increasing mortality due to increased predation and stress, ultimately reducing escapement in the Western Cleddau. The impact on river lamprey migration is therefore considered to be **major adverse** from August to September in Reach 1.

Mature sea lamprey migrate upstream into freshwater in April and May prior to spawning; outside of the drought order implementation period. Sea lamprey ammocoetes metamorphose after approximately five years in freshwater and then descend to marine environments between July to September<sup>30</sup>, coinciding with the implementation of the drought order. Similar to river lamprey, under extreme low flows, significant impacts on downstream migration may occur at Town Weir in particular, and combined with the national importance and scarcity of the species in the catchment, the impact on downstream sea lamprey migration is considered to be **major adverse** from August to September in Reach 1.

#### *Spawning and Juvenile (ammocoete and transformer) Brook, River and Sea Lamprey Habitat*

Impacts on geomorphological processes associated with a reduction in flow have the potential to impact lamprey spawning habitat. River lamprey spawn in March to April; outside of the drought order implementation period. A reduction in river levels and wetted width could pose a particular significant risk to juvenile (ammocoetes and transformer) lamprey habitat which tends to consist of silt in shallow, marginal areas. There is the potential for a loss or degradation of this habitat along with gravel spawning 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 then increase. The impact on juvenile lamprey habitat is therefore considered to be **moderate adverse** from August to September in Reach 1.

#### *Water Quality*

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

#### Atlantic Salmon

##### *Atlantic Salmon Migration*

The Western Cleddau within the hydrological zone of influence is an essential migratory

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<sup>30</sup> Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No.5. English Nature, Peterborough

pathway for Atlantic salmon (both upstream-migrating adults and out-migrating smolt and kelt). The upstream migration of adult Atlantic salmon is linked primarily to increased flow and can occur over the period June to December and therefore a drought order in the summer/autumn (August to November) has the potential to impact their entry to the Western Cleddau. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature; outside of the drought order implementation period. Minimum flows are required for upstream migrating fish to negotiate barriers such as weirs, and fish passes (like the pass located at Town Weir at the downstream end of Reach 1) to operate effectively. Very low flows are likely to delay migration and potentially prevent adult fish from accessing the Western Cleddau, thereby increasing mortality due to increased predation and stress, and limiting recruitment upstream. This may be a significant issue at Town Weir in Haverfordwest (the tidal limit), however, the drought order only impacts the very lowest flows (i.e.  $Q_{99}$ ) when Atlantic salmon are unlikely to migrate with or without a drought order. The impact on extreme low river flows ( $Q_{99}$ ) in Reach 1 has been assessed as being moderate adverse and the impact on Atlantic salmon migration over and above that of a natural drought is considered to be **minor adverse** from August to September in Reach 1.

#### *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 any reduction in available habitat and delays to migration to increase stress and subsequent loss of condition. Atlantic salmon are susceptible to poor water quality, particularly dissolved oxygen and extremes of water temperature. Water quality impacts have been assessed as minor adverse and the impact on Atlantic salmon is therefore considered to be **minor adverse** in Reach 1, due to a potential reduction in water quality.

#### *Atlantic Salmon Juvenile and Spawning Habitat*

There is the potential for reduced flow to result in a decrease in river levels, wetted width and velocity. 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. Due to the likely timing of the drought order, gravels containing alevins and / or early-stage fry (likely to occur in April and May) would not be affected. However, the available data suggest that habitat within the hydrological zone of influence is not optimal for Atlantic salmon spawning and fry/parr habitat is limited in extent; therefore impacts are likely to be limited. The impact on juvenile Atlantic salmon and spawning habitat is therefore considered to be **minor adverse** in Reach 1.



## Bullhead

The species is known to be sensitive to a reduction in flow and water quality associated with implementation of the drought order, which may have a limited impact on bullhead populations. Bullhead are likely to be abundant throughout the Western Cleddau catchment, however, the generally deep, slow-flowing habitat present within the hydrological zone of influence does not constitute optimal habitat. Spawning and egg incubation takes place from March to May; outside of the drought order implementation period. The impact on bullhead is therefore considered to be **minor adverse** in Reach 1.

## Brown / Sea Trout

### *Sea Trout Migration*

The Western Cleddau within the hydrological zone of influence is known to be an important migratory pathway for sea trout (both upstream-migrating adults and out-migrating smolt). The majority of sea trout migration into the Western Cleddau is likely to occur from September to November, coinciding with the drought order implementation period. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature; outside of the drought order implementation period. Minimum flows are required for upstream migrating fish to negotiate barriers such as weirs, and fish passes (like the pass located at Town Weir at the downstream end of Reach 1) to operate effectively. Very low flows are likely to delay migration and potentially prevent adult fish from accessing the Western Cleddau, thereby increasing mortality due to increased predation and stress, and limiting recruitment upstream. This may be a significant issue at Town Weir in Haverfordwest (the tidal limit), however, the drought order only impacts the very lowest flows (i.e.  $Q_{99}$ ) when sea trout are unlikely to migrate with or without a drought order. The impact on extreme low river flows ( $Q_{99}$ ) in Reach 1 has been assessed as being moderate adverse and the impact on Atlantic salmon migration over and above that of a natural drought is considered to be **minor adverse** from August to September in Reach 1.

### *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 and delays to migration 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 the particularly sensitive juvenile life stages. Water quality impacts have been assessed as minor adverse and the impact on brown / sea trout is therefore considered to be **minor adverse** in Reach 1.

### *Juvenile Brown / Sea Trout*

There is the potential for reduced flow to result in a decrease in river levels, wetted width and

velocity. 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. Due to the likely timing of the drought order, gravels containing alevins and / or early-stage fry (likely to occur in April and May) would not be affected. However, the available data suggest that habitat within the hydrological zone of influence is not optimal for brown/sea trout spawning and fry/parr habitat is limited in extent; therefore impacts are likely to be limited. The impact on juvenile brown/sea trout and spawning habitat is therefore considered to be **minor adverse** in Reach 1.

### European Eel

Elver enter rivers in early spring and a general upstream migration occurs throughout the course of the year. Elver migration is not linked to periods of increased flow, with low flow conditions unlikely to impact migration. The downstream migration of mature (silver) eel tends to occur between September and December, coinciding with the drought order implementation period. European eel of a wide age range are likely to be present in low densities throughout the Western Cleddau catchment, however, the species is considered to be tolerant of high temperatures, relatively poor water quality and is resilient to drought conditions. The impacts on European eel are therefore considered to be **minor** in Reach 1.

### Other Fish Species

Minnow, stone loach and three-spined stickleback spawning and egg incubation occurs within the August to September period for drought order implementation. Whilst all of these species typically spawn in late spring/summer, any late spawning may be adversely impacted by the impacts associated with a reduction in flow. However, the habitat within the hydrological zone of influence is not optimal for these species as the river in this reach is generally deep and slow-flowing. Juvenile flounder (recorded in Reach 1 in 2017) typically enter brackish/fresh water in spring to feed and develop into adults. A reduction in habitat availability due to the impacts associated with low flows are likely to result in flounder being susceptible to increased predation risks and mortality. The impact on other fish species is considered to be **minor adverse** in Reach 1.

### Summary

The potential impacts of the Crowhill drought order on the fish community are summarised in **Table D3.5**. 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 D3.5** represent the worst case impacts of implementing the drought order, over and above the impacts potentially caused by a natural drought.

**Table D3.5 Summary of Impacts on Fish Community**

Feature	Impact	Significance of Impact
<b>Reach 1 – Western Cleddau</b>		
River lamprey	<ul style="list-style-type: none"> <li>• Migration of juvenile river lamprey and transformer life stages affected or halted by a reduction in flow</li> </ul>	<b>Major</b>
Sea lamprey	<ul style="list-style-type: none"> <li>• Migration of juvenile sea lamprey and transformer life stages affected or halted by a reduction in flow</li> </ul>	<b>Major</b>
Brook, river and sea lamprey	<ul style="list-style-type: none"> <li>• Loss of juvenile habitat as a result of reduced flow related impacts</li> </ul>	<b>Moderate</b>
	<ul style="list-style-type: none"> <li>• Reduced water quality</li> </ul>	<b>Negligible</b>
Atlantic salmon	<ul style="list-style-type: none"> <li>• Delays and potential cessation of adult migration due to reduced flows</li> </ul>	<b>Minor</b>
	<ul style="list-style-type: none"> <li>• Reduced water quality</li> </ul>	<b>Minor</b>
	<ul style="list-style-type: none"> <li>• Loss of spawning and juvenile habitat as a result of reduced river levels</li> </ul>	<b>Minor</b>
Bullhead	<ul style="list-style-type: none"> <li>• Reduction in spawning and juvenile survival and an increase in adult mortality due to habitat loss.</li> </ul>	<b>Minor</b>
Brown / sea trout	<ul style="list-style-type: none"> <li>• Delays and potential cessation of adult migration due to reduced flows.</li> </ul>	<b>Minor</b>
	<ul style="list-style-type: none"> <li>• Reduced water quality</li> </ul>	<b>Minor</b>
	<ul style="list-style-type: none"> <li>• Reduction in spawning and juvenile survival due to habitat loss.</li> </ul>	<b>Minor</b>
European eel	<ul style="list-style-type: none"> <li>• Habitat loss and reduced water quality</li> </ul>	<b>Minor</b>
Other fish species	<ul style="list-style-type: none"> <li>• Habitat loss and reduced water quality</li> </ul>	<b>Minor</b>

The fish element of the W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) WFD waterbody is currently classified as Moderate in the interim 2018 cycle 2. There is a risk of short-term deterioration in status of the fish element of the W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) waterbody 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 **minor risk** of short-term deterioration.

## **D.3.4 Phyto**benthos****

### **D.3.4.1 Baseline**

No baseline diatom monitoring information was received from the NRW, within the reaches subject to hydrological impact.

### **D.3.4.2 Assessment**

Impacts on the diatom assemblages of the Western Cleddau within hydrological Reach 1 could occur due to the operation of the drought order, including changes in community composition due to: decreases in velocity; 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, diatom communities can respond to rapidly to environmental change and a response in diatom community composition to the reduction in flows due to the drought order would be expected.

WFD EQR metrics for diatoms (TDI4 in DARLEQ)<sup>31</sup> are designed to detect differences in nutrient levels, particularly SRP. Implementation of the drought order is expected to result in minor impacts to SRP, which in turn may affect the diatom community and associated WFD status. Impacts on the diatom community are likely to be **minor adverse**, short term, temporary and reversible.

Due to the rapid response of diatom communities to environmental variables, this effect is expected to be short lived, with communities recovering rapidly following return to the normal hydrological regime, and therefore any effect of the drought order on WFD phytobenthos assessment is likely to be **minor**.

### Summary

The potential impacts of the Crowhill drought order on the diatom 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 diatom 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.

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<sup>31</sup> WFD-UKTAG(2014) Phytobenthos: Diatoms for Assessing River and Lake Ecological Quality (River DARLEQ2)

**Table D3.6 Summary of Impacts on Phytobenthos**

Feature	Impact	Significance of Impact
<b>Reach 1 – Western Cleddau</b>		
Phytobenthos	<ul style="list-style-type: none"> <li>• Changes to community composition due to changes in velocity</li> <li>• Changes to community composition and TDI4 scores due to increases in soluble reactive phosphorous</li> <li>• Increases in filamentous algae smothering the substrate.</li> </ul>	<b>Minor</b>

The diatom element of the W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) WFD waterbody is currently classified as Good in the interim 2018 cycle 2. There is a risk of short-term deterioration in status of the diatom element of the W Cleddau - Anghof conf to Cartlett Brook conf (GB110061031340) waterbody due to the drought order. Impacts of drought order implementation on the diatom communities of the impacted reaches have been summarised as minor adverse, short-term, temporary and reversible. Consequently, the phytobenthos component of these waterbodies is considered to be at **minor** risk of short-term deterioration.