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Energy & Environment

Dŵr Cymru Welsh Water

Environmental Assessment of Canaston Drought Order (8206-8)

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NON-TECHNICAL SUMMARY

INTRODUCTION AND PURPOSE OF THIS REPORT

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

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

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

Canaston intake is located downstream of Llys-y-Fran Reservoir 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. Water from Llys-y-Fran reservoir discharges into the Afon Syfynwy, a tributary of the Eastern Cleddau. Both rivers are components of the Afonydd Cleddau / Cleddau Rivers Special Area of Conservation (SAC) and the Eastern Cleddau Special Site of Scientific Interest (SSSI) 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 Canaston, 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 Welsh Ministers for a drought order to vary the conditions of its abstraction licence from Canaston intake downstream of Llys-y-Fran reservoir.

If granted, the drought order involves the relaxation of two parts of the abstraction licence: (1) a proposed 50% reduction in the hourly flow rate downstream of the Canaston intake which triggers the requirement to ensure that the hourly rate of discharge from Llys-y-Fran Reservoir equals or exceeds the hourly abstraction rate, and; (2) a relaxation of the seasonal flow-related limits on daily abstraction which normally apply during the months of October to December inclusive. The combined effect of these two relaxations would reduce the requirement for regulation releases such that releases are only triggered once the abstraction would cause flow downstream of the intake to fall below 34.1 Ml/d.

Whenever the flow downstream of the authorised point of abstraction is below 34.1 Ml/d, the drought order will have no impact on the need to regulate, nor on the flows downstream of the intake. However, the drought order will reduce the threshold for regulation releases being required.

The flow reduction (which will be limited to no more than the maximum hourly rate of abstraction), due to reducing the need to make regulation releases, will conserve the longevity of reservoir storage and improve the probability of reservoir winter refill. The drought order scheme will influence the Afon Syfynwy downstream of Llys-y-Fran Reservoir outfall and its continuation as the Eastern Cleddau River until the tidal limit.

The drought order is most likely to occur during the late summer/early autumn period, considered to not extend outside the period August to November. This has been confirmed by Welsh Water by water resources modelling. The assessment has therefore considered potential impacts during the summer months of August to September and the winter months of October to November.

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

NEED FOR THE DROUGHT ORDER

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

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

ALTERNATIVE SOURCES CONSIDERED

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

POTENTIAL IMPACTS OF DROUGHT ORDER IMPLEMENTATION

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

Summary of the Hydrological Assessment

The assessment has concluded that there is a **major-moderate** impact on flows in the Afon Syfynwy and Eastern Cleddau as a result of implementing the drought order. These hydrological impacts are assessed as leading to **moderate** impacts on the physical environment of the river, including water quality.

Summary of the Environmental Features Screening

Environmental assessment is required and included for features where screening has identified a major or moderate impact.

Screening identified designated sites, WFD status and Community Assessment / Environment Act (Wales) Section 7 Species, invasive fauna, archaeology and recreation as environmental features for which an environmental assessment was required. The assessment has concluded that there are **major** impacts on the Eastern Cleddau SSSI, fish, macroinvertebrates and macrophytes and minor impacts on phytoenthos.

The HRA Screening could not conclude that implementation of a drought order would not result in likely significant effects on the brook and river lamprey and bullhead populations and macrophyte within the Cleddau Rivers SAC. The HRA Screening could also not concluded that the drought order would not result in likely significant effects on the estuaries, Atlantic salt meadows, mudflats and sandflats not covered by seawater at low tide, sea and river lamprey and allis and twaite shad 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 Canaston intake

MITIGATION AND MONITORING

The environmental assessment has identified significant impacts of implementation of a drought order at Canaston intake. Consequently, in line with the DPG, an

Environmental Monitoring Plan has been proposed. Potential mitigation measures have also been proposed and further discussion with NRW is required in order to develop suitable mitigation measures.

CONCLUSIONS

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

Contents

Non-Technical Summary

1	Introduction	1
1.1	Purpose of the Environmental Assessment	1
1.2	Supporting Studies.....	2
1.3	Consultation.....	3
1.4	Structure and Content of the Report	3
2	Background to the Drought Order.....	4
2.1	Welsh Water's Supply System.....	4
2.2	Description of Existing Arrangements at Canaston Intake	5
2.3	Welsh Water's Drought Planning Process	9
2.4	Statement of the Need for Drought Order	9
2.5	Drought Order– Regulatory Arrangements	9
2.6	Review of Alternative Options	10
2.7	Proposed Drought Order Details	10
2.8	Drought Order Programme	12
2.9	Drought Order Baseline.....	13
3	Approach.....	14
3.1	Introduction.....	14
3.2	Approach to Screening and Scoping.....	15
3.3	Approach to Assessing Impacts, Mitigation and Monitoring.....	19
3.4	Limitations of the Assessment and Uncertainties	22
4	Canaston Drought Order - Hydrology and the Physical Environment	23
4.1	Introduction.....	23
4.2	Summary of Stage 1 Screening.....	23
4.3	Summary of Potential Effects on the Physical Environment	24
5	Canaston Drought Order Environmental Features Assessment	27
5.1	Introduction.....	27
5.2	Summary of Stage 2 Screening and Scoping	27
5.3	Features Assessment.....	31
6	Canaston Drought Order– Mitigation.....	42
7	Cumulative Impacts	44
8	Canaston Drought Order - Summary of Residual Impacts.....	46
9	Habitats Regulations Assessment: Stage 1 Screening	47
9.1	Introduction.....	47
9.2	Stage 1 Screening of Canaston Drought Order	48
10	Environmental Monitoring Plan (EMP).....	64
10.1	Introduction.....	64
10.2	Basis of the EMP	64
10.3	Monitoring Recommendations.....	66
11	Conclusions	77

Appendix A – Hydrology and Hydrogeological Methodology

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). The drought order involves the relaxation of two parts of the abstraction licence: (1) a proposed 50% reduction in the hourly flow rate downstream of the Canaston intake which triggers the requirement to ensure that the hourly rate of discharge from Llys-y-Fran Reservoir equals or exceeds the hourly abstraction rate, and; (2) a relaxation of the seasonal flow-related limits on daily abstraction which normally apply during the months of October to December inclusive. The combined effect of these two relaxations would reduce the requirement for regulation releases such that releases are only triggered once the abstraction would cause flow downstream of the intake to fall below 34.1 Ml/d. The flow reduction will conserve the longevity of water storage at Llys-y-Fran Reservoir, used to provide public water supplies to Welsh Water's Pembrokeshire Water Resource Zone (WRZ) (see Section 2.1).

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

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

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

- the Afon Syfynwy - Llys-y-fran to confluence with Eastern Cleddau (GB110061030700)
- Eastern Cleddau - confluence with Syfynwy to tidal limit (GB110061030670).

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 Guideline¹ (DPG); specifically Section 5 and Appendices I and J, and Welsh Government / Defra / NRW / Environment Agency guidance on drought permits and drought orders².

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.

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

² Welsh Government / Defra / Natural Resources Wales / Environment Agency (2015) *Apply for a drought order or emergency drought order*. <https://www.gov.uk/government/collections/apply-for-a-drought-permit-drought-order-or-emergency-drought-order>. Accessed 21 December 2018.

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 NRW).

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

1.3 CONSULTATION

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

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

1.4 STRUCTURE AND CONTENT OF THE REPORT

This EAR comprises the following sections:

Section 1: Introduction

Section 2: Background to the Drought Order

Section 3: Approach

Section 4: Hydrology and the Physical Environment

Section 5: Environmental Features Assessment

Section 6: Mitigation

Section 7: Cumulative Impacts

Section 8: Summary of Residual Impacts

Section 9: Impacts on Statutory Designated Sites

Section 10: Environmental Monitoring Plan (EMP)

Section 11: Conclusions

2 BACKGROUND TO THE DROUGHT ORDER

2.1 WELSH WATER'S SUPPLY SYSTEM

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

Figure 2.1 Welsh Water Water Resource Zones

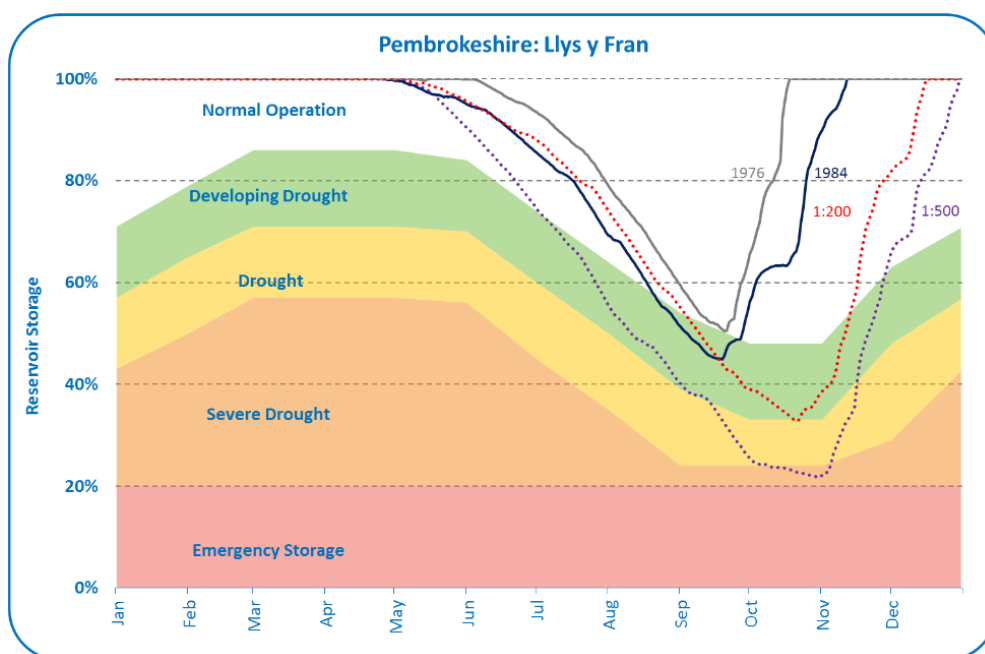


The Pembrokeshire WRZ covers the far south west corner of Wales, stretching from Pendine Sands in the east to the Pembrokeshire Coastal National Park in the west, and from the village of Manobier in the south to Fishguard in the north.

The trigger levels for applying for a drought order at Canaston 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 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 Drought Action Zones and Historic Droughts



2.2 DESCRIPTION OF EXISTING ARRANGEMENTS AT CANASTON INTAKE

Welsh Water owns and operates Llys-y-Fran Reservoir. The company is permitted to abstract up to 5.0Ml/d each day and 1825Ml/year from the reservoir (as per licence number 22/61/4/38V002). There are further restrictions on the abstraction linked to an upstream abstraction at Rosebush Reservoir (also known as Preseli Reservoir) (licence number 22/61/4/1) and a downstream abstraction at Canaston Intake on the Eastern Cleddau river (licence number 22/61/4/10) as set out below:

- The aggregate quantity of water abstracted from Llys-y-Fran and Preseli Reservoirs shall not exceed 5,909.8Ml/year
- The aggregate quantity of water abstracted from Llys-y-Fran Reservoir and at Canaston shall not exceed 25,000Ml/year
- The aggregate maximum daily quantity abstracted from Llys-y-Fran Reservoir and at Canaston shall not exceed a quantity determined from the volume of water available in Llys-y-Fran Reservoir in accordance with operating rules that have been agreed with Natural Resources Wales (NRW).

There are a number of additional conditions relating to the abstraction, as follows:

- Provision of a uniform statutory compensation water release to the Afon Syfynwy

of 13.64Ml/d at all times

- At the request of NRW, release up to 955Ml into the downstream watercourse (at a daily rate no greater than 68Ml/d) for the benefit of fisheries
- Release water into the Afon Syfynwy to support the abstractions at Canaston (authorised under licence number 22/61/4/10, described below).

Welsh Water may release water from the reservoir into the downstream Afon Syfynwy in order to support flows in the Eastern Cleddau River so that it can continue to abstract a routine amount of water at the downstream Canaston intake. The timing of such regulation releases are described below with reference to the Canaston abstraction licence, as follows:

- Welsh Water may abstract up to 85Ml/d and 25,000Ml/year at Canaston intake, downstream of Canaston Bridge.
- Abstraction may not occur if it were to cause the rate of flow in the river downstream of the abstraction to be reduced to less than 2.84Ml/hour (68.2Ml/d) as a hands off flow (HoF) condition, unless the rate of discharge from Llys-y-Fran Reservoir is equal to or greater than the hourly rate of abstraction
- As described above, Welsh Water may release water from Llys-y-Fran Reservoir (regulation releases) to support river flow during periods of low flow, so that routine abstractions are achieved without breach of the HoF.
- From April to June (inclusive) and October to December (inclusive), the maximum daily abstraction rate shall not exceed the values set out in **Table B1.1** if unsupported flow in the River Eastern Cleddau at the Canaston Bridge Gauging Station (gauged flow minus Llys-y-Fran reservoir releases plus abstractions at Pont Hywel) is within the specified ranges. Any abstraction in excess of these rates must be supported by regulation releases from Llys-y-Fran reservoir equating to the excess amounts.

Table 1.1 Flow-related seasonal daily abstraction limits

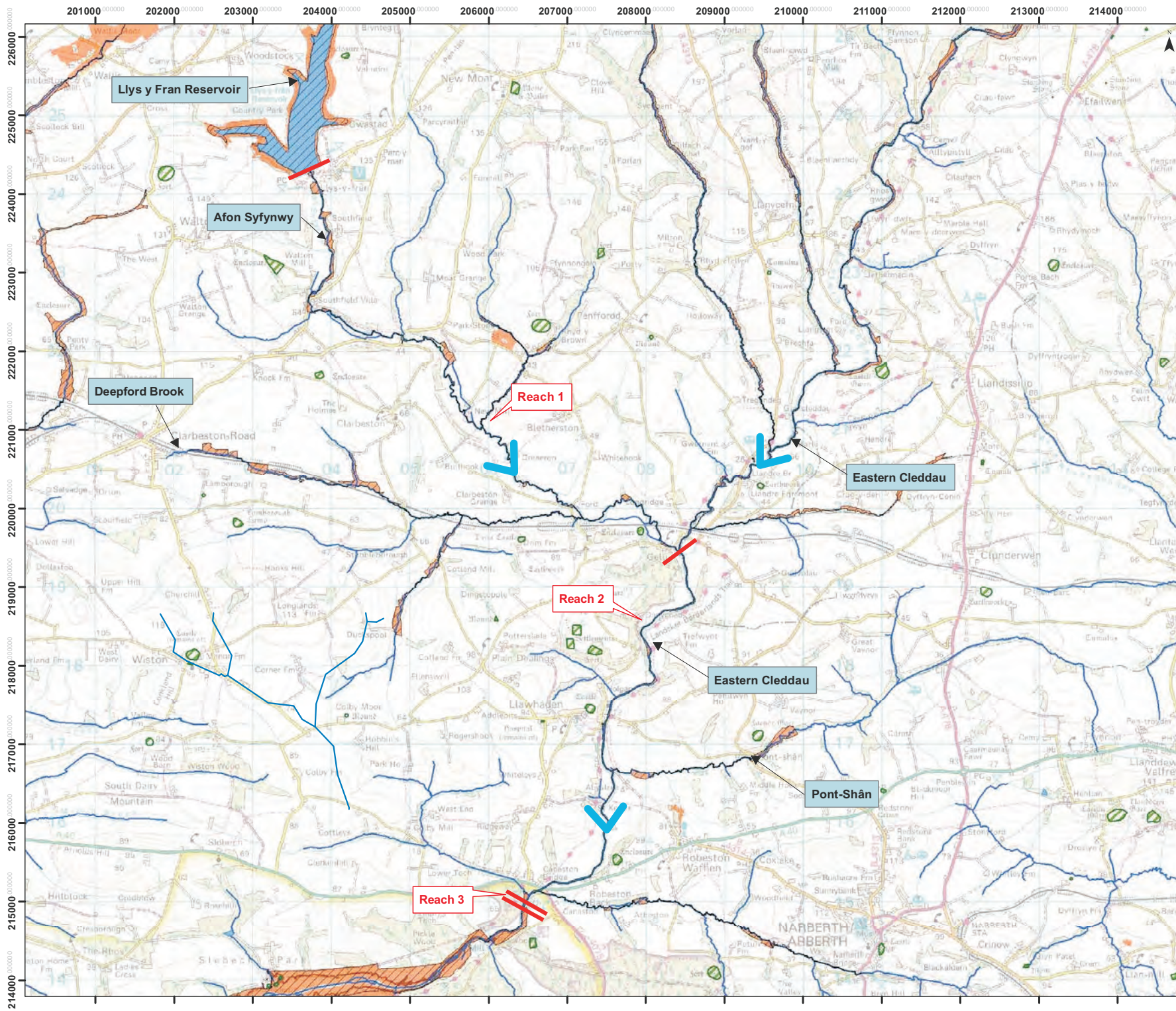
Unsupported flow in the Eastern Cleddau at Canaston Bridge Gauging Station (Ml/d)	Maximum daily abstraction (Ml/d)
Below 110.592	12.96
110.592 – 194.376	38.016
194.377 – 270.408	63.072

- At any time, the maximum hourly rate of abstraction and corresponding rate of discharge from Llys-y-Fran Reservoir shall be determined from the volume of water available in the reservoir in accordance with the reservoir operating rules.

- The aggregate quantity of water abstracted from Canaston, Llys-y-Fran Reservoir and Pont Hywel (licence number 22/61/4/3) shall not exceed 85Ml/d.

The Canaston licence conditions have been amended following a review of Welsh Water's abstractions by NRW under the environmental requirements of the EU Habitats Directive ("Review of Consents" process). The new licence conditions come into force on 31 March 2019 and therefore the drought option has been assessed relative to these new licence conditions, subject to the availability of hydrological data sets which currently do not include any periods with the new licence conditions in force.

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



- Legend**
- Water Courses
 - Reservoir
 - Hydrological Reach
 - Direction of Flow
 - Special Area of Conservation
 - Site of Special Scientific Interest
 - Scheduled Ancient Monuments



1:45,000
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: 8206-8
Canaston 50% reduction in HoF

Figure Number: Figure 2.3
Date: February 2019

2.3 WELSH WATER'S DROUGHT PLANNING PROCESS

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

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

4(b) for a revised drought plan –

if section 39B(6)(a) of the Act applies, within 6 months after the date on which the material change of circumstances occurs; and

if section 39B(6)(c) of the Act(c) applies, no later than 4 years after the date on which its drought plan, or its last revised drought plan, is published.

2.4 STATEMENT OF THE NEED FOR DROUGHT ORDER

This section will be completed at the time of application for a drought order.
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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 Canaston intake downstream of Llys-y-Fran Reservoir.

If granted, the drought order involves the relaxation of two parts of the abstraction licence: (1) a proposed 50% reduction in the hourly flow rate downstream of the Canaston intake which triggers the requirement to ensure that the hourly rate of discharge from Llys-y-Fran Reservoir equals or exceeds the hourly abstraction rate, and; (2) a relaxation of the seasonal flow-related limits on daily abstraction which normally apply during the months of October to December inclusive. The combined effect of these two relaxations would reduce the requirement for regulation releases such that releases are only triggered once the abstraction would cause flow downstream of the intake to fall below 34.1 Ml/d.

Whenever the flow downstream of the authorised point of abstraction is below 34.1 Ml/d, the drought order will have no impact on the need to regulate, nor on the flows downstream of the intake. However, the drought order will reduce the threshold for regulation releases being required.

The flow reduction (which will be limited to no more than the maximum hourly rate of abstraction), due to reducing the need to make regulation releases, will conserve the longevity of reservoir storage and improve the probability of reservoir winter refill. The drought order scheme will influence the Afon Syfynwy downstream of Llys-y-Fran Reservoir outfall and its continuation as the Eastern Cleddau River until the tidal limit.

The drought order is most likely to occur during the late summer/early autumn period, considered to not extend outside the period August to November. This has been confirmed by Welsh Water by water resources modelling. The assessment has therefore considered potential impacts during the summer months of August to September and the winter months of October to November.

Table 2.1 Canaston Existing and Proposed Drought Order Abstraction

Abstraction Water Source	NGR	Normal Abstraction	Proposed Drought Order Abstraction	Benefit ML/d
Canaston Intake	SN 0667615205	<p>Welsh Water licence (22/61/4/38) permits abstraction of up to 5ML/d each day and 765ML/year from Llys-y-Fran Reservoir. Further restrictions on the abstraction linked to downstream abstraction at Canaston (22/61/4/10) include:</p> <ul style="list-style-type: none"> The aggregate quantity of water abstracted from Llys-y-Fran Reservoir and at Canaston shall not exceed 25,000ML/year. The aggregate maximum daily quantity abstracted from Llys-y-Fran Reservoir and at Canaston shall not exceed a quantity determined from the volume of water available in Llys-y-Fran Reservoir in accordance with operating rules that have been agreed to by NRW. A statutory compensation flow release of 13.64 ML/d must be released from Llys-y-Fran Reservoir each day whenever regulation releases are not being made. <p>Welsh Water may release water from the reservoir into the downstream Afon Syfynwy in order to support flows in the Eastern Cleddau River so that it can continue to abstract a routine amount of water at the downstream Canaston intake (authorised under licence number 22/61/4/10). The timing of such regulation releases are as follows:</p> <ul style="list-style-type: none"> Welsh Water may abstract up to 85ML/d and 25,000ML/year at Canaston intake, downstream of Canaston Bridge. Abstraction may not occur if it were to cause the rate of flow in the river downstream of the abstraction to be reduced to less than 2.84ML/hour (68.2ML/d) as a hands off flow (HoF) condition, unless the rate of discharge from Llys-y-Fran Reservoir is equal to or greater than the hourly rate of abstraction As described above, Welsh Water may release water from Llys-y-Fran Reservoir (regulation releases) to support river flow during periods of low flow, so that routine abstractions are achieved without breach of the HoF. From April to June (inclusive) and October to December (inclusive), the maximum daily abstraction rate shall not exceed the values set out in Table B1.1 if unsupported flow in the River Eastern Cleddau at the Canaston Bridge Gauging Station (gauged flow minus Llys-y-Fran reservoir releases plus abstractions at Pont Hywel) is within the specified ranges. Any abstraction in excess of these rates must be supported by regulation releases from Llys-y-Fran reservoir equating to the excess amounts. 	<p>The drought order involves the relaxation of two parts of the abstraction licence: (1) a proposed 50% reduction in the hourly flow rate downstream of the Canaston intake which triggers the requirement to ensure that the hourly rate of discharge from Llys-y-Fran Reservoir equals or exceeds the hourly abstraction rate, and; (2) a relaxation of the seasonal flow-related limits on daily abstraction which normally apply during the months of October to December inclusive. The combined effect of these two relaxations would reduce the requirement for regulation releases such that releases are only triggered once the abstraction would cause flow downstream of the intake to fall below 34.1 ML/d.</p>	<p>Max benefit 36.36ML/d for short periods</p>

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

2.8 DROUGHT ORDER PROGRAMME

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

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

2.9 DROUGHT ORDER BASELINE

It is important for the assessment to establish the environmental "baseline" conditions that would exist in drought conditions but in the absence of the drought order being implemented. For the purposes of this assessment, the "without drought order" baseline includes the continuation of abstraction from Llys-y-Fran Reservoir and Canaston Intake on the Eastern Cleddau River in accordance with the licensed arrangements described below, including a flow condition which, when flows are below 68.2Ml/d downstream of the Canaston abstraction intake, requires an increase in the discharge from Llys-y-Fran Reservoir such that the rate of discharge is equal to or greater than the rate of abstraction from Canaston intake. The assessed drought order involves a 50% reduction (of 34.1Ml/d) in the flow condition and a relaxation of the seasonal flow-related limits on daily abstraction which normally apply during the months of October to December inclusive.

3 APPROACH

3.1 INTRODUCTION

The DPG states that the environmental report must include:

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

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

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

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

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

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

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

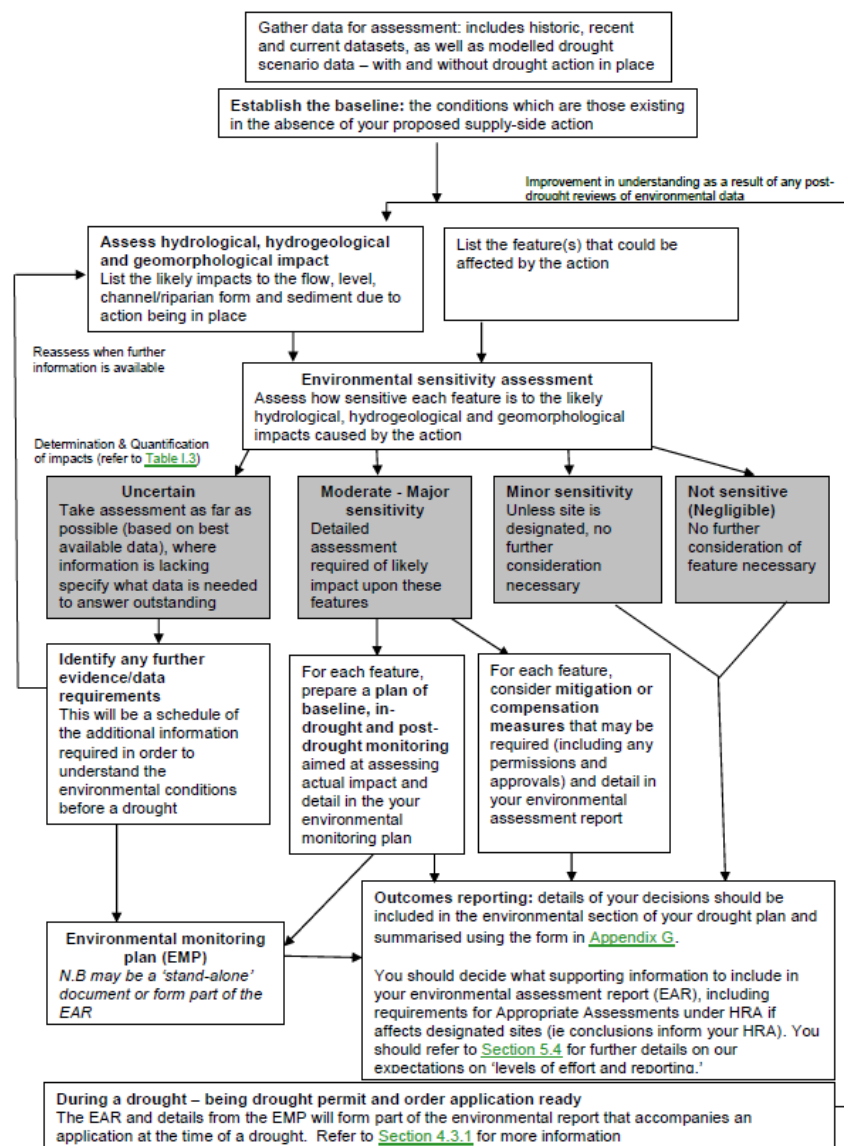
This is discussed further in Section 7.

3.2 APPROACH TO SCREENING AND SCOPING

3.2.1 Screening

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

Figure 3.1 Environmental Impact Activities Identified in the Drought Plan Guideline



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

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

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

Stage 1 – Hydrological and Hydrogeological Impact

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

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

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

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

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

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

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

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

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

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

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

Stage 2 - Environmental Sensitivity

With the extent and level of flow impact mapped, using GIS and other data sources, potentially sensitive receptors (sites / features) located within the extents of impact have been identified. Potentially sensitive features investigated in the screening have

been drawn from Box 1 in Appendix I of the DPG. These include:

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

As set out in **Figure 3.1**, the environmental sensitivity screening identifies the

outcome for each listed feature. Four outcomes are possible from the screening: uncertain; moderate-major sensitivity; minor sensitivity; not sensitive (negligible); and identifies appropriate next steps. Sections 4.2 and 5.2 present the findings which show that a number of features were identified as either: 1) uncertain; 2) moderate-major sensitivity; or 3) minor sensitivity in a designated site and in accordance with the DPG are features for which further assessment work will be required. These features alone form the scope of monitoring, environmental assessment, and consideration of mitigation actions.

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

3.3 APPROACH TO ASSESSING IMPACTS, MITIGATION AND MONITORING

3.3.1 General Approach

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

- NRW (2017) Water Company Drought Plan Technical Guideline (DPG)
- Welsh Ministers (2017) The Drought Plan (Wales) Direction
- Institute of Environmental Management and Assessment (2004) Guidelines for Environmental Assessment
- Chartered Institute of Ecology and Environmental Management (CIEEM) (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland³
- 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

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

- 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.

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

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

3.3.2 Assessment Methodologies

The aim of the Environmental Assessment is to provide:

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

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

The impact assessment for sensitive features is feature specific and is dependent on

the availability and resolution of available data. Where possible, quantitative assessments have been undertaken. However, for many features, it is acknowledged that the assessments are qualitative and based on professional judgement, and using, where relevant, experience of local knowledge and reference to literature. This introduces uncertainty into the impact assessment. A precautionary approach has been used to assigning impact significance where data are absent or found not to be robust.

The assessment of impacts on designated sites has been undertaken using professional judgement with reference to conservation objectives and condition status of habitats and species, for which a site has been designated. The ecological assessment has been undertaken recognising the IEMA^{4,5} and the CIEEM study guidelines⁶. The assessment of impacts on other environmental receptors e.g. recreation and landscape has been carried out largely by qualitative expert judgement.

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

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

3.3.3 Mitigation and Monitoring

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

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

The mitigation and monitoring proposals (see Sections 6 and 10) will act as a safeguard that responds and is responsive to both predicted and unpredicted drought impacts. Future data collection and monitoring can then be focused to identify the aquatic

⁴ IEMA (2004) Guidelines for Environmental Impact Assessment.

⁵ IEMA (2011) Special Report – The State of Environmental Impact Assessment Practice in the UK

⁶ CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland.

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

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

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

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

4 CANASTON 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 Llys-y-Fran Reservoir and its downstream catchment, consisting of the Afon Syfynwy and the Eastern Cleddau River, during the period of implementation of the drought order. The “without drought order” baseline is set out in Section 2.9.

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

1. It is used to “list likely changes in flow, level, channel/riparian form and sediment due to implementing the action’ as required by the DPG and set out in Figure 2 of the DPG
2. It is used to support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Section 5 of this report
3. Where sensitive features are the physical environment itself, it provides supporting technical information for their screening and assessment.

Each of these are summarised below.

4.2 SUMMARY OF STAGE 1 SCREENING

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

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

These requirements are addressed in the following sections.

1. The perceived extent of potential impact:

The study area (see **Figure 2.3**) the Llys-y-Fran reservoir, the Afon Syfynwy downstream of the reservoir and the Eastern Cleddau down to its tidal limit. Note that the impact on Llys-y-Fran Reservoir itself would be a marginal increase in water levels / storage volume, relative to the position without the drought order. This would be considered as a minor beneficial impact and has not been assessed further.

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 in Afon Syfynwy and the Eastern Cleddau .

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

3. The length of the potential impact:

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

4.3 SUMMARY OF POTENTIAL EFFECTS ON THE PHYSICAL ENVIRONMENT

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

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

Issue	Identified Impact
Afon Syfynwy (Reach 1)	
Flows in the Afon Syfynwy <i>Major impacts during the summer period August to September; moderate impacts during the winter period October to November</i>	<ul style="list-style-type: none"> Impacts to river flow (hydrology) in the reach downstream of Llys-y-Fran Reservoir have been assessed as potentially major during summer months (reduction in releases of up to 36.4Ml/d), but moderate during winter months (reduction in releases of up to 36.4Ml/d)
Water quality in the River Afon Syfynwy <i>Medium risk during period August-November</i>	<ul style="list-style-type: none"> Impacts to water quality in the reach downstream of Llys-y-Fran Reservoir have been assessed as medium risk for soluble reactive phosphorous, and low risk for ammonia and dissolved oxygen and.
Consented discharges <i>Negligible risk at any time of year</i>	<ul style="list-style-type: none"> These discharges are considered to have negligible pressure on the water environment during implementation of the drought order.
Eastern Cleddau (Reach 2)	
Flows in the Eastern Cleddau <i>Major impacts during the summer period August to September; moderate impacts during the winter period October to November</i>	<ul style="list-style-type: none"> Impacts to river flow (hydrology) in the reach downstream of the Afon Syfynwy confluence have been assessed as potentially major during summer months (reduction in releases of up to 36.4Ml/d), but moderate during winter months (reduction in releases of up to 36.4Ml/d)
Water quality in the River Eastern Cleddau <i>Medium risk during period August-November</i>	<ul style="list-style-type: none"> Impacts to water quality in the reach downstream of Llys-y-Fran Reservoir have been assessed as medium risk for soluble reactive phosphorous, and low risk for ammonia and dissolved oxygen and.
Consented discharges <i>Minor risk at any time of year</i>	<ul style="list-style-type: none"> The Narberth West STW discharges are considered to exert a minor pressure on the water environment during implementation of the drought order.
Eastern Cleddau (Reach 3)	
Flows in the Eastern Cleddau <i>Major impacts during the summer period August to September; moderate impacts during the winter period October to November</i>	<ul style="list-style-type: none"> Impacts to river flow (hydrology) in the reach downstream of the Canaston abstraction intake have been assessed as potentially major during summer months (reduction in residual flow of up to 36.4Ml/d, from 68.2Ml/d to 34.1Ml/d), but moderate during winter months (reduction in residual flow of up to 36.4Ml/d).
Water quality in the River Eastern Cleddau <i>Medium risk during period August-November</i>	<ul style="list-style-type: none"> Impacts to water quality in the reach downstream of Llys-y-Fran Reservoir have been assessed as medium risk for soluble reactive phosphorous, and low risk for ammonia and dissolved oxygen and.

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 CANASTON 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 Canaston 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)
Afon Syfynwy & Eastern Cleddau (Reaches 1-3)				
Afonydd Cleddau / Cleddau Rivers SAC / Eastern Cleddau Rivers SSSI	Major / Moderate	The Cleddau Rivers SAC / Eastern Cleddau Rivers SSSI is designated for <i>Ranunculus</i> community habitat, <i>Potamogeton berchtoldii</i> x <i>P. polygonifolius</i> and a range of important fish species, which are sensitive to flow and level changes in the Afon Syfynwy and Eastern Cleddau.	Major	Yes
Macrophyte community	Major / Moderate	Reduction in flows and level as a result of the drought order could reduce the overall extent of habitat availability for freshwater macrophytes in the study area.	Major	Yes
Notable Species – Macrophytes <i>Ranunculus</i> and <i>Chalico-Batrachion</i> communities <i>Potamogeton berchtoldii</i> hybrid with <i>P. polygonifolius</i>	Major / Moderate	These species often develop within specific hydraulic and nutrient conditions, and thus alteration as a result of a drought order would impact on the species, although the level of impact beyond that of a natural drought is uncertain.	Major	Yes
Macroinvertebrate community	Major / 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.	Major	Yes

Site/Feature and designation	Hydrological Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
Notable Species – Fish 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>	Major / 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 during October to December. 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.	Major	Yes
Phytobenthos community	Major / Moderate	The phytobenthos community is likely to be sensitive to changes in flow as a result of the drought order.	Moderate	Yes
Notable Species – Mammals Otter <i>Lutra lutra</i>	Major / Moderate	Otter are known to be present in the catchment. Implementation of the drought order is considered unlikely to lead to adverse effects on habitat or prey availability.	Negligible	No
Invasive Species – Himalayan Balsam <i>Impatiens glandulifera</i> Non-native flatworm <i>Dugesia tigrina</i>	Major / Moderate	Invasive plant species utilise flow of the watercourse for dispersal but are not reliant on it. Implementation of the drought order is unlikely to increase the risk of dispersal. Invasive non-native flatworm found on the Syfynwy and Eastern Cleddau.	Uncertain	Yes
Landscape and visual amenity	Major / Moderate	The Pembrokeshire Coast National lies less than 500m downstream of the zone of hydrological influence. As the flow and level impacts are assessed as negligible in Reach 3 no impacts on landscape and visual amenity are anticipated.	Negligible	No
Recreation	Major / Moderate	The Afon Syfynwy and Eastern Cleddau River provide numerous recreational opportunities including; angling, canoeing, kayaking, walking, cycling and bird watching.	Major	Yes
Archaeology	Major / Moderate	Several Scheduled Ancient Monuments are located within the proximity of the study area including a number of defence enclosures Walton Mill Rath, Knock Rath, Drim Camp and Gelly Earthwork but none are dependent on flows in Afon Syfynwy.	Uncertain	No

Site/Feature and designation	Hydrological Impact at Location (Major, Moderate, Minor)	Susceptibility to flow and level impacts	Sensitivity (Uncertain, Moderate/ Major, Minor, Negligible)	Further Consideration Required (Yes/No)
		A number of Scheduled Ancient Monuments are located within the proximity of the study area including Llawhaden Castle and Bridge. As the flow and level impacts are assessed as negligible in these reaches no impacts from implementation of the drought order are anticipated.		

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	Syfynwy - Llys-y-Fran to confluence with Eastern Cleddau (GB110061030700)		Eastern Cleddau – confluence with Syfynwy to tidal limit (GB110061030670)	
Hydrological Impact at Location (Major, Moderate, Minor, Negligible)	Major		Major	
Heavily Modified Waterbody (Y/N)	No		No	
RBMP Cycle	RBMP2 (2015) ⁷	2018 C2 Interim ⁸	RBMP2 (2015)	2018 C2 Interim
Overall Biological	Good	Moderate	Good	Moderate
Fish	Good	Good	Not classified	Not classified
Macrophytes	Not classified	Not classified	Not classified	Not classified
Phytobenthos	Not classified	Moderate	Not classified	Moderate
Macro-invertebrates	High	Good	Not classified	High
Total P/ Phosphate	Good	Moderate	High	Good
Ammonia	High	Good	High	High
Dissolved Oxygen	High	High	High	High
pH	High	High	High	High
Sensitivity (Uncertain, Moderate/ Major, Minor, Not sensitive)	Major		Major	
Further Consideration Required (Y/N)	Yes		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 Canaston drought order hydrological zone of impact. Each feature assessment describes the analyses carried out and a statement of the

⁷ NRW (2017) <https://drive.google.com/file/d/0B2hsDbbdxztZHIItRU9lNkg1YWw/view>.

⁸ NRW (2018) https://drive.google.com/file/d/14w17jLo5sNuToVELqMCK_yc6DdHU7STb/view.

assessed impact. All impacts are considered to be negative / adverse unless otherwise stated in the feature assessment. The approach is described in Section 3.3.

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

5.3.2 Summary of Features Assessment

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

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

Month		J	F	M	A	M	J	J	A	S	O	N	D
Cleddau Rivers SAC / Eastern Cleddau SSSI		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Pembrokeshire Marine SAC		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Afon Syfynwy (Reach 1)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Notable macrophyte species – <i>Ranunculus</i> communities		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Notable macroinvertebrate species – <i>Oulimnius troglodytes</i>		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
River lamprey	Spawning and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
	Upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Atlantic salmon	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Adult upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N			N/A
	Smolt migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Brown / sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Juveniles (habitat loss)	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
European eel		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Other fish species- Grayling, minnow, three spined stickleback and stone loach		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody fish status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Phy to benthos		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Invasive Species		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Recreation	Angling	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N			N/A
	Other recreational activities	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Archaeology		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Eastern Cleddau (Reach 2)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Notable macrophyte species – <i>Ranunculus</i> communities		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Notable macroinvertebrate species – <i>Metalyte fragilis</i>		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
River lamprey	Spawning and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Atlantic salmon	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Adult upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N			N/A

Month		J	F	M	A	M	J	J	A	S	O	N	D
	Smolt migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Brown / sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Juveniles (habitat loss)	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
European eel		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Other fish species - Grayling, minnow, three spined stickleback and stone loach		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody fish status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Phy to benthos		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Invasive Species		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Recreation	Angling	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N			N/A
	Other recreational activities	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Archaeology		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Eastern Cleddau (Reach 3)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Notable macrophyte species – <i>Ranunculus</i> communities		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Notable macroinvertebrate species – <i>Metalyte fragilis</i>		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
River lamprey	Spawning and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Atlantic salmon	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Adult upstream migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N			N/A
	Smolt migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Brown / sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Juveniles (habitat loss)	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Other fish species - Grayling, minnow, three spined stickleback and stone loach		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Risk to WFD waterbody fish status		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Phy to benthos		N/A	N/A	N/A	N/A	N/A	N/A	N/A					N/A
Invasive Species		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N/A
Recreation	Angling	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A	N/A
	Other recreational activities	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N			N/A
Archaeology		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N/A

Key to Environmental Effects:

N/A	Outside implementation period
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
Reach 1 – Afon Syfynwy Reaches 2 & 3 - Eastern Cleddau		
Cleddau Rivers SAC / Eastern Cleddau SSSI	<ul style="list-style-type: none"> The impacts of the drought order on the macrophyte habitats for which the sites are designated have been assessed as moderate-major 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 minor - major during the period October to January. No adverse effects of the drought order are likely on alluvial forest and active raised bog habitats nor on otter. 	Major
Pembrokeshire Marine SAC	<ul style="list-style-type: none"> Impacts on river and sea lamprey (qualifying feature of the SAC designation) have been assessed as major during the drought permit implementation period, however, the presence of populations in other rivers associated with the SAC reduce the impact significance. 	Moderate

5.3.4 WFD and Community Assessment

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

WFD Definitions

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

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

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

Moderate ecological status - the values of the biological quality elements for the surface water body type deviate moderately from those normally associated with the

surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.

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

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

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

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

The Environment Agency⁹ identify that a number of different factors need be considered when making an assessment of the ecological potential of HMWBs. Of primary importance is the need to put a specified range of mitigation measures in place to address the effects of the anthropogenic impact. Selected ecological quality elements may also be required to be at GES for the waterbody to be classified as GEP. Where the designated use includes for impacts on flow and flow-related mitigation measures the measured status of the fish and macroinvertebrate communities do not affect the classification of GEP.

Assessment

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

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

Macrophytes

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

Table 5.5 Summary of Impacts of Drought Order Implementation on Macrophytes

WFD Status/ Community	Impact	Significance of Impact
Sy fynwy - Llys-y-fran to confluence with Eastern Cleddau (GB110061030700) Current Status: Not assessed	Macrophyte status not assessed	N/A
Eastern Cleddau – confluence with Syfynwy to tidal limit (GB110061030670) Current Status: Not assessed	Macrophyte status not assessed	N/A
Feature	Impact	Significance of Impact
Reach 1 – Afon Syfynwy		
Macrophyte communities	<ul style="list-style-type: none"> Reduction in growth as a result of impacts on water levels and flows Alteration to community composition as a result of changes in water quality 	Major (August-September) Moderate (October-November)
Notable and designated SAC and SSSI species, including <i>Ranunculus</i> communities	<ul style="list-style-type: none"> Reduction in growth as a result of impacts on water levels and flows Alteration to community composition as a result of changes in water quality. 	Major
Reach 2 – East Cleddau Syfynwy conf – Canaston intake		
Macrophytes	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	Major (August-September) Moderate (October-November)
Notable and designated SAC and SSSI species, including <i>Ranunculus</i> communities	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	Major
Reach 3 – Eastern Cleddau Canaston intake – tidal limit		
Macrophytes	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	Major (August-September) Moderate (October-November)
Notable and designated SAC and SSSI species, including <i>Ranunculus</i> communities	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	Major

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
GB110061030700 Sy fynwy - Lly s-y-Fran to confluence with Eastern Cleddau Current status: Good	<ul style="list-style-type: none"> There is moderate a risk of short-term deterioration in the status of the macroinvertebrate component of the waterbody due to the major adverse, short-term, temporary and reversible impacts on the macroinvertebrate community 	Major
GB110061030670 Eastern Cleddau – confluence with Sy fynwy to tidal limit Current status: High	<ul style="list-style-type: none"> There is minor a risk of short-term deterioration in the status of the macroinvertebrate component of the waterbody due to the moderate adverse, short-term, temporary and reversible impacts on the macroinvertebrate community 	Major
Feature	Impact	Significance of Impact
Reach 1 – Afon Syfynwy		
Macroinvertebrate communities	<ul style="list-style-type: none"> Reduction in species diversity as a result of the loss of flow-sensitive taxa Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats 	Major
Notable species - <i>Oulimnius troglodytes</i>	<ul style="list-style-type: none"> Reduction in velocity/area of preferred habitat. 	Major
Reach 2 – East Cleddau Syfynwy conf – Canaston intake		
Macroinvertebrates	<ul style="list-style-type: none"> Reduction in species diversity as a result of the loss of flow-sensitive taxa Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats 	Major
Notable species - <i>Metalype fragilis</i>	<ul style="list-style-type: none"> Reduction in velocity/area of preferred habitat. Disruption to emergence and recolonisation 	Major
Reach 3 – Eastern Cleddau Canaston intake – tidal limit		
Macroinvertebrates	<ul style="list-style-type: none"> Reduction in species diversity as a result of the loss of flow-sensitive taxa Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats 	Major
Notable species - <i>Metalype fragilis</i>	<ul style="list-style-type: none"> Reduction in velocity/area of preferred habitat. Disruption to emergence and recolonisation 	Major

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
GB110061030700 Syfynwy - Llys-y-Fran to confluence with Eastern Cleddau Current status: Good		<ul style="list-style-type: none"> There is a major 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 	Major
GB110061030670 Eastern Cleddau – confluence with Syfynwy to tidal limit Current status: Not assessed		<ul style="list-style-type: none"> Not assessed 	N/A
Feature		Impact	Significance of Impact
Reach 1 – Afon Syfynwy			
Environment (Wales) Act Section 7 Species	Brook and river lamprey	<ul style="list-style-type: none"> Loss of juvenile habitat as a result of reduced river levels. 	Major
		<ul style="list-style-type: none"> Reduced water quality. 	Negligible
	River lamprey	<ul style="list-style-type: none"> Migration of a adult river lamprey affected or halted by a reduction in flow. 	Major
	Bullhead	<ul style="list-style-type: none"> Increase in mortality due to habitat loss. 	Major
	Atlantic salmon	<ul style="list-style-type: none"> Delays and potential cessation of a adult migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Reduced water quality 	Minor
		<ul style="list-style-type: none"> Delays and potential cessation of smolt migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Reduction in spawning and juvenile survival due to habitat loss. 	Major
	Brown/sea trout	<ul style="list-style-type: none"> Delays and potential cessation of smolt migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Delays and potential cessation of a adult sea trout migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Reduced water quality 	Minor
		<ul style="list-style-type: none"> Reduction in spawning and juvenile survival due to habitat loss. 	Major
	European eel	<ul style="list-style-type: none"> Delays and potential cessation of silver eel migration due to reduced flows. 	Moderate
Other fish species		<ul style="list-style-type: none"> Habitat loss and reduced water quality 	Moderate
Reach 2 – Eastern Cleddau			
Environment (Wales) Act	Brook and river lamprey	<ul style="list-style-type: none"> Loss of juvenile habitat as a result of reduced river levels. 	Major
		<ul style="list-style-type: none"> Reduced water quality. 	Minor

WFD Status/ Community		Impact	Significance of Impact
Section 7 Species	River lamprey	<ul style="list-style-type: none"> • Migration of a adult river lamprey affected or halted by a reduction in flow. 	Major
	Bullhead	<ul style="list-style-type: none"> • Increase in mortality due to habitat loss. 	Moderate
	Atlantic salmon	<ul style="list-style-type: none"> • Delays and potential cessation of a adult migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> • Reduced water quality 	Minor
		<ul style="list-style-type: none"> • Delays and potential cessation of smolt migration due to reduced flows. 	Major
	Brown / sea trout	<ul style="list-style-type: none"> • Reduction in spawning and juvenile survival due to habitat loss. 	Major
		<ul style="list-style-type: none"> • Delays and potential cessation of a adult migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> • Delays and potential cessation of smolt migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> • Reduced water quality 	Minor
		<ul style="list-style-type: none"> • Reduction in spawning and juvenile survival due to habitat loss. 	Major
	European eel	<ul style="list-style-type: none"> • Delays and potential cessation of silver eel migration due to reduced flows. 	Moderate
Other fish species		<ul style="list-style-type: none"> • Habitat loss and reduced water quality 	Moderate
Reach 3 – Eastern Cleddau			
Environment (Wales) Act Section 7 Species	Brook and river lamprey	<ul style="list-style-type: none"> • Loss of juvenile habitat as a result of reduced river levels. 	Major
		<ul style="list-style-type: none"> • Reduced water quality. 	Minor
	River lamprey	<ul style="list-style-type: none"> • Migration of a adult river lamprey affected or halted by a reduction in flow. 	Major
	Bullhead	<ul style="list-style-type: none"> • Increase in mortality due to habitat loss. 	Moderate
	Atlantic salmon	<ul style="list-style-type: none"> • Delays and potential cessation of a adult migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> • Delays and potential cessation of smolt migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> • Reduced water quality 	Minor
		<ul style="list-style-type: none"> • Reduction in spawning and juvenile survival due to habitat loss. 	Major
	Brown / sea trout	<ul style="list-style-type: none"> • Delays and potential cessation of a adult migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> • Delays and potential cessation of smolt migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> • Reduced water quality 	Minor
		<ul style="list-style-type: none"> • Reduction in spawning and juvenile survival due to habitat loss. 	Major
	European eel	<ul style="list-style-type: none"> • Delays and potential cessation of silver eel migration due to reduced flows. 	Moderate
	Other fish species	<ul style="list-style-type: none"> • Habitat loss and reduced water quality 	Minor

Phytobenthos

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

Table 5.8 Summary of Impacts of Drought Order Implementation on Phytobenthos

WFD Status/ Community	Impact	Significance of Impact
GB110061030700 Sy fynwy - Llys-y-Fran to confluence with Eastern Cleddau Current Status: Moderate (2018 interim)	There is a minor risk of short-term deterioration in status of the fish component of the waterbody due to the minor, short-term, temporary and reversible impacts associated with the drought order	Minor
GB110061030670 Eastern Cleddau – confluence with Syfynwy to tidal limit Current Status: Not assessed	Phytobenthos status not assessed	-
Feature	Impact	Significance of Impact
Reach 1 – Afon Syfynwy		
Phytobenthos communities	<ul style="list-style-type: none"> Changes to community composition due to changes in velocity Changes to community composition and nutrient status (TDI4 scores) due to risk of increased concentrations of soluble reactive phosphorous 	Minor

5.3.5 Invasive Flora and Fauna

Table 5.9 presents a summary of the potential impacts of the drought order identified from the assessment of invasive flora and fauna.

Table 5.9 Summary of Impacts of Drought Order Implementation on Invasive Flora and Fauna

Feature	Impact	Significance of Impact
Reach 1		
Invasive Species – <i>Dugesia tigrina</i>	Implementation of the drought order will do nothing favour proliferation of this species.	Negligible

5.3.6 Archaeology and Recreation

Table 5.10 presents a summary of the potential impacts of the drought order identified from the assessment of recreation and archaeology.

Table 5.10 Summary of Impacts of Drought Order Implementation on Heritage and Recreation

Feature	Impact	Significance of Impact
Reach 1 – Reach 3		
Recreation – cycling, walking, birdwatching	Impacts on non-water dependant activities are not anticipated over and above the impacts of the baseline drought conditions.	Negligible
Recreation – angling	Impacts on angling are anticipated during October and November, when impacts of the drought order may coincide with the end of the fishing season	Major (October - November only)
Archaeology	None of the known designated assets are in sufficient proximity to the Afon Syfynwy result in impacts to their setting.	Negligible

6 CANASTON DROUGHT ORDER– MITIGATION

The environmental assessment has identified some significant impacts, including major hydrological impacts, major aquatic ecology impacts including on fish, macrophytes and macroinvertebrates.

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

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

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

- 1) measures to reduce impacts at source
- 2) measures to modify environmental conditions in the river/lake
- 3) management of sensitive ecological species and communities.

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

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

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

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

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

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

7 CUMULATIVE IMPACTS

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

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

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

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

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

Other relevant Welsh Water drought permit / orders

No cumulative hydrological effects of implementing the Canaston drought order with drought order / permit schemes have been identified. However, this should be

reviewed at the time of any future application for a drought order at Canaston.

The Appropriate Assessment of the Canaston drought order includes consideration of the in-combination effects with the Crowhill 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 NRW Drought Plan with a drought order at Canaston intake are anticipated. However, this should be reviewed at time of future application for a drought order.

National Policy Statements for Wastewater and Renewable Energy Infrastructure

No cumulative schemes have been identified for assessment.

Environmental Monitoring

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

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

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

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

Stage 3 – Alternative Options Stage

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

Stage 4 – Assessment where adverse impacts remain

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

9.2 STAGE 1 SCREENING OF CANASTON DROUGHT ORDER

The objective of this section is to bring together all relevant information to enable a HRA to be undertaken of the impacts of the Canaston 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 Llys-y-Fran Reservoir to influence their status. For species, impacts on populations, range and supporting habitats and species have been considered.

9.2.1 Potential Impacts on Cleddau Rivers SAC Qualifying Features

In carrying out the screening process, the assessment has considered the main possible sources of effects on the sites arising from the potential drought order, possible pathways to the designated sites and the effects on possible sensitive receptors in the sites. Only if there is an identifiable pathway between the impacted reaches and the designated sites, or individual receptors, is there likely to be an impact and where this is absent those sites have been screened out. The screening assessment has also considered the 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.

Sea Lamprey

There are no records of sea lamprey within or near to the hydrological zone of impact and so this species is screened out from further consideration in this assessment with no likely significant effects.

Brook and River Lamprey

The assessment has identified the potential for impacts on brook and river lamprey as a result of a reduction in river levels and wetted width in Reaches 1-3. There is the potential for reduced flow to result in a decrease in river levels and wetted width. This has particular significance for juvenile (ammocoetes and transformer) lamprey habitat which tends to consist of silt in shallow, marginal areas. Gravel spawning habitat may also be affected. There is therefore the potential for a loss or degradation of this habitat. Juvenile lamprey are likely to be able to relocate to areas of suitable habitat as river

levels decrease, however, competition and stress would likely increase. The major reduction in low and extreme low flows is expected to have a significant effect on marginal habitats. All these could result in an impact on breeding successes and consequently the conservation status of the designated features.

Mature river lamprey migrate upstream into freshwater in the autumn (from October to December¹¹). 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^{Error! Bookmark not defined.}. Upstream migration requires a reasonable flow of water to aid passage past natural and non-natural in-channel barriers. Low flows may limit upstream passage and hinder downstream passage, leaving both migratory life stages exposed to higher risks of predation and ultimately a reduction in recruitment.

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 and river lamprey within the Cleddau Rivers SAC.

Bullhead

Bullhead are present throughout the hydrological zone of influence. The species is flow sensitive, with spawning and egg incubation occurring from March to May and young-of-the-year fish reliant on flows to distribute to other areas between July and September. Particularly susceptible juvenile life stages may therefore be impacted by reduced flows (and likely reduced water quality) associated with implementation of the drought order.

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 Reach 1 within 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. Consequently, this species is screened out of the assessment with no likely significant effects.

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

¹¹ Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No.5. English Nature, Peterborough

The assessment has identified the potential for impacts to affect the designated 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, although these changes of lesser significance for the habitat given the drought order would only be implemented outside of the main growing season.

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).

As a result, it can be concluded that implementation of a drought order is unlikely to result in any likely significant effects on the alluvial forests habitats within the Cleddau Rivers SAC and is therefore screened out of this assessment with no likely significant effects.

Active Raised Bogs

A drought order would have negligible impact on this designated feature as this habitat type is rain-fed and is not hydrologically connected to the river (in terms of the river feeding the active raised bog).

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 and is therefore screened out of this assessment with no likely significant effects.

Table 9.1 Summary of Impacts of Drought Order Implementation Against Conservation Objectives for the Cleddau Rivers SAC and Eastern Cleddau SSSI

Feature	Attribute (taken directly from NRW Conservation Objectives document)	Site Specific Target Range and Measures	Impact of Drought Order and Level of Certainty	Potential Impact on Achievement of Objective
Sea lamprey	Distribution within the catchment	Any silt beds adjacent to or downstream of suitable spawning sites should contain <i>Petromyzon ammocoetes</i> .	No risk to achievement of conservation objective; probable.	No
	Ammocoete density	Any silt beds adjacent to or downstream of suitable spawning sites should contain <i>Petromyzon ammocoetes</i> .	No risk to achievement of conservation objective; probable.	No
Brook and river lamprey	Age/size structure of ammocoete population	Samples < 50 ammocoetes 2 size classes Samples > 50 ammocoetes at least 3 size classes	Potential adverse impacts of drought order implementation on the age / size structure of ammocoete	Yes
	Distribution of ammocoetes within catchment	Present at not less than 2/3 of sites surveyed within natural range No reduction in distribution of ammocoetes	Potential adverse impacts of drought order implementation on distribution of ammocoetes	Yes
	Ammocoete density	Optimal habitat: >10m ² Overall catchment mean: >5m	Potential adverse impacts of drought order implementation on ammocoete density	Yes
Bullhead	Adult densities	No less than 0.2 m ⁻² in sampled reaches	Potential adverse impacts of drought order implementation on adult bullhead densities	Yes
	Distribution	Bullheads should be present in all suitable reaches. As a minimum, no decline in distribution from current	Potential adverse impacts of drought order implementation on the distribution of bullhead	Yes
	Reproduction / age structure	Young-of-year fish should occur at densities at least equal to adults	Potential adverse impacts of drought order implementation on reproduction / age structure of bullhead	No
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; probable.	No
	Breeding activity	2 reports (within the catchment) of otter cub/family sightings or 2 reports of cubs, lactating females or pregnant females from otter road casualties are recorded for at least 1 year in any three year period	No risk to achievement of conservation objective; probable.	No
	Actual and potential breeding sites	There should be no reduction or decline in	No risk to achievement of conservation objective;	No

		the number or quality of identified actual or potential breeding sites	probable.	
	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; probable.	No
	Food availability	Fish biomass stays within expected natural fluctuations	No risk to achievement of conservation objective; probable.	No
	Riparian habitat	No overall permanent decrease and no overall loss in sensitive areas.	No risk to achievement of conservation objective; probable.	No
	Anthropogenic mortality	No increase in numbers of recorded Road Deaths.	No risk to achievement of conservation objective; probable.	No
	Disturbance	No significant change to bank side usage, no significant development, particularly in sensitive areas.	No risk to achievement of conservation objective; probable.	No
Water courses of plain to montane levels with the <i>Ranunculus fluitantis</i> and <i>Callitriche-Batrachion</i> vegetation	Distribution within catchment	Distribution within site units 1, 3, 7 & 10	Potential adverse impacts of drought order implementation on the distribution of habitat.	Yes
	Typical species (including <i>Potamogeton berchtoldii</i> x <i>P. polygonifolius</i> – a SSSI qualifying feature)	Characteristic plant species should dominate the assemblage	Potential adverse impacts of drought order implementation on community composition.	Yes
	Native species	Cover of indicators of eutrophication maintained below threshold over the medium to long term	No risk to achievement of conservation objective; probable.	No
	Alien / introduced species	No impact on native biota from alien or introduced species	No risk to achievement of conservation objective; probable.	No
Fluvial woodland	Extent	No reduction in the total number of sites (72)	No risk to achievement of conservation objective; probable.	No
	Quality	3 out of 4 sample woodlands on each arm of the Cleddau to meet site-specific assessment of good condition alluvial woodland.	No risk to achievement of conservation objective; probable.	No
	Structure and processes	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. At least one example of each age component present (sapling if the survey	No risk to achievement of conservation objective; near certain.	No

		<p>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 >40% of survey sites</p> <p>Dense thickets of bramble cover <10% of individual sites and are confined to drier margins of habitat</p> <p>Deadwood, lying or standing > 20 cm diameter and > 1 m length present at 80% of survey sites</p> <p>No evidence of alder disease</p>		
	Regeneration	Regeneration occurring and 90% alder and willow	No risk to achievement of conservation objective; near certain.	No
	Non-native species	<5% of the canopy forming trees across the woodland are non-native Exotics cover < 10% ground	No risk to achievement of conservation objective; near certain.	No
	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</i> spp, tufted hair-grass <i>Deschampsia cespitosa</i> , hemlock water-dropwort <i>Onanthe crocata</i> , and wild angelica <i>Angelica sylvestris</i> .	No risk to achievement of conservation objective; probable.	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 maybe drying out)	No risk to achievement of conservation objective; probable.	No
	Grazing	No impact on regeneration and ground flora criteria satisfied	No risk to achievement of conservation objective; near certain.	No

Active Raised Bog	Extent	No reduction in extent.	No risk to achievement of conservation objectives for bog has been identified due to the absence of hydrological connectivity between the river and the bog habitat; near certain.	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 following communities: M6: c. 1.0 ha M23: 1.8 ha M25: 7.1 ha M27: 0.3 ha S4: 0.1 ha W4: 0.1 ha		
	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 scrub	On the mire expanse, trees and shrubs no more than rare and < 5% cover On the bog margin woody species < 10% cover		
	Drainage	Water table depths should not exceed 20 cm below ground level in an average summer. Flooding should be confined to natural hollows only and result from rainfall and not overbank flooding		
	Atmospheric deposition	Not to exceed 10 kg N/ha/yr		

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*
- Twaite 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 produced¹². 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,

¹² 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 Eastern 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.

Estuaries

The proposed drought order will lead to a reduction in freshwater low flows which could impact the hydrodynamics of the transitional waterbody. The reduction in freshwater flow could result in an increase in the flushing time (due to a reduced residual river flow velocity) and an alteration to the mixing characteristics, leading to a possible increase in saline intrusion distance and migration of the turbidity maximum upstream. There could also be a reduction in connectivity at low spring tide. These changes could result in effects to species composition, distribution and abundance (primarily in the mudflat and saltmarsh habitats, including invertebrate

communities) and changes to migration patterns, spawning habitat and fish recruitment. However, these potential effects will be confined to the very upper estuarine section of the Eastern Cleddau, whereby the influence of freshwater input is likely to be more pronounced. It is therefore concluded that the drought order could give rise to likely significant effects.

Atlantic salt meadows

The tributaries of the Milford Haven functional unit are characterised by pioneer salt-marsh and Atlantic salt-meadows. EMODnet seabed habitat mapping shows an area of saltmarsh close to Pickle Wood with saltmarsh then extending along both banks downstream, often with an area of low energy littoral rock (A1.3) between the saltmarsh and littoral muds. Sediment grain size is of particular importance to saltmarsh communities and decreased flows could potentially result in changes in the composition of deposited sediment leading to smothering of pioneer communities and a change in nutrient availability, with fewer nutrients being transported into the estuary. In drought conditions the marsh may become hypersaline, with potential desiccation in areas reliant on freshwater seepages and inflow, which could be compounded by the drought order. This could lead to changes in community composition and potential reductions in productivity, the effects of more significance in any brackish zone at the transition between the saline and fresh waters. It is therefore concluded that the drought order could have likely significant effects on the Atlantic saltmarsh habitat

Mudflats and sandflats not covered by seawater at low tide

The physical processes within mudflat habitats are not driven by the freshwater inputs to the estuary alone, with tidal influences considered to be a more significant factor in determining the extent and quality of mudflat habitat. As such, the potential impacts of the drought order will mainly arise during low tide. The decrease in freshwater inputs will potentially have an impact on both the sediment and nutrient dynamics within the mudflats. The mudflats support a variety of macroinvertebrate and phytobenthos species, the composition and abundance of which could be altered by the drought order. It is therefore concluded that the drought order could give rise to likely significant effects.

Sea and river lamprey

Mature river lamprey migrate upstream into freshwater in the autumn (from October to December¹³), descending to estuarine and marine environments between July and September in smaller rivers^{Error! Bookmark not defined.} after three to five years. Upstream

¹³ Ma itland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No.5. English Nature, Peterborough

igration requires a reasonable flow of water to aid passage past natural and non-natural in-channel barriers. Low flows in the upper estuary may limit upstream passage and hinder downstream passage, leaving both migratory life stages exposed to higher risks of predation and ultimately a reduction in recruitment. River lamprey also use the estuary as feeding areas, and nursery habitat, therefore it should be assumed that juveniles are present throughout the year.

Adult sea lampreys migrate through the estuary between March and June to reach their spawning grounds. Juvenile sea lampreys migrate through the estuary between December and June, and may feed in the estuary before moving offshore.

The use of estuarine habitats as feeding and nursery grounds is unclear. It is therefore concluded that the drought order could give rise to likely significant effects to the river and sea lamprey populations.

Allis and twaite shad

Depending on the timing of the drought order implementation, fish migration patterns up and downstream the Eastern Cleddau could be affected, as could the suitability of nursery and feeding habitats within the estuary as a result of changes in the salinity gradient, water quality and sedimentation patterns.

The use of estuarine habitats as feeding and nursery grounds is unclear. It is therefore concluded that the drought order could give rise to likely significant effects to the allis and twaite shad populations.

9.2.3 Summary

In summary, it cannot be concluded that implementation of a drought order would not result in likely significant effects on the brook and river lamprey and bullhead populations and Water courses of plain to montane levels with the *Ranunculus fluitantis* and *Callitriche-Batrachion* vegetation within the Cleddau Rivers SAC.

It also cannot be concluded that the implementation of the drought order would not result in likely significant effects on the estuaries, Atlantic salt meadow, mudflats and sandflats not covered by seawater at low tide habitat features, and the sea and river lamprey, and allis and twaite shad species features of the Pembrokeshire Marine SAC.

Stage 2 Appropriate Assessments have therefore been carried out to identify whether the implementation of the drought order will result in adverse effects on the sites' conservation objectives and therefore whether the overall site integrity would be compromised. These are reported separately.

9.2.4 Cumulative and In-combination Impacts

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

Consideration of potential plans or projects with cumulative effects is presented in Section 7.

10 ENVIRONMENTAL MONITORING PLAN (EMP)

10.1 INTRODUCTION

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

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

The basis of the development of the EMP is provided in Section 10.2. Monitoring recommendations are set out in Section 10.3.

10.2 BASIS OF THE EMP

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

The guidance states that:

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

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

reduced flows).

10.3 MONITORING RECOMMENDATIONS

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

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

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

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

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

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

- Any potential changes in the assessment of the hydrological, water quality and geomorphological impacts based on baseline conditions at the onset of drought;

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

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

Feature and reach	Potential Impact identified in EA R	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
N/A		Walkover survey during low flow conditions - Mapping of sensitive habitats, communities, species and any monitoring sites that are required in order to improve understanding of the baseline communities.	N/A				Welsh Water
		Hydrology of Sensitive Locations – Reaches 1 - 3 - Cross-sectional profile (depth and wetted width), flow and velocity. Location to be informed by walkover surveys.					Welsh Water
		Spot flow gauging surveys	One site per hydrological reach. Three occasions.	One site per hydrological reach. Three occasions.	N/A	One site per hydrological reach. Three occasions.	Welsh Water
		Biochemical water quality sampling.	One site per hydrological reach. Monthly. Consider continuous monitoring.	One site per hydrological reach. Weekly. Consider continuous monitoring.	N/A	One site per hydrological reach. Monthly, until recovery to pre-drought levels. Consider continuous monitoring.	Welsh Water
Macrophytes Reaches 1-3	<ul style="list-style-type: none"> Reduction in growth as a result of major impacts on water levels and flows. Changes to community 	The macrophyte community in the impacted reaches is not well understood as limited monitoring has been undertaken. Most recent NRW data (post 2007) is absent, meaning an up to date status of the community is lacking.	<p>Survey to be undertaken and macrophytes identified. Follow LEA FPACS2 standard methodology¹⁵.</p> <p>Walkover survey to identify any key sources of nutrient loading.</p>	<p>Walkover of key sections known to be susceptible to lower flows, informed by pre-drought survey.</p> <p>If drought permit implementation occurs in plant growing season, carry out</p>	<p>Mitigating impacts to the macrophyte community as a result of lowered flow and water level is not feasible during drought permit implementation.</p> <p>Mitigating this impact should be triggered by post drought macrophyte community assessments to</p>	In the two years following drought permit implementation and in June to September monitoring period carry out LEA FPACS2 macrophyte surveys at the baseline monitoring sites. To be extended if recovery has not occurred in two years.	

¹⁵ Environment Agency (2011). Surveying freshwater macrophytes in rivers. Operational instruction 131_07. (Unpublished procedures manual)

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set environmental drought	During Drought Permit Implementation		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger monitoring and inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	<p>composition due to changes to flow rates and increase in nutrients (SRP) and habitat loss due to reduction in wetted width.</p> <ul style="list-style-type: none"> Increase in filamentous and epiphytic algae levels due to increased nutrients (SRP) or water temperature and decreased velocity. 	<p>Macrophyte surveys were undertaken on behalf of Welsh Water in 2017, however this covered Reach 1 only¹⁴.</p> <p>Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Two sites per impacted reach. To complement any existing NRW monitoring, in discussion with NRW. Monitoring sites are located at:</p> <ul style="list-style-type: none"> D/S Bridge Near Southfield Villa – SN 03700 22600 Gelli - SN08250 19540 Canaston Gauging STN - SN07188 15295 U/S Canaston Intake - SN06500 15050 	<p>Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.</p>	<p>macrophyte surveys at baseline sites. Follow LEAFACS2 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>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>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 reseedling /replanting where possible to promote recovery. Replanting of macrophyte community composition to be informed by pre-drought community.</p>	
<p>Macroinvertebrates</p> <p>Reaches 1 -3</p>	<ul style="list-style-type: none"> Reduction in species diversity and abundance as a result of reduced recruitment. 	<p>The macroinvertebrate community in the impacted reaches reasonably well understood as a result of monitoring carried out by NRW, although there is limited recent data.</p>	<p>Seasonal monitoring of macroinvertebrates at the baseline survey site (summer and autumn).</p> <p>Samples to be collected and identified to species level.</p>	<p>Seasonal monitoring of macroinvertebrates at the baseline survey sites (summer and autumn).</p>	<p>Mitigating impacts to the macroinvertebrate community as a result of lowered flow and water level is not feasible during drought permit implementation.</p>	<p>In the two years following drought permit 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</p>	Welsh Water

¹⁴ Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018: Llys y Fran Reservoir, August 2018

Feature and reach	Potential Impact identified in EA R	Pre-drought baseline monitoring	On-set environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger monitoring and inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	<ul style="list-style-type: none"> Reduction in species diversity as a result of the loss of flow-sensitive taxa. Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats. 	<p>Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Two sites per impacted reach.</p> <p>To complement any existing NRW monitoring, in discussion with NRW.</p> <p>Monitoring sites should be informed by the location of NRW monitoring sites:</p> <ul style="list-style-type: none"> Llysyfran Macroinvertebrate site (Boathouse) - SN0385724058 D/S Bridge Near Southfield Villa - SN0370022600 Gelli – SN0825019540 Canaston Gauging STN - SN0718815295 Eastern Cleddau U/S Canaston Intake - SN-0650015050 	<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>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 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, including:</p> <p>Targeted installation of woody debris features to increase localised flow velocity/scour at the most flow impacted areas of the channel in order to sustain habitat requirements for flow sensitive taxa.</p>	<p>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 community, consider the removal of fine silt by manual raking of any accessible shallow marginal areas.</p>	
Fish (including river, brook and sea lamprey, Atlantic salmon, bullhead,	<ul style="list-style-type: none"> Decreased growth, alteration to 	The fish community in the Reach 1 is reasonably well understood as a	Electric-fishing surveys to monitor fish populations at one sites in the impacted reaches.	No fish population surveys are advised during drought as this may cause further	Targeted installation of woody debris features to provide fish with the habitat required to support	Two years of annual post-drought fish population surveys at baseline monitoring sites	Welsh Water

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set environmental drought	During Drought Permit Implementation		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger monitoring and inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
brown / sea trout, European eel and Otherfish species) Reaches 1 to 3	feeding and migration <ul style="list-style-type: none"> Siltation of spawning gravels Loss of important habitats (spawning gravels, nursery habitat, resting pools) Stranding of individuals as a result of a reduction in velocity Fragmentation of habitats and increased significance of obstacles/barriers Changes in flows and water levels may delay or prevent passage over barriers to migration 	result of monitoring carried out by NRW Monitoring sites in Reach 3 and additional monitoring sites in Reaches 1 and 2 should be selected following initial walkovers. Quantitative electric fishing surveys to be carried out at historic monitoring sites control site (to be identified during walkover survey outlined above). Surveys to be repeated every three years. Quantitative, lamprey-specific electric fishing surveys targeting known optimal and sub-optimal habitat. Monitoring sites in Reach 1 and Reach 2 are located at: <ul style="list-style-type: none"> Southfield Villa – SNO37226 EC19 (Site ID: 61083) SNO751317338 	Quantitative, lamprey-specific electric fishing surveys targeting known optimal and sub-optimal habitat. Two sites in the impacted reach. In severe drought conditions, no fish population surveys are advised during drought as this may cause further stress. Walkover of key sections known to be susceptible to lower flows: <ul style="list-style-type: none"> Identification of key habitats which are at risk of fragmentation. Identification of key structures which may provide a barrier at lower flows. Identification of key spawning locations recording the number of redds potentially affected, undertaken during the salmonid winter spawning period (depending on order being implemented during the salmonid winter 	stress. Additional walkovers, if situation is expected to deteriorate in stream sections known to contain high fish densities, spawning, nursery and cover habitats. Record extent of exposed marginal habitats, spawning habitats, bed substrates and estimates of overlaying silt cover. Frequency of walkovers to be determined based on the on-set of environmental drought walkover and expert judgement of the resolution required to monitor the impacts of the drought. Targeted fish passage assessment of barriers/obstructions to fish passage and any associated fish passes should be undertaken to ascertain if they pose an increased risk to the free movement of fish during key migration	feeding and development (growth). If the results of the walkovers deem spawning gravels to be at risk to siltation, the following mitigation action/s may be undertaken: <ul style="list-style-type: none"> Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)¹⁶ Targeted installation of woody debris features to increase localised flow velocity/scour at impacted spawning gravels (to aid sediment transport and increase water depth for spawning depth) If the results of the walkovers deem important habitats to be at risk to exposure/ reduction (in extent), the following mitigation action/s may be undertaken: <ul style="list-style-type: none"> Targeted installation of woody debris features to increase flow 	(corresponding with a control and impact site/s) to determine any changes in population dynamics both temporally and spatially. Quantitative, lamprey-specific electric fishing surveys targeting known optimal and sub-optimal habitat. Two sites in the impacted reach. The results of the fish population surveys should help inform mitigation targeting habitat restoration where deemed to be appropriate to support and enhance affected populations. Walkover of key spawning locations recording the number of redds potentially affected, undertaken during the winter spawning period. Record extent of exposed marginal habitats, spawning habitats, composition of the bed substrate and estimates of overlaying silt cover. If the results of the walkovers deem spawning gravels to have suffered from siltation, the following mitigation action/s may be undertaken:	

¹⁶ Wild Trout Trust Habitat Management Sheet – Gravel Cleaning http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set environmental drought	During Drought Permit Implementation		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger monitoring and inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
			<p>spawning period). Record extent of exposed marginal habitats, spawning habitats, composition of the bed substrate and estimates of overlying silt cover.</p> <p>Approximation of the number of each fish species (e.g. 10s, 100s) in each ponded reach, where safe and practical to do so.</p>	<p>periods, i.e. during adult salmonid and downstream lamprey migration period (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>heterogeneity/scour and marginal cover in shallow areas of the channel¹⁷</p> <ul style="list-style-type: none"> • Deployment of aeration equipment in key reaches that have standing or slow flowing water with low oxygen levels. • Targeted installation of woody debris features to provide submerged and overhead cover from predation where significant abundances of fish have been identified by walkover surveys. <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 concentrated abundances of fish deemed to be</p>	<p>Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)¹⁸</p> <p>Targeted installation of woody debris features to:</p> <ul style="list-style-type: none"> • increase flow heterogeneity/scour and marginal cover in shallow areas of the channel¹⁹ • increase localised flow velocity/scour at impacted spawning gravels (to aid sediment transport and increase water depth for spawning depth) <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"> • 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 	

¹⁷ Wild Trout Trust Chalkstream Habitat Manual – Use of Large Woody Debris http://www.wildtrout.org/sites/default/files/library/Large_Woody_Debris.pdf

¹⁸ Wild Trout Trust Habitat Management Sheet – Gravel Cleaning http://www.wildtrout.org/sites/default/files/library/Gravel_Cleaning_Apr2012_WEB.pdf

¹⁹ Wild Trout Trust Chalkstream Habitat Manual – Use of Large Woody Debris http://www.wildtrout.org/sites/default/files/library/Large_Woody_Debris.pdf

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger monitoring and inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
					<p>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 & 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> <p>Alternatively, mitigation should seek to protect any populations 'trapped' as a result of the barrier/s until flows increase for example by using aeration (if dissolved oxygen levels are low) or preventing</p>	<p>to the free movement of fish during key migration periods, i.e. during juvenile eel migration (spring/summer).</p> <ul style="list-style-type: none"> Modify any impacted fish passes (where possible) to ensure passage is achievable during key migration periods (e.g. agree to provide an appropriate proportion of flow into the pass to enable passage). Where fish passage is not currently provided at a barrier, investigate appropriate methods of improving passage (e.g. fish passage design and installation). 	

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger monitoring and inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
					predation (see Increased Mortality impact mitigation actions outlined above). Deployment of aeration equipment in key reaches that have standing or slow flowing water with low oxygen levels.		
Cleddau Rivers SAC	<ul style="list-style-type: none"> Impacts on <i>Ranunculus</i> habitat river lamprey, brook lamprey, sea lamprey and bullhead (Annex II species for which the SAC has been designated) have been assessed as major in Reach 1 - 3 	See macrophyte and fisheries surveys.	<p>See macrophyte and fisheries surveys.</p> <p>At the onset of drought conditions and at least four-weeks prior to the implementation of the drought order, detailed survey to inform the mapping of the distribution of lamprey, and bullhead habitat will be required</p> <p>The mapping of lamprey habitat and the determination of the percentage distribution of optimal, sub-optimal and unsuitable lamprey habitat within the zone of influence.</p> <p>Semi quantitative and quantitative surveys to inform targets for attributes as indicated in the SAC Core Management Plan.</p>	See macrophyte and fisheries surveys. Semi quantitative and quantitative surveys to inform targets for attributes as indicated in the SAC Core Management Plan.	See macrophyte and fisheries surveys.	See macrophyte and fisheries surveys. Semi quantitative and quantitative surveys to inform targets for attributes as indicated in the SAC Core Management Plan.	Welsh Water

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set 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)	
Pembrokeshire Marine SAC	<ul style="list-style-type: none"> Impacts on river and sea lamprey (Annex II species which are a qualifying feature of the SAC) have been assessed as major in Reach 1 – 3 and moderate in the SAC. 	<p>Due to the monitoring of lamprey populations in the marine life stage considered to be unfeasible, impacts to the anadromous lamprey populations of the SAC will utilise juvenile monitoring data collected as part of the assessment within the Eastern Cleddau (as outlined above). Juvenile monitoring data can be combined with adult ingress from the SAC into the Eastern Cleddau via the installation of fish counting equipment at the Canaston Intake Weir fish pass during the upstream migration period for each species. Correlation of adult ingress combined with juvenile abundance can be used to inform impacts of the status of anadromous lamprey within the Marine SAC</p>	<p>Fish counting equipment at the Canaston Intake Weir fish pass to assess ingress of adult lamprey from the SAC into the Eastern Cleddau.</p>	<p>Continuation of fish counting as outlined for on-set of drought. If results of the monitoring undertaken during the drought permit implementation deem upstream passage to be limited, consider fish surveys immediately downstream of the barrier to migration to assess numbers of each species.</p>	<p>If fish survey capture adult lamprey, consider the re-location of individuals upstream beyond migratory barriers.</p>	<p>Monitoring of juvenile lamprey for two years following cessation of drought permit.</p>	Welsh Water

11 CONCLUSIONS

This EAR provides an assessment of the potential environmental impacts relating to the implementation of the Canaston drought order. If granted and implemented, the drought order involves the relaxation of two parts of the abstraction licence: (1) a proposed 50% reduction in the hourly flow rate downstream of the Canaston intake which triggers the requirement to ensure that the hourly rate of discharge from Llys-y-Fran Reservoir equals or exceeds the hourly abstraction rate, and; (2) a relaxation of the seasonal flow-related limits on daily abstraction which normally apply during the months of October to December inclusive. The combined effect of these two relaxations would reduce the requirement for regulation releases such that releases are only triggered once abstraction would cause flow downstream of the intake to fall below 34.1 Ml/d.

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

The assessment has concluded that there is a **major-moderate** impact on flows in the Afon Syfynwy and Eastern Cleddau as a result of implementing the drought order. These hydrological impacts are assessed as leading to **moderate** impacts on the physical environment of the river, including water quality.

An environmental assessment was therefore required and included for features where screening has identified a major or moderate impact. Screening identified designated sites, WFD status and Community Assessment / Environment Act (Wales) Section 7 Species, invasive fauna, archaeology and recreation as environmental features for which an environmental assessment was required. The assessment has concluded that there are **major** impacts on the Eastern Cleddau SSSI, fish, macroinvertebrates and macrophytes and minor impacts on phytobenthos.

The HRA Screening could not conclude that implementation of a drought order would not result in likely significant effects on the brook and river lamprey and bullhead populations and macrophyte within the Cleddau Rivers SAC.

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

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

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

APPENDIX A

HYDROLOGY AND HYDROGEOLOGY

METHODOLOGY

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

Consideration is required (by the DPG¹) 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 approach² 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 upland³. Where possible, the hydrological assessments presented in previous EMPs and EARs of the drought options have been used to

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

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

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

The Directions set out the principles of classification of surface water and groundwater bodies, including the use of 80m above Ordnance Datum as the altitude that differentiates water quality requirements for upland and lowland biology. Where there are ambiguities, or thresholds are crossed, upland is assumed to apply to ensure a precautionary assessment.

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

Figure A.1 Hydrological Assessment Matrix (Upland)

% 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 Q₉₅, summer⁴) and very high sensitivity to changes in extreme low flow (represented by Q₉₉, 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 Q₉₅), but similarly sensitive to reductions in extreme summer low flows (summer Q₉₉).

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

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

% 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

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

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

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

The matrices are used to identify 1) the overall study area – which extends downstream of the abstraction until the hydrological impact has reduced to negligible; 2) reaches with similar scales of impact within the overall study area; and 3) the scale of hydrological impact within each reach. Typically reaches have been delimited by the addition of flow from a significant tributary or discharge; although the similarity of geomorphological characteristics of the reach may also be important in reach specification. The matrices can be applied to a variety of upland or lowland catchments respectively including those dominated by groundwater, and can be applied until the tidal limit.

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

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

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

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

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

Intermittently flowing watercourse hydrological methodology

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

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

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

Reservoir hydrological methodology

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

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

Figure A.6 Hydrological Assessment Matrix (Reservoir Impacts)

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

Additional Considerations

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

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

APPENDIX B

HYDROLOGY AND

PHYSICAL ENVIRONMENT ASSESSMENT

B1 INTRODUCTION

This appendix assesses the potential impacts on the physical environment of the Llys-y-Fran Reservoir and its downstream catchment, consisting of the Afon Syfynwy and the Eastern Cleddau River, during the period of implementation of the drought order.

For the purposes of this assessment, the “without drought order” baseline includes the continuation of abstraction from Llys-y-Fran Reservoir and Canaston Intake on the Eastern Cleddau River in accordance with the licensed arrangements described below, including a flow condition which, when flows are below 68.2Ml/d downstream of the Canaston abstraction intake, requires an increase in the discharge from Llys-y-Fran such that the rate of discharge is equal to or greater than the rate of abstraction from Canaston Bridge. The assessed drought order involves a 50% reduction (of 34.1Ml/d) in the flow condition and a relaxation of the seasonal flow-related limits on daily abstraction which normally apply during the months of October to December inclusive.

B.1.1 Welsh Water’s Existing Operations

Welsh Water owns and operates Llys-y-Fran Reservoir. The company is permitted to abstract up to 5.0Ml/d each day and 1825Ml/year from the reservoir (as per licence number 22/61/4/38V002). There are further restrictions on the abstraction linked to an upstream abstraction at Rosebush Reservoir (also known as Preseli Reservoir) (licence number 22/61/4/1) and a downstream abstraction at Canaston Intake on the Eastern Cleddau river (licence number 22/61/4/10) as set out below:

- The aggregate quantity of water abstracted from Llys-y-Fran and Preseli Reservoirs shall not exceed 5,909.8Ml/year
- The aggregate quantity of water abstracted from Llys-y-Fran Reservoir and at Canaston shall not exceed 25,000Ml/year
- The aggregate maximum daily quantity abstracted from Llys-y-Fran Reservoir and at Canaston shall not exceed a quantity determined from the volume of water available in Llys-y-Fran Reservoir in accordance with operating rules that have been agreed with Natural Resources Wales (NRW).

There are a number of additional conditions relating to the abstraction, as follows:

- Provision of a uniform statutory compensation water release to the Afon Syfynwy of 13.64Ml/d at all times
- At the request of NRW, release up to 955Ml into the downstream watercourse (at a daily rate no greater than 68Ml/d) for the benefit of fisheries
- Release water into the Afon Syfynwy to support the abstractions at Canaston

(authorised under licence number 22/61/4/10, described below).

Welsh Water may release water from the reservoir into the downstream Afon Syfynwy in order to support flows in the Eastern Cleddau River so that it can continue to abstract water at the downstream Canaston intake. The timing of such regulation releases are described below with reference to the Canaston abstraction licence, as follows:

- Welsh Water may abstract up to 85Ml/d and 25,000Ml/year at Canaston intake, downstream of Canaston Bridge.
- Abstraction may not occur if it were to cause the rate of flow in the river downstream of the abstraction to be reduced to less than 2.84Ml/hour (68.2Ml/d) as a hands off flow (HoF) condition, unless the rate of discharge from Llys-y-fran is equal to or greater than the hourly rate of abstraction
- As described above, Welsh Water may release water from Llys-y-Fran Reservoir (regulation releases) to support river flow during periods of low flow, so that routine abstractions are achieved without breach of the HoF.
- From April to June (inclusive) and October to December (inclusive), the maximum daily abstraction rate shall not exceed the values set out in **Table B1.1** if unsupported flow in the Eastern Cleddau at the Canaston Bridge Gauging Station (gauged flow minus Llys-y-Fran reservoir releases plus abstractions at Pont Hywel) is within the specified ranges. Any abstraction in excess of these rates must be supported by regulation releases from Llys-y-Fran reservoir equating to the excess amounts.

Table B1.1 Flow-related seasonal daily abstraction limits

Unsupported flow in the Eastern Cleddau at Canaston Bridge Gauging Station (Ml/d)	Maximum daily abstraction (Ml/d)
Below 110.592	12.96
110.592 – 194.376	38.016
194.377 – 270.408	63.072

- At any time, the maximum hourly rate of abstraction and corresponding rate of discharge from Llys-y-Fran Reservoir shall be determined from the volume of water available in the reservoir in accordance with the reservoir operating rules.
- The aggregate quantity of water abstracted from Canaston, Llys-y-Fran Reservoir and Pont Hywel (licence number 22/61/4/3) shall not exceed 85Ml/d.

The Canaston licence conditions have been amended following a review of Welsh Water's abstractions by NRW under the environmental requirements of the EU Habitats Directive ("Review of Consents" process). The new licence conditions come into force on 31 March 2019 and therefore the drought option has been assessed relative to these new licence conditions,

subject to the availability of hydrological data sets which currently do not include any periods with the new licence conditions in force.

B.1.2 Welsh Water's Proposed Drought Order Operations

The drought order involves the relaxation of two parts of the abstraction licence: (1) a proposed 50% reduction in the hourly flow rate downstream of the Canaston intake which triggers the requirement to ensure the hourly rate of discharge from Llys-y-Fran reservoir equals or exceeds the hourly abstraction rate, and; (2) a relaxation of the seasonal flow-related limits on daily abstraction which normally apply during the months of October to December inclusive (as shown in **Table B1.1**). The combined effect of these two relaxations would reduce the requirement for regulation releases such that releases are only triggered once the abstraction would cause flow downstream of the intake to fall below 34.1 Ml/d.

Whenever the flow downstream of the authorised point of abstraction is below 34.1 Ml/d, the drought order will have no impact on the need to regulate, nor on the flows downstream of the intake. However, the drought order will reduce the threshold for regulation releases being required.

The flow reduction (which will be limited to the maximum hourly rate of abstraction) due to reducing the need to make regulation releases will conserve the longevity of reservoir storage and improve the probability of reservoir winter refill. The drought order scheme will influence the Afon Syfynwy downstream of Llys-y-Fran Reservoir outfall and its continuation as the Eastern Cleddau River until the tidal limit.

The drought order is most likely to occur during the late summer/early autumn period, considered to not extend outside the period August to November. This has been confirmed by Welsh Water by water resources modelling. The assessment has therefore considered potential impacts during the summer months of August to September and the winter months of October to November.

The assessment includes the Llys-y-Fran Reservoir and the downstream reaches of the Afon Syfynwy. The study area is shown on **Figure B1.1**. The Afon Syfynwy, a large tributary, joins the Eastern Cleddau approximately 6km upstream of the tidal limit.

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

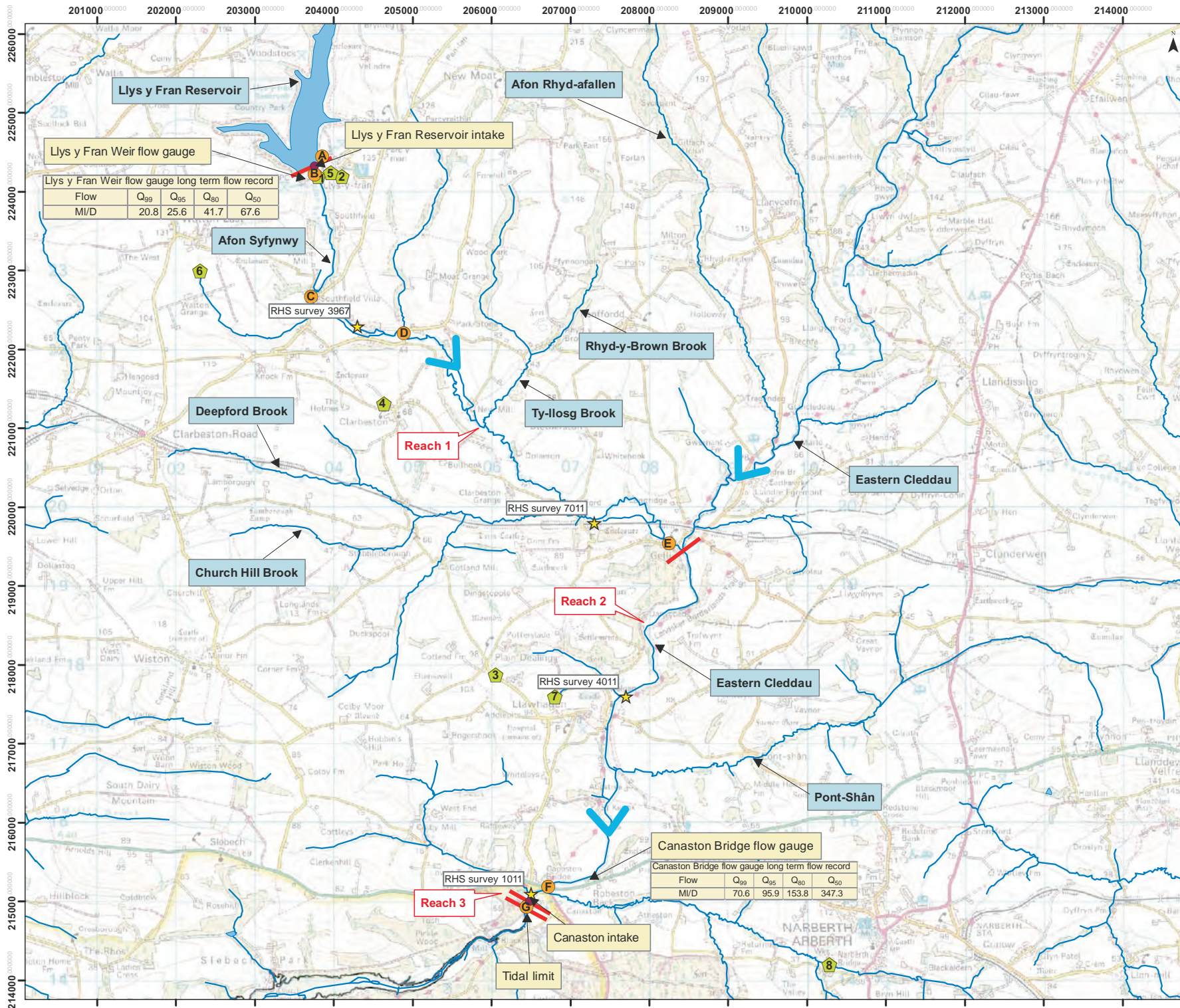
1. To “list the likely impacts to the flow, level, channel/riparian form and sediment due to action being in place” as required by the DPG¹ and set out in Figure 2 of the DPG
2. It is used to support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Section 5 of this report

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

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.



Legend

- Water Courses
- Reservoir
- Hydrological Reach
- Llisyfran Reservoir Intake
- Canaston Intake
- Direction of Flow
- River Habitat Surveys (RHS)

Water Quality Monitoring Sites

- A** 32688: Llys y Fran Reservoir at boathouse
- B** 32402: Afon Syfynwy at Llys y Fran
- C** 86046: Syfynwy below Walton Mill Fish Farm
- D** 73775: Syfynwy at Stepside Bridge Sample U/S of Bridge
- E** 32406: Gelli
- F** 88181: E.Cleddau at Canaston RB
- G** 120010: Eastern Cleddau Source

Discharges

- 1** Llys y Fran (Fish Farm)
- 2** Ivy House, Clarboston Road
- 3** ST at Caffle Brewery
- 4** Clarboston STW
- 5** Llys y Fran STW
- 6** Walton East STW
- 7** Llawhaden STW
- 8** Narberth West STW

1:45,000

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: **Hydrological Overview: 8206-8
Canaston 50% reduction in HoF**

Figure Number:
Figure B1.1

Date:
February 2019

B2 HYDROLOGICAL AND HYDROGEOLOGICAL IMPACT

B.2.1 Reference Conditions

B.2.1.1 Catchment Overview

The Afon Syfynwy is located in south west Wales, with its source in the Preseli Hills, Pembrokeshire at ~300m above sea level. The Afon Syfynwy is a tributary of the Eastern Cleddau, with the confluence at Gelli ~21km downstream from the source of the Syfynwy. Two on-line impounding reservoirs are situated along the Afon Syfynwy, the lowest and most significant being Llys-y-Fran Reservoir. The Eastern Cleddau flows into the far eastern end of Milford Haven at Canaston Bridge and drains an area of ~208km². Downstream of Llys-y-Fran Reservoir, the Afon Syfynwy generally flows through improved grassland and other mixed agricultural land with significant tree coverage between Llys-y-Fran Reservoir and Stepaside Brook. Downstream of its confluence with the Afon Syfynwy, the Eastern Cleddau flows through improved grassland and some heavily wooded areas. There is little urbanisation in the catchment.

B.2.1.2 Baseline Data Availability

Continuous monitoring of Afon Syfynwy flow is undertaken by Welsh Water at the Llys-y-Fran weir flow gauge located immediately downstream of the Llys-y-Fran Reservoir outflow. NRW monitors river flow at the Eastern Cleddau River at Canaston Bridge (0.9km upstream of the Canaston intake). Welsh Water monitors the rate of abstraction at Canaston.

Data are available for:

- Llys-y-Fran weir flow gauge: daily river flow record from 1994 to present (weekly data available for 1993 to 1994)
- Llys-y-Fran weir flow gauge: intermittent spot gauging data (level, velocity and wetted parameters such as wetted width and cross sectional area)
- Measurement of the managed outflows made by Welsh Water from Llys-y-Fran Reservoir into the Afon Syfynwy: daily metered flow from 2004 to present
- Canaston Bridge flow gauge: daily river flow record from 1960 to present
- Canaston intake abstraction: daily metered flow from 1995 to present
- Intermittent spot gauging data (flow, level, velocity and wetted parameters such as wetted width and cross sectional area) at a number of locations on the Afon Syfynwy and Eastern Cleddau River (locations indicated in **Figure B1.1**), although the availability of the parameters varies dependent upon location.

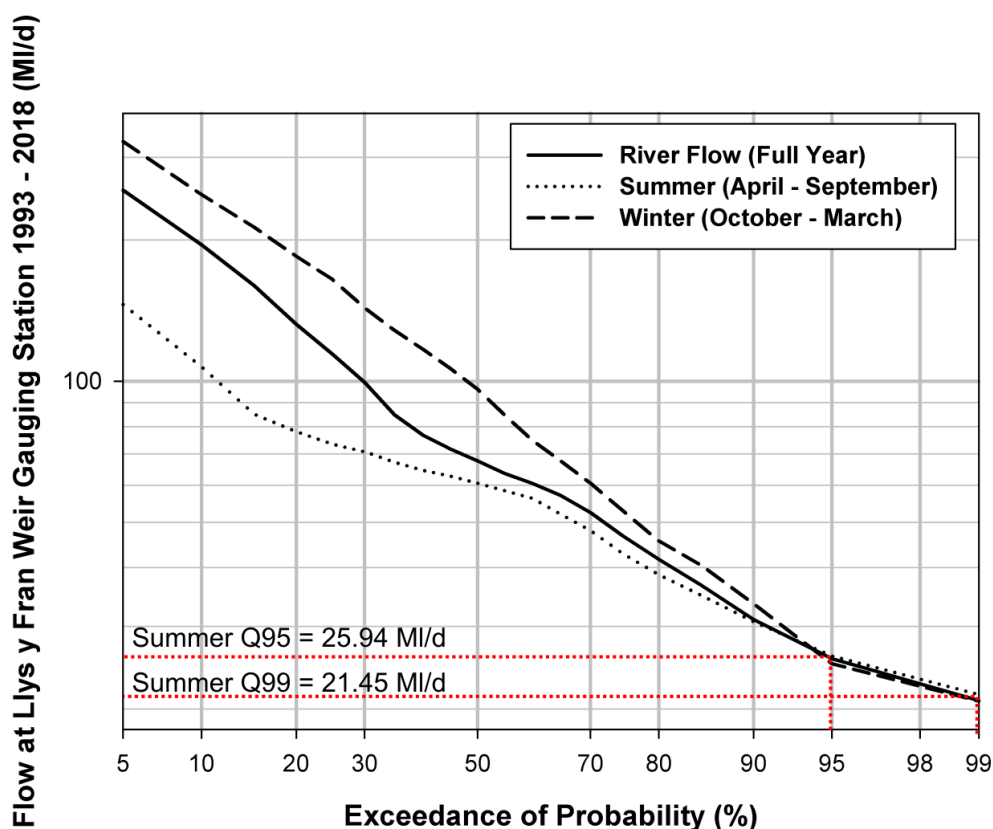
A summary of recorded flow in the Afon Syfynwy is presented in **Table B2.1**.

Table B2.1 Summary of Recorded Mean, Maximum and Minimum Daily Flow in the Afon Syfynwy at Llys-y-Fran weir flow gauging station (1993 - 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	763	697	611	369	594	526	724	554	500	763	763	763	763
10% (high flow)	294	226	171	135	88	83	93	112	130	167	287	299	195
50%	131	101	71	54	48	57	64	67	63	60	115	119	68
80%	64	57	42	33	32	34	45	57	51	39	36	67	42
90%	41	46	33	28	26	26	35	47	36	26	26	37	31
95% (low flow)	36	39	27	26	22	23	30	40	30	23	23	25	26
99% (extreme low flow)	21	25	23	21	21	22	27	33	24	21	21	20	21
Minimum flow	18	20	18	20	19	17	23	22	20	17	21	18	17

The low flow statistics for the winter period (1st October to 31 March inclusive) are: $Q_{95} = 25.0$ Ml/d; $Q_{99} = 20.8$ Ml/d. The summer low flow and extreme low flow statistics (1st April to 30th September inclusive) are $Q_{95} = 26.3$ Ml/d and $Q_{99} = 21.4$ Ml/d. Low flows at this location are strongly influenced by the statutory compensation flow rate of 13.64 Ml/d from Llys-y-Fran Reservoir. The flow duration curve for this location is shown in **Figure B2.1**.

Figure B2.1 Flows in the Afon Syfynwy at Llys-y-Fran Weir (1993-2018)



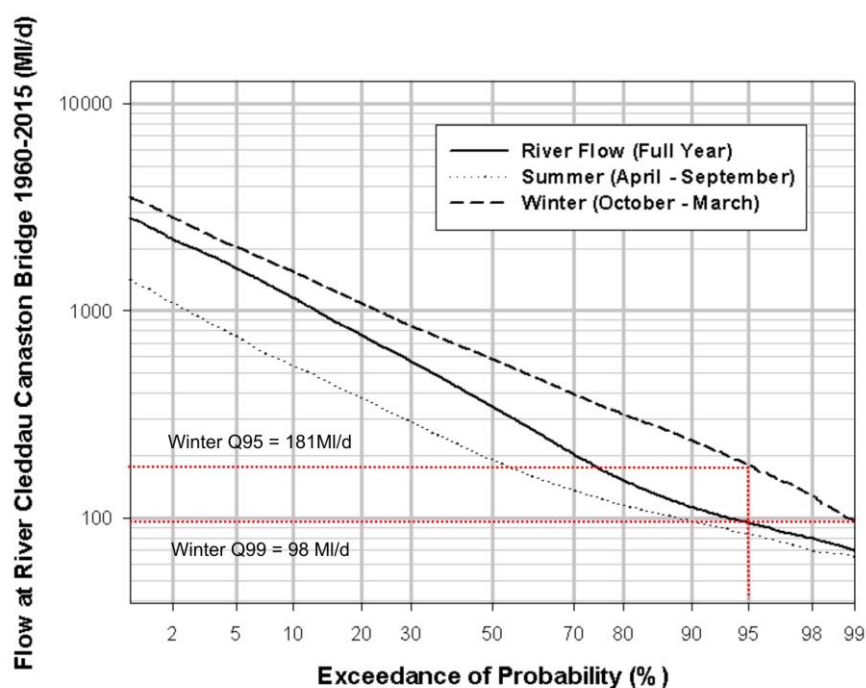
A summary of recorded flow in the Eastern Cleddau River at Canaston Bridge is presented in Table B2.2. The HoF condition at this location means that normally Welsh Water may not abstract such a volume at Canaston intake (0.9km downstream) as may cause the flow at this location to drop below 2.84 Ml/hr (68Ml/d). Recent additional licence conditions limiting abstraction in certain flow ranges (as shown in Table B1.1) are not yet reflected in the recorded data.

Table B2.2 Summary of Recorded Mean, Maximum and Minimum Daily Flow in the Eastern Cleddau River at Canaston Bridge gauging station (1960 - 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	5279	5970	5391	4009	2393	3309	4311	9850	4553	8320	6903	9331	9850
10% (high flow)	1771	1400	1041	769	508	414	344	550	620	1280	1772	1871	1166
50%	739	544	438	318	222	159	135	170	199	404	695	750	347
80%	432	345	269	200	148	114	98	102	116	203	388	435	154
90%	315	287	223	163	128	98	85	90	92	134	289	340	114
95% (low flow)	242	239	193	141	113	89	75	75	79	98	202	288	96
99% (extreme low flow)	171	162	159	122	94	69	60	62	67	75	114	208	71
Minimum flow	128	129	137	110	75	58	51	55	63	65	84	132	51

The low flow statistics for the winter period (1st October to 31st March inclusive) are: $Q_{95} = 185$ Ml/d; $Q_{99} = 99$ Ml/d. The summer low flow and extreme low flow statistics (1st April to 30th September inclusive) are $Q_{95} = 84.3$ Ml/d and $Q_{99} = 65.8$ Ml/d. The flow duration curve for this location is shown in **Figure B2.3**.

Figure B2.3 Flows in the Eastern Cleddau River at Canaston Bridge (1960-2018)



B.2.1.3 Hydrology

Afon Syfynwy

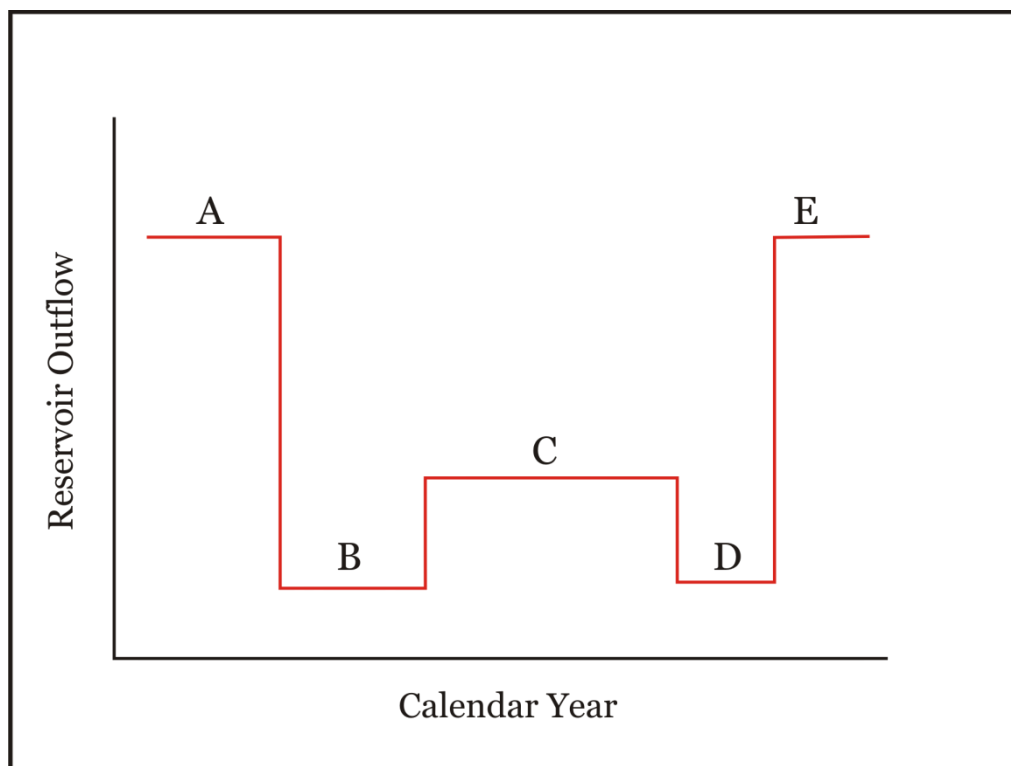
Hydrological Reach 1 (Afon Syfynwy) is characterised by irregular meanders in a very shallow vee-shaped valley. Channel widths vary slightly throughout the reach between 7-10m. Channel depth is typically shallow at approximately 0.35m. Riparian tree cover along the reach is dense and is characterised by semi-continuous to continuous tree cover. In Reach 1, flows are dominated by Llys-y-Fran Reservoir outflows, with flow accretion downstream arising from the remainder of the Afon Syfynwy catchment.

Outflows from Llys-y-Fran Reservoir to Afon Syfynwy follow a seasonal pattern, as illustrated in **Figure B2.5** below. The following describes the typical stages of flow, applicable to the data records up to and including 2018:

- A. Reservoir overflows (“spills”) occur regularly and extensively every winter (typically ranging from over 100Ml/d to 300Ml/d, although peak flows of up to 763Ml/d do occur in some years).
- B. When the reservoir level drops below the spillway crest, outflows from the reservoir comprise just the compensation flow releases. This is most likely during the spring.
- C. If river flow at Canaston becomes insufficient to maintain the required river abstraction rate (according to the terms of the HoF), then regulation releases are made from the reservoir in addition to compensation releases. This occurs in most, but not all summers. In an environmental drought, this period would likely extend into the autumn.
- D. When river flows at Canaston recover, regulation ceases and reservoir outflow reverts to just the compensation flow release. This period is typically from late summer / autumn. In an environmental drought, this period would likely be delayed to later in the autumn.
- E. Wetter weather in late autumn / winter will refill the reservoir until it starts spilling again. This period of overflow extends from early / mid-winter to spring.

Under the new licence conditions in force from 31 March 2019, additional regulation releases will be required during the periods April to June and October to December when unsupported flow is below 270Ml/d. At the time of this assessment, there is no historic data available reflecting the revised mode of operation. The assessment is based on the available hydrological and operational data sets (up to 2018), but consideration has been given to the potential effects of additional seasonal regulation releases on the estimated hydrological impacts. Additionally, a modelled data set has been used to determine the theoretical effects of the drought order on long term flow series, in particular during notable historic droughts. This is discussed further in section B.2.2.2.

Figure B2.5 Stylised Pattern of Llys-y-Fran Reservoir Outflow Over a Calendar Year



Eastern Cleddau River

Reaches 2 and 3 (Eastern Cleddau River) are characterised by irregular meanders in a very shallow vee-shaped valley. Channel widths are predominantly between 12-14m through most of the reach, increasing towards the end of the reach to 18-23m. Riparian tree cover along the reach is dense and is characterised by semi-continuous to continuous tree cover in the upper portion of the reach, decreasing to isolated / scattered in the lower portion of the reach.

In Reach 2, flows from the Eastern Cleddau River add considerable flow to that of the Afon Syfynwy. The Eastern Cleddau River is not impounded and, although subject to abstractions and discharges, retains a degree of natural flow variability. In most summers and in periods of environmental drought, flows in Reach 2 are elevated by regulation releases from Llys-y-Fran Reservoir (period C on **Figure B2.5**). Flows in the lower part of Reach 2 are characterised by the Canaston Bridge flow gauge records.

In Reach 3, flows are reduced from those in Reach 2. Under the lowest flow conditions, including those of environmental drought, (and only at period C on **Figure B2.5**), the flow in Reach 3 is not protected by the HoF and a semi-natural flow regime is present. At low flows, when regulation releases are not being made (only during periods B and D on **Figure B2.5**), flow in Reach 3 is maintained at the HoF value - albeit such occasions are rare. Under the new licence conditions, low flows occurring during the spring and autumn are more likely to require regulation releases to be made to support abstraction.

Hydrometric Parameters

Spot gauging records on the Afon Syfynwy provide relatively limited water level and flow data. Additional cross section monitoring was undertaken for Welsh Water at representative natural river sections on 4 August 2011 and 21 September 2011. Two locations (one on the Afon Syfynwy (SNo48222) and another on the Eastern Cleddau River (SNo74166) were surveyed on the first date whilst one was surveyed on the second date, for health and safety reasons (river was too fast and high to safely enter). On the dates of survey, the flows at the Llys-y-Fran weir were 56.0Ml/d (4 August - regulation releases being made) and 20.6Ml/d (21 September - compensation releases only being made). On 4 August 2011 the gauged flow at Canaston Bridge was 241Ml/d, which corresponds with the full year Q_{63} of the site. Although no formal spot flow sampling was undertaken, a number of velocity measurements were made. Results from the sampling are provided in **Table B2.3**.

Table B2.3 2011 Hydrometric Parameters Obtained from Cross Section Survey of the Afon Syfynwy and Eastern Cleddau River

Hydrometric Parameter	Afon Syfynwy Cross Section		Eastern Cleddau River Cross Section
	4.8.2011	21.9.2011	4.8.2011
Wetted Width (m)	8.5	8.5	16.0
Wetted width with depth greater than 0.1m (m)	7.0	7.0	12.3
Maximum Depth (m)	0.9	0.68	0.65
Mean Depth (m)	0.33	0.37	0.33
Mean Velocity (m/s)	0.30	0.22	0.48

At the Afon Syfynwy survey site, there was no recorded difference in wetted width or mean velocity corresponding to regulation releases (4 August) and compensation flow releases (21 September). Reductions in maximum wetted depth are apparent, but not in wetted usable depth (width with depths greater than 0.1m). With only the one survey at the Eastern Cleddau River site it is not possible to determine how wetted parameters vary with flow.

Drought Order Assessment

The timing of the reduction in the Canaston hands-off flow condition is most likely to occur during the period August to November inclusive, based on water resources modelling undertaken by Welsh Water. We have therefore assessed the potential impacts of a reduction in reservoir regulation release of up to the daily abstraction rate minus the statutory compensation rate, during either the summer months of August to September, or the winter months of October to November.

In order to assess the hydrological impact of the drought order on flows downstream of the reservoir, key flow statistics were calculated for the Eastern Cleddau River at Canaston Bridge Gauging Station (the lower end of Reach 2), downstream of the Canaston abstraction intake (the top of Reach 3) and, by area-flow apportionment based on relative catchment areas and standard annual average rainfall (SAAR) values, immediately downstream of the Afon Syfynwy confluence (the top of reach 2). The ratio is based on calculating Annual Average Flow

(AAF) as catchment area x SAAR. The estimated flow values at each location are shown in **Table B2.4** below.

In addition, spot flow gauging results are available at a number of intermediate locations on the Afon Syfynwy downstream of Llys-y-Fran Reservoir. A selection of the lowest flow results are summarised in **Table B2.5** below, and have been compared with the corresponding daily gauged flow values at the Canaston Bridge Gauging Station to estimate the approximate flow percentile applicable to each value. A moderate flow result at approximately Q₆₆ has also been included. The results are not entirely conclusive but do give an approximate indication of summer and winter extreme low flow values at the lower end of reach 1 (Gelli), winter extreme low flow values in the middle of reach 1 (Clarbeston), and an extreme low value of flow accretion along the length of reach 1 (6.5Ml/d on 28/10/1969).

Table B2.4 Catchment Areas, Annual Rainfall values and Estimated Key Flow Statistics

Location	Grid Reference	Catchment Area (km ²)	SAAR (mm)	AAF Ratio to CB GS	Year Round Q ₅₀ (Ml/d)	Year Round Q ₉₅ (Ml/d)	Summer Q ₉₅ (Ml/d)	Summer Q ₉₉ (Ml/d)
Eastern Cleddau River, Downstream of Canaston Intake (Top of Reach 3)	SN064149	-	-	-	314.2	71.1	57.9	42.3
Canaston Bridge Gauging Station, R. Eastern Cleddau river (Lower part of Reach 2)	SN072152	183.1	1437	-	347.3	95.9	84.7	66.3
Eastern Cleddau River, d/s of Afon Syfynwy confluence (Top of Reach 2)	SN084194	159.0	1463	0.88	307.1	84.8	74.9	58.6

CB GS = Canaston Bridge Gauging Station.

Table B2.5 Selected Spot Flow Gauging Results, 1968 – 2006 (Reach 1)

	Location and Grid Reference – Mean Daily Flows in Ml/d					Approximate percentile of Canaston Bridge flow distribution
	Afon Syfynwy at Llys-y-Fran Weir	Afon Syfynwy at Walton Mill	Afon Syfynwy at Clarbeston	Afon Syfynwy at Gelli	Canaston Bridge Gauging Station	
Date	SN03782420	SN03982296	SN04902220	SN08351950	SN0722615292	-
9/12/1968				163.1	428.5	Q66 (Winter)
31/7/1969				28.1	73.2	Q98 (Summer)
22/9/1969				24.4	89.0	Q94 (Summer)
13/10/1969				22.3	127.9	Q98 (Winter)
28/10/1969	17.1			23.6	91.6	Q99 (Winter)
16/7/1970				25.2	62.4	Q99 (Summer)
14/10/1970	51.4			73.8	273	Q86 (Winter)
4/11/1970	185.6			427.3	1252.8	Q15 (Winter)
7/11/1978	27.3		31.8		95.9	Q99 (Winter)
13/11/1978			24.9		132.2	Q98 (Winter)
3/11/1993		25.9			330	Q78 (Winter)
1/8/1996	54.3	19.6			112.3	Q82 (Summer)

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 Llys-y-Fran Reservoir has identified the areas where the proposed drought order impacts upon hydrology. The study area includes the Llys-y-Fran reservoir, the Afon Syfynwy downstream of the reservoir and the Eastern Cleddau down to its tidal limit; it comprises three distinct hydrological reaches as listed in **Table B2.8** and **Table B2.9** and identified on **Figure B1.1**.

The potential hydrological impact of the drought order has been reviewed for each hydrological reach and is discussed below. Note that the impact on Llys-y-Fran Reservoir itself would be a marginal increase in water levels / storage volume, relative to the position without the drought order. This would be considered as a minor beneficial impact and has not been assessed further.

B.2.2.2 Hydrological Impact Assessment

For Reaches 1 and 2, which are all or partly in upland areas, estimated percentage reductions in river flow statistics as presented in **Table B2.8** and **Table B2.9** have been compared against both the summer and winter hydrological assessment matrices, as appropriate, for upland locations (**Figures A.1** and **A.3** in Appendix A), to determine the significance of the hydrological impacts. The summer and winter matrices for lowland locations (**Figures A.2** and **A.4** in Appendix A) have been applied to the assessment for Reach 3.

Reach 1 – Afon Syfnwy, Llys-y-Fran Reservoir to Eastern Cleddau Confluence

The drought order involves potentially decreasing the regulation releases from the Llys-y-Fran Reservoir into the Afon Syfnwy, at times when flow measured downstream at the Canaston Bridge Gauging Station is sufficiently low to require abstraction at the Canaston intake to be supported by regulation releases. Implementation of the drought order would reduce the required regulation release by up to the difference between the daily abstraction rate and the compensation rate, as the requirement to support abstraction by releasing no less than the daily abstraction rate would occur at a lower trigger flow..

During a drought it is likely that Llys-y-Fran reservoir will be below top water level and flows from the reservoir will be limited to compensation and/or regulation releases only. The summer flow statistics at Llys-y-Fran weir of $Q_{95}=26.3\text{ML/d}$ and $Q_{99}=21.4\text{ML/d}$ are therefore not applicable to this particular scenario. Reservoir outflow would be dependent on gauged flows downstream at Canaston Bridge and daily abstraction rates, which are typically in the range $30\text{ML/d} - 50\text{ML/d}$. **Table B2.6** below indicates the typical reservoir outflow rates for key flow statistics as measured at Canaston Bridge Gauging Station, both in a baseline drought and with the drought order in place, and for two different abstraction rates (30ML/d and 50ML/d), noting that the minimum release rate is the compensation flow of 13.64ML/d .

The figures in **Table B2.6** indicate that the drought order would lead to a reduction in reservoir outflows of up to 36.4ML/d (73%) at both summer low flows (Q_{95}) and summer extreme low flows (Q_{99}). This would be assessed as a **major** hydrological impact during the summer period of April to September inclusive.

During the winter months, the drought order would not lead to any change in the year round moderate (Q_{50}) flows, but there would be a reduction in the year round low flow (Q_{95}) of up to 36.4ML/d (73%). This would be assessed as a **moderate** hydrological impact during the months of October to March inclusive.

Table B2.6 Reservoir outflow rates at key flows measured at Canaston Bridge Gauging Station, baseline and with drought order

Flow Scenario	Flow at Canaston Bridge Gauging Station (ML/d)	Abstraction at 30ML/d			Abstraction at 50ML/d		
		Reservoir Release (Baseline, ML/d)	Reservoir Release (With drought order, ML/d)	Reduction due to Drought Order (ML/d)	Reservoir Release (Baseline, ML/d)	Reservoir Release (With drought order, ML/d)	Reduction due to Drought Order (ML/d)
Summer Q_{99}	65.8	30.0	13.64	16.36	50.0	13.64	36.36
Summer Q_{95}	84.3	30.0	13.64	16.36	50.0	13.64	36.36
Year Round Q_{95}	95.9	30.0	13.64	16.36	50.0	13.64	36.36
Year Round Q_{50}	347.3	13.64	13.64	0	13.64	13.64	0

Under the new licence conditions, there may be additional regulation releases required during low to moderately low flow conditions occurring during April to June and October to

December. These would most likely increase the winter flow statistics and so the percentage flow reductions in the winter Q_{95} would be lower, thus reducing the impact. In the absence of hydrological data sets reflecting the new conditions, however, we have taken a precautionary approach and based the assessment on the existing Llys-y-Fran and Canaston Bridge flow data sets as outlined above.

Reach 2 – Eastern Cleddau, Afon Syfynwy confluence to Canaston intake

Flow in lower Reach 2 (upstream of the river abstraction but including the reservoir release flow) can be characterised as: year round low flow (Q_{95}) 95.9Ml/d and year round moderate flow (Q_{50}) 347.3Ml/d. The 36.4Ml/d reduction in reservoir release rate at year round low flow is therefore equivalent to a 37.9% reduction in Q_{95} .

Immediately downstream of the Eastern Cleddau River / Afon Syfynwy confluence, river flow is estimated to be around 88% of the Canaston Bridge gauged flows (based on flow apportionment by annual average flow). Flow statistics at the top of Reach 2 are therefore estimated as year round low flow (Q_{95}) 84.8Ml/d and moderate flow (Q_{50}) 307.1Ml/d. A 36.4Ml/d reduction in the reservoir release rate at year round low flow would thus equate to a reduction in Q_{95} of 42.9%.

The reduction of 36.4Ml/d in the reservoir release rate results in river flow reductions of up to 42.9% at times of low flow (Q_{95}) but there would be no flow reductions in Reach 2 at times of moderate (Q_{50}) flow. This is therefore assessed as a **moderate** hydrological impact for the winter period of October to November inclusive.

For the summer period (April to September inclusive), the relevant flow statistics at the top of Reach 2 are: summer Q_{95} 74.9Ml/d, summer Q_{99} 58.6Ml/d. The flow reductions at these summer low and extreme low values are estimated to be up to 36.4Ml/d (depending on abstraction rate at Canaston), representing reductions of 48.5% and 62% respectively. At the lower end of the reach, the relevant flow values are: summer Q_{95} 84.7Ml/d, summer Q_{99} 66.3Ml/d, with the 36.36Ml/d flow reduction representing 42.9% and 54.8% percentage reductions. The hydrological impact of the drought order in Reach 2 is therefore assessed as **major** during the summer period of August to September inclusive.

As for Reach 1, the new seasonal licence conditions could potentially involve additional regulation releases occurring during April to June and October to December, and this will in practice have some influence on the flow regime. However the estimated flow statistics are still representative of typical low flows downstream of the confluence, and percentage flow reductions would not be any greater under a scenario with additional releases taking place.

Reach 3 – Eastern Cleddau, Canaston intake to tidal limit

In Reach 3, flow is reduced by the Welsh Water abstraction intake at Canaston. Flow statistics at the top of Reach 3 are therefore estimated as: year round low flow (Q_{95}) 71.1Ml/d and year round moderate flow (Q_{50}) 314.2Ml/d. No reduction in the year round moderate flow would be anticipated as a result of the drought order. A 36.36Ml/d reduction in the reservoir release

rate would equate to a reduction in year round low flow (Q_{95}) of 51%. The hydrological impacts of the drought order in Reach 3 have therefore been assessed as being **moderate** for the winter period of October to November inclusive.

For the summer period of April to September inclusive, the relevant flow statistics are: summer Q_{95} 57.9Ml/d, summer Q_{99} 42.3Ml/d. The daily abstraction rate is required to be supported by regulation releases from Llys-y-Fran Reservoir when the residual flow is 68.2Ml/d or below, downstream of Canaston intake, but this flow condition could be reduced to 34.1Ml/d under the drought order. Reductions of up to 36.4Ml/d in the residual flow value represent reductions of 63% and 86% in the Q_{95} and Q_{99} values respectively. The hydrological impacts of the drought order in Reach 3 have therefore been assessed as being **major** for the summer period (August to September inclusive). It should be noted that is an extreme scenario which would only occur during the period when residual flows are dropping between the values of 68.2Ml/d and 34.1Ml/d.

As for Reach 2, there may be some increases in flow during the periods April to June and October to December due to additional regulation releases required under the new licence conditions, however it is assumed that percentage reductions will not be any greater than the values estimated above. As a precautionary approach the assessment is based on the percentage reductions determined from existing data sets as above.

At the tidal limit of the Eastern Cleddau, the catchment area has increased by approximately 25km² (a 13.6% increase) relative to the Canaston Bridge Gauging Station and therefore some further flow accretion may be anticipated. However, the magnitude of this additional catchment flow at the key low flow values indicated in **Table B2.6** would be relatively small, giving estimated flow statistics of summer Q_{95} 69.4Ml/d and summer Q_{99} 51.2Ml/d. The flow reduction of up to 36.4Ml/d represents reductions of 52% and 71% respectively, and so the hydrological impact of the drought order in summer months would still be assessed as **major** at the tidal limit. In winter months, the year round low flow (Q_{95}) would be estimated at 84.1Ml/d and so the flow reduction of up to 36.4Ml/d would represent a percentage reduction of 43%. The hydrological impacts of the drought order at the tidal limit are therefore been assessed as being **moderate** for the winter period.

Downstream of the tidal limit, there are about ten small streams flowing into the Eastern Cleddau before it merges with the Western Cleddau, including the Penglyn Brook and the Minwear Brook. There are no flow records available for these small tributaries, however the ratio of their combined catchment area (15.17km²) with that of the Eastern Cleddau at Canaston Bridge can be used to estimate summer low and extreme low flow contributions of 4.84Ml/d (Q_{95}) and 2.85Ml/d (Q_{99}) respectively. These freshwater flows provide some limited mitigation of the flow reduction due to the drought order, however the percentage reductions in the summer Q_{95} and Q_{99} still represent 49% and 67% of the freshwater flow to the tidal stretch of the Eastern Cleddau. This would be assessed as a **major** hydrological impact during the summer months. In the winter, the year round low flow contribution from the ten small tributaries can be estimated by catchment area ratio to be 6.32Ml/d (Q_{95}). The percentage flow

reduction due to the drought order in the overall freshwater flow to the tidal stretch of the Eastern Cleddau would therefore be about 40%. This would be assessed as a **moderate** hydrological impact during the winter months.

Habitats Directive Ecological River Flow Analysis

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}

In order to calculate a HDERF flow series for the river reach downstream of the Canaston intake, a data set produced by Welsh Water using their water resources model for the Eastern Cleddau catchment was used. The model output was from a baseline run using the new licence conditions applicable from 31 March 2019 and therefore enabled the effect of the drought order to be estimated with the new licence conditions applied to the historic inflow series. A semi-naturalised flow was calculated from the model output to represent the unsupported flow at Canaston Bridge (as defined in the abstraction licence), and this was then multiplied by a factor of 1.1 to represent the flow accretion from two small tributaries between the gauging station and the abstraction intake.

Daily HDERF flow values were calculated using the year-round Q_{50} and Q_{95} flow statistics of the modelled semi-naturalised flow series to determine the maximum percentage reductions in naturalised daily flows as specified above. The resulting flow statistics were 461.36Ml/d (Q_{50}) and 86.75Ml/d (Q_{95}). As a comparison the year-round Q_{50} and Q_{95} flow statistics were also calculated by area-flow apportionment from the 1969 – 2017 gauged record for the nearby Afon Gwaun at Cilrhedyn Bridge, as shown in **Table B2.7**.

Table B2.7 Estimation of long-term naturalised flow statistics for Canaston Bridge by area-flow apportionment with Gwaun at Cilrhedyn Bridge

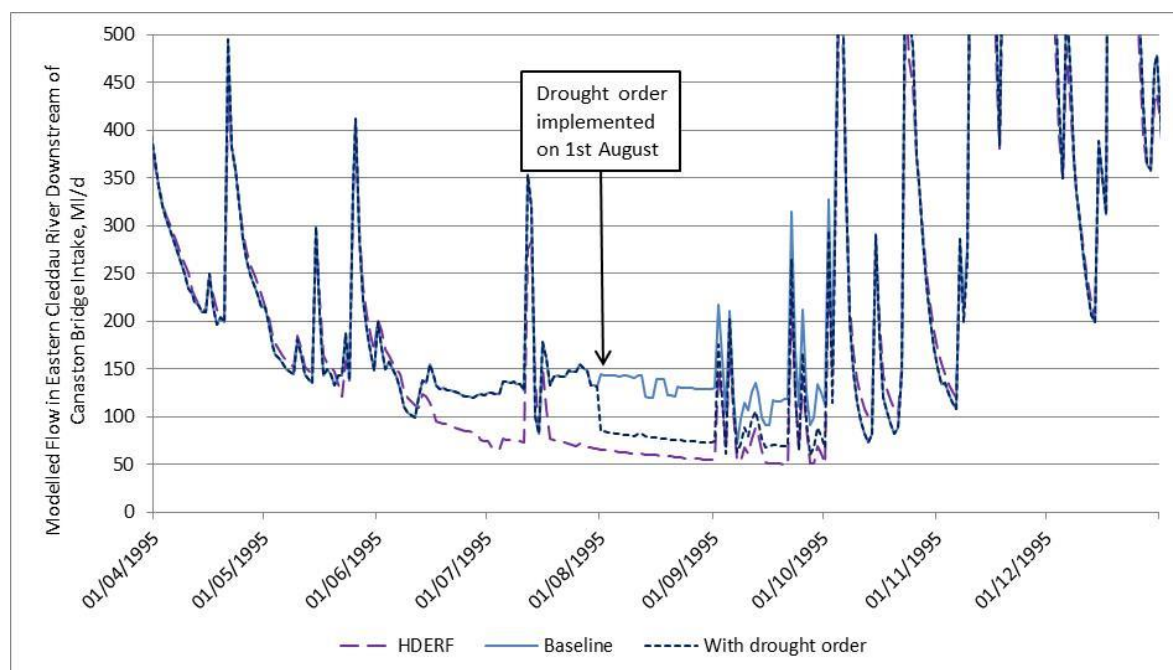
Location	Grid Reference	Catchment Area (km ²)	SAAR (mm)	AAF Ratio to Gwaun at Cilrhedyn Bridge	Year Round Q_{50} (Ml/d)	Year Round Q_{95} (Ml/d)
Canaston Bridge Gauging Station, R. Eastern Cleddau river (Natural)	SN072152	183.1	1437	5.37	358.2	84.9
Afon Gwaun at Cilrhedyn Bridge (1969 – 2017)	SN005349	31.3	1565	-	66.7	15.8

The value for Q_{95} is very similar; the value for Q_{50} is somewhat lower however this is less critical as the low flow values are of more relevance to the assessment of drought option effects. The similarity of the Q_{95} values provides assurance that the scaled Gwaun flow values are a reasonable proxy.

Figure B2.6 below illustrates the theoretical change in flow downstream of Canaston Bridge intake due to the drought order in a representative dry year (1995). Note that the change in reservoir outflow due to the drought order conditions has been calculated theoretically from the daily modelled values of regulation release, abstractions and downstream flows, and may not reflect how the regulation releases would be operated in practice.

Note also that the vertical scale is limited to 500Ml/d in order to highlight the changes in the low flow regime, so higher flows above 500Ml/d are not shown. The HDERF flow series for the Eastern Cleddau at Canaston intake, as outlined above, is also shown on this hydrograph.

Figure B2.6 Modelled Mean Daily Flow in the Eastern Cleddau River downstream of Canaston Bridge Intake, Baseline & With Drought Order (1995)



Analysis of the adjusted/modelled flows downstream of the Canaston intake indicates that for the baseline case the HDERF daily flows are met on around 269 days (73.7%) of the calendar year of 1995. With the drought order in place, the HDERF flows are met on 264 (72.3%) of the year, a reduction of 5 days or 1.4% of the days overall. The potential impact of the drought order is to increase the number of days that the HDERF is not met in the year of implementation, by less than a week, based on theoretical analysis of summer 1995 flow data and assuming that the drought order would be implemented on 1/8/1995. However the impact on achieving the HDERF objective in any future drought would depend on the drought conditions and flow patterns occurring at the time.

As a sensitivity check, the water resources model data set was also used to determine the maximum reduction in regulation release under the drought order (61.8Ml/d) and calculate the percentage reduction in the modelled flows downstream of the Canaston intake (i.e. Reach 3). The resulting percentage reductions in the summer Q_{99} and Q_{95} values were 78% and 63% respectively, which would be assessed as a **major** hydrological impact. In the winter months, the reduction in the year round Q_{95} flow value would be 57%, which would be assessed as a **moderate** hydrological impact. These results are broadly consistent with the assessment for Reach 3 based on the historic data.

B.2.2.3 Hydrological Impact Summary

Three reaches have been considered of which all have a **major** hydrological impact due to the drought order during the summer period (August – September inclusive). During the winter months (October – March inclusive) the impact for all three reaches is assessed as **moderate**. The three impacted reaches are shown in **Table B2.8** and **Table B2.9** and establish the full in-channel zone of influence of the drought order for environmental sensitivity screening (see **Figure B1.1**).

As outlined previously, as a precautionary approach and in the absence of suitable data sets reflecting the new licence conditions, the assessment has been based on the existing data sets to determine potential percentage changes in flow. Under the revised licence conditions, additional regulation releases could potentially be required during low flow periods occurring during April to June and October to December, and these are likely to generally reduce the impact of the drought order. However, there may be specific occasions on which a partial regulation release is required, due to the flow bands specified in the licence conditions, so that the flow reduction resulting from the reduced trigger flow condition at Canaston may at certain times be a greater percentage reduction of the flow.

Analysis of modelled flows for 1995, as outlined previously, suggests that the drought order may increase the number of days that the HDERF indicator value is not met downstream of the Canaston Bridge intake. Depending on the period of implementation, the HDERF is breached for an additional 5 days approximately, compared to the baseline drought.

Table B2.8 Hydrological Reaches Identified in the Study Area – Winter (October to March) Impact

Hydrological Reach		Reach Boundary		Reach Length (km)	% flow reduction		Hydrological Impact - Winter
					Year round Q ₅₀	Year round Q ₉₅	
1	Afon Syfynwy	Llys-y-Fran Reservoir	Confluence with the Eastern Cleddau River	10km	0%	73%	Moderate
2	Eastern Cleddau	Confluence with the Afon Syfynwy	Canaston Intake	6.5km	0%	42.9%	Moderate
3	Eastern Cleddau	Canaston Intake	Tidal limit	0.1km	0%	51%	Moderate

Table B2.9 Hydrological Reaches Identified in the Study Area – Summer (April to September) Impact

Hydrological Reach		Reach Boundary		Reach Length (km)	% flow reduction		Hydrological Impact - Summer
					Summer Q ₉₅	Summer Q ₉₉	
1	Afon Syfynwy	Llys-y-Fran Reservoir	Confluence with the Eastern Cleddau River	10km	73%	73%	Major
2	Eastern Cleddau	Confluence with the Afon Syfynwy	Canaston Intake	6.5km	48.5%	62%	Major
3	Eastern Cleddau	Canaston Intake	Tidal limit	0.1km	63%	86%	Major

B3 PHYSICAL ENVIRONMENT ASSESSMENT

B.3.1 Geomorphology

Geomorphology information for the Afon Syfynwy and Eastern Cleddau catchment has been obtained from the results of walkover surveys undertaken for Welsh Water during summer 2011. In addition, there are two NRW River Habitat Survey (RHS) sites located in Reach 1 (Survey ID 3967 and 5083) and two located in Reach 2 (Survey ID 1011 and 4011). There are no RHS sites in Reach 3 (see **Figure B1.1**).

Reach 1 - Afon Syfynwy, Llys-y-Fran Reservoir to Eastern Cleddau Confluence

Reach 1 is characterised by irregular meanders in a very shallow vee-shaped valley. Channel widths vary slightly throughout the reach although are between 7-10m. Riparian tree cover along the reach is dense and is characterised by semi-continuous to continuous tree cover.

A review of the walkover survey data shows that the reach is predominantly a mixture of gravel / pebble and cobble sized particles, with some silt noted towards the end of the reach. Riffles are noted as occurring extensively in the reach. Silt is also noted as being present at the margins of the river in this reach.

The flow type in Reach 1 was recorded as predominantly rippled with broken and unbroken standing waves. This reflects the extensive nature of riffles within the reach and interactions between flow depth and the channel substrate. Smooth flow was also noted throughout the reach, likely representing pools between riffles.

The walkover survey has identified that the reach is characterised predominantly by erosional features, although depositional features are present, particularly in the initial 2.7km of the reach. The erosional features are linked to erosion of the earth banks and are characterised by active eroding cliffs and slumping and poaching. However, no significant areas of bank collapse or signs of channel avulsion have been noted. Depositional features are characterised by channel bars. These data highlight that the reach is predominantly erosional but appears to be responding to the current flow and sediment regime.

Surrounding land use is predominantly rough pasture and improved grassland with some areas of broadleaf woodland towards the start of the reach.

Reach 2 – Eastern Cleddau

Reach 2 is characterised by irregular meanders in a very shallow vee-shaped valley. Channel widths are predominantly between 12-14m through most of the reach, increasing towards the end of the reach to 18-23m. Riparian tree cover along the reach is dense and is characterised by semi-continuous to continuous tree cover in the upper portion of the reach, decreasing to isolated / scattered in the lower portion of the reach.

A review of the walkover survey data shows that the reach is predominantly a mixture of gravel / pebble and cobble sized particles. Riffles are noted as occurring frequently and extensively

in the reach. Sand forms the bed substrate towards the middle of the reach ~3.0km downstream with bedrock also noted here.

The flow type in Reach 2 was recorded as predominantly rippled with broken and unbroken standing wave. This reflects the extensive nature of riffles within the reach and interactions between flow depth and the channel substrate. Smooth flow was also noted throughout the reach, likely representing pools between riffles. A single area of upwelling was also noted towards the end of the reach.

The walkover survey has identified that the reach is characterised predominantly by erosional features, although depositional features are present, particularly in the initial 3.0km of the reach. The erosional features are linked to erosion of the earth banks and erosion is characterised by active eroding cliffs and slumping and poaching. However, no significant areas of bank collapse or signs of channel avulsion have been noted. Depositional features are characterised by channel bars. These data highlight that the reach is dominantly erosional but appears to be responding to the current flow and sediment regime.

Surrounding land use is predominantly improved grassland with some areas of broadleaf woodland towards the start of the reach.

Reach 3 – Eastern Cleddau

Reach 3 is very short and is slightly sinuous and is surrounded by floodplains. Channel width is approximately 25m. Riparian tree cover along the reach is limited and is characterised by isolated/scattered trees on the right bank and semi-continuous to continuous on the left bank.

A review of the walkover survey data shows that in the initial 0.6km of Reach 2 bed substrate is predominantly gravel / pebble sized particles, although some bedrock was noted around the margins during a field visit in July 2011.

The flow type in Reach 3 was recorded as wholly smooth with no other flow types identified.

The walkover survey has identified no erosional or depositional features in the reach.

Surrounding land use is predominantly improved grassland on the right bank with broadleaf woodland on the left bank.

B.3.1.1 Anthropogenic Features

Reach 1 - Afon Syfnwy, Llys-y-Fran Reservoir to Eastern Cleddau Confluence

The walkover survey has identified three barriers in Reach 1. The existing RHS sites within this reach indicate low anthropogenic influence in the upper section of the reach with only poaching noted. The RHS data notes a significant increase in anthropogenic features towards the end of the reach with fords, outfalls, reinforced banks and bridges contributing to a Habitat Modification Score of 365.

Reach 2 – Eastern Cleddau

No barriers have been identified by the walkover survey in Reach 2. The existing RHS sites within this reach indicate low anthropogenic influence in the upper section of the reach, with only poaching and reinforced banks noted. The RHS data in the lower reach records a significant increase in anthropogenic features, particularly from reinforced banks and the presence of bridges, which contribute to a Habitat Modification Score of 690.

Reach 3 – Eastern Cleddau

A weir is present at both the upstream and downstream boundaries of Reach 3.

B.3.1.2 Conclusions

In drought conditions, it is assumed that no significant geomorphological activity (i.e. erosion or transport or depositional processes) will be occurring within the catchment or river and sediment supply to the river is likely to be negligible (given the nature of the catchment described above and the presence of the reservoir in controlling sediment movement). The existing data show that total suspended solid concentrations in the river are generally very low (see Section 3.2 below). Therefore, it is concluded that the impact of the drought order on sediment dynamics in all three reaches is **negligible**.

During the operation of a drought order, flows would be reduced significantly in Reach 1. These decreases in flow may result in changes in flow depth and increased exposure of channel banks. This could potentially lead to desiccation of earth banks during drought conditions, increasing the risk of bank collapse due to gravity and increasing the potential for erosion of dry earth as normal flows resume post the drought order. Furthermore, as the drought order is operating during the winter months, there is an increased risk of erosion of the banks due to freeze-thaw action. However, given the dominantly erosive nature of all reaches in the study area (as set out above), and the fact that the features all suggest that the Afon Syfynwy and Eastern Cleddau are responding to the current flow and sediment regime and variations therein, the influence and impact of bank erosion caused by reducing flows is taken to be **negligible**.

The change in flow depth may also expose sections of the channel bed, particularly in Reach 1. This could lead to increased exposure of any in channel features such as riffles (which were noted as being extensive throughout Reach 1) and bars. In addition, the reduction in flow depth may impact on flow velocity due to increasing friction between the bed surface and flow, possibly leading to protrusion of the coarser bed particles through the flow surface. The reduction in velocities could impact on particle dynamics. However, given the very low total suspended solid concentrations and, where visible, the general gravel / pebble nature of the channel bed, the impacts of reductions in flow are concluded to be **negligible**.

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 wastewater/sewage treatment works), 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 Water Framework Directive (WFD) classification, NRW has set out² (following UK Technical Advisory Group (UKTAG) evidence³) 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 permit 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 it may not be necessary to undertake a separate temperature assessment).

Ten years of NRW routine water quality monitoring data were reviewed to provide an overview of water quality in the zone of hydrological impact. On the Afon Syfynwy, within the extent of influence of the drought order (Reach 1), there are five NRW water quality sampling sites. On the Eastern Cleddau (Reaches 2 and 3), 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.

Where data are lacking the assessment has been undertaken using professional judgement. Values at the limit of detection have been halved in line with standard NRW / Environment Agency practice.

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

³ 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 Water Quality Sampling Points on the Afon Syfynwy

Reach	Site Name	NRW Site Code	Grid reference	Location
1	Llys-y-Fran Reservoir at boathouse	32688	SN0385024450	Llys-y-Fran Reservoir at boathouse
	Afon Syfynwy at Llys-y-Fran	32402	SN0375824226	Afon Syfynwy D/S of Llys-y-Fran Reservoir
	Syfynwy below Walton Mill Fish Farm	86046	SN0371222674	Upstream of Slade Brook
	Syfynwy at Stepside Bridge Sample U/S of Bridge	73775	SN0488722211	Afon Syfynwy at Stepside Bridge
	Gelli	32406	SN0825019540	Afon Syfynwy U/S of confluence with Eastern Cleddau
2	E.Cleddau at Canaston RB	88181	SN0671715186	Eastern Cleddau U/S of confluence with Narbeth Brook
3	Eastern Cleddau Source	120010	SN0644514931	Eastern Cleddau near tidal limit D/S of confluence with Narbeth Brook

These reaches fall within the Cleddau SAC and as such have been compared against the specific conservation objectives. The specific water quality objectives for this SAC are given in **Table B3.2**.

Table B3.2 – Cleddau SAC specific water quality objectives

Dissolved Oxygen	Biological Oxygen demand	Total ammonia	Unionised ammonia	pH	Phosphate
85	1.5	0.25	0.021	6-9	0.039

Reach 1 (Afon Syfynwy, Llys-y-Fran Reservoir to Eastern Cleddau confluence)

Water quality data are available for five NRW monitoring points on Reach 1 (major hydrological impact). Data are available for: Llys-y-Fran Reservoir at boathouse (site 32688); Afon Syfynwy at Llys-y-Fran (site 32402); Syfynwy below Walton Mill Fish Farm (site 86046); Syfynwy at Stepside Bridge Sample U/S of Bridge (site 73775) and Gelli (site 32406).

The average pH at Llys-y-Fran Reservoir at boathouse over the ten year review period was 7.4 and the maximum water temperature was 20.5 °C. The average pH at Afon Syfynwy at Llys-y-Fran over the ten year review period was 7.4 and the maximum water temperature was 19.2 °C. The average pH at Syfynwy below Walton Mill Fish Farm over the ten year review period was 7.5 °C and the maximum water temperature was 7.2 °C. The average pH at Syfynwy at Stepside Bridge Sample U/S of Bridge over the ten year review period was 7.5 °C and the maximum water temperature was 7.5 °C. The average pH at Gelli over the ten year review period was 7.3 and the maximum water temperature was 18.0 °C.

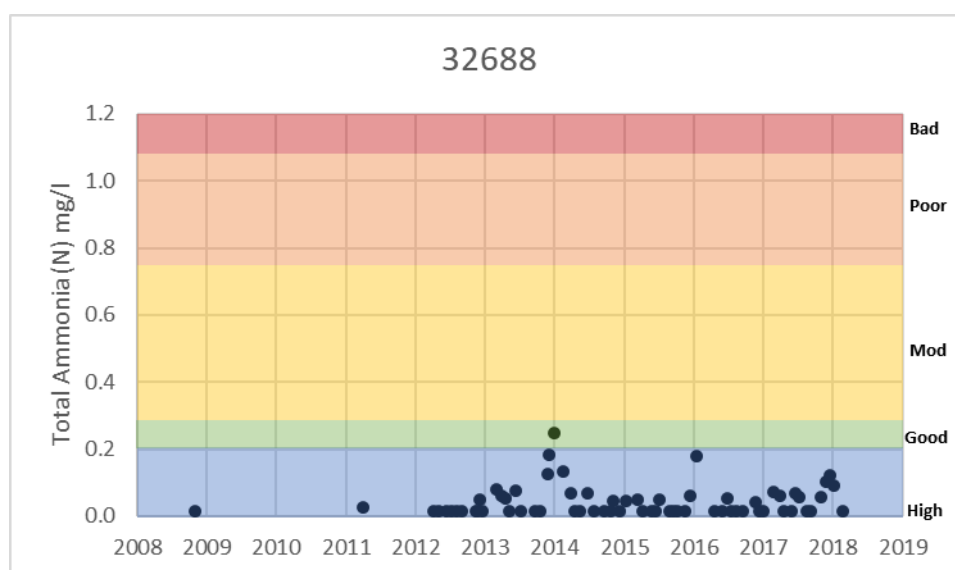
Sites on the Afon Syfynwy show low concentrations of total suspended solids. Afon Syfynwy

at Llysyfran has a maximum total suspended solids of 7.4mg/l and a median of 1.5mg/l, suggesting total suspended solids are low for most of the available monitoring period. At the Gelli site, the maximum total suspended solids values was 108mg/l, with median total suspended solids of 4.15mg/l. Values above 20mg/l are the response to storm events in the catchment.

Total ammonia concentration

Total ammonia concentration for the Llys-y-Fran Reservoir at boathouse was reviewed and data presented in **Figure B3.1** against the relevant WFD standards for an upland low alkalinity river⁴.

Figure B3.1 Total Ammonia in the Llys-y-Fran Reservoir at boathouse, Incorporating Appropriate WFD Status Bands



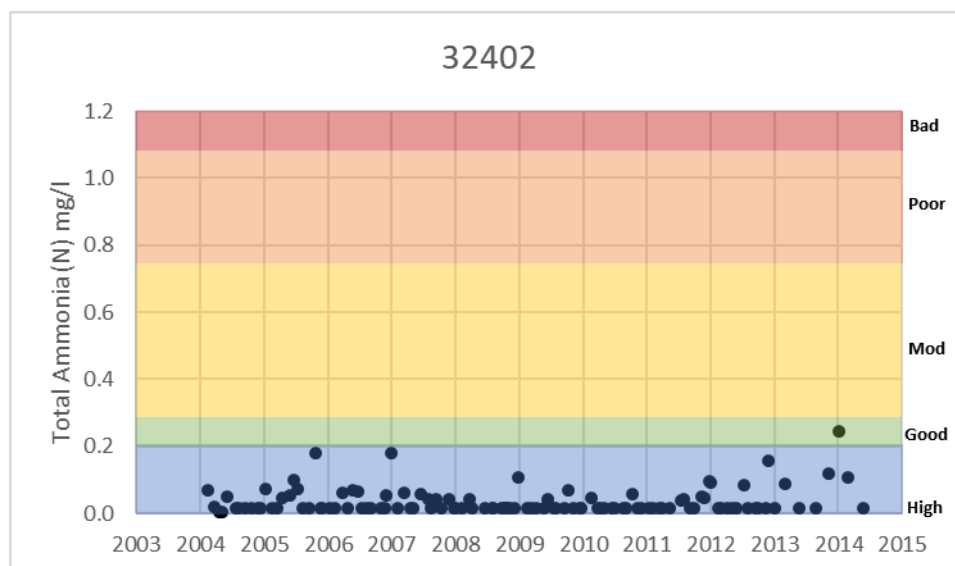
Total ammonia (N) concentrations at the Llys-y-Fran Reservoir at boathouse (see **Figure B3.1**) were all consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). One instance of Good status is observed on 02/12/2014 with 0.25 mg/l suggesting an isolated incident.

Total ammonia concentration for the Afon Syfynwy at Llys-y-Fran was reviewed and data presented in **Figure B3.2** against the relevant WFD standards for an upland low alkalinity river⁵.

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

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

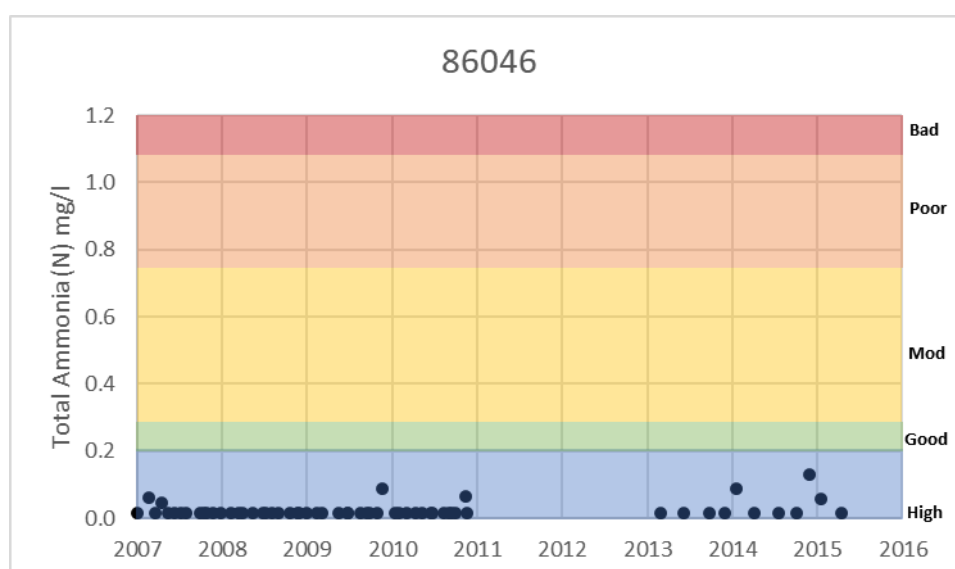
Figure B3.2 Total Ammonia in the Afon Syfynwy at Llys-y-Fran, Incorporating Appropriate WFD Status Bands



Total ammonia concentrations on the Afon Syfynwy at Llys-y-Fran (see **Figure B3.2**) were all consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). One exception is noted on 04/12/2014 with 0.24 mg/l. Consequently good WFD status is achieved on this date.

Total ammonia concentration for the Syfynwy below Walton Mill Fish Farm, above Slade Brook was reviewed and data presented in **Figure B3.3** against the relevant WFD standards for an upland low alkalinity river⁶.

Figure B3.3 Total Ammonia in the Syfynwy below Walton Mill Fish Farm, above Slade Brook, Incorporating Appropriate WFD Status Bands

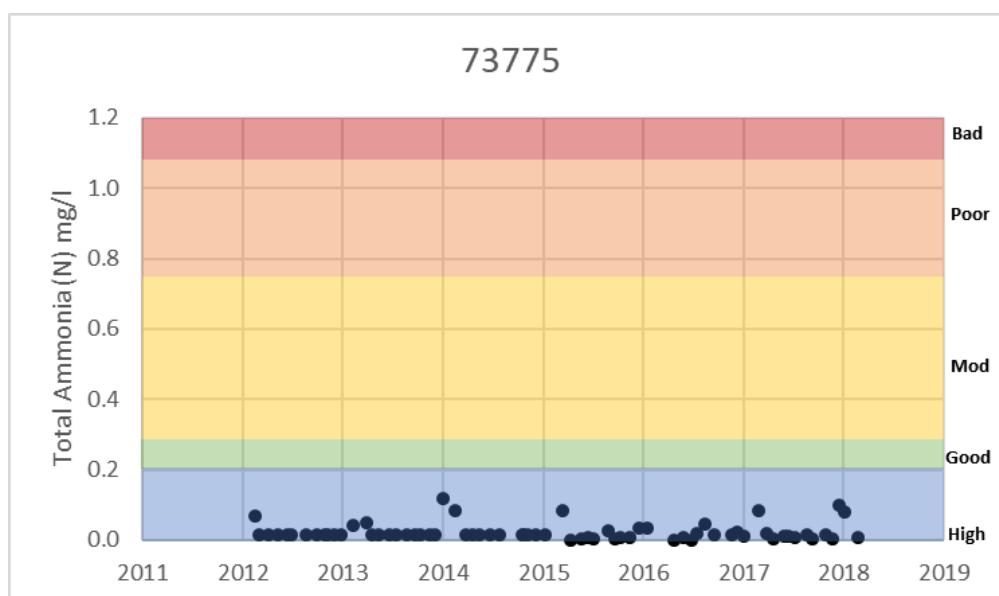


⁶ The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

Total ammonia concentrations on the Syfynwy below Walton Mill Fish Farm, above Slade Brook (see **Figure B3.3**) were all consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l).

Total ammonia concentration for the Afon Syfynwy at Stepside Bridge was reviewed and data presented in **Figure B3.4** against the relevant WFD standards for an upland low alkalinity river⁷.

Figure B3.4 Total Ammonia in the Afon Syfynwy at Stepside Bridge, above Slade Brook, Incorporating Appropriate WFD Status Bands



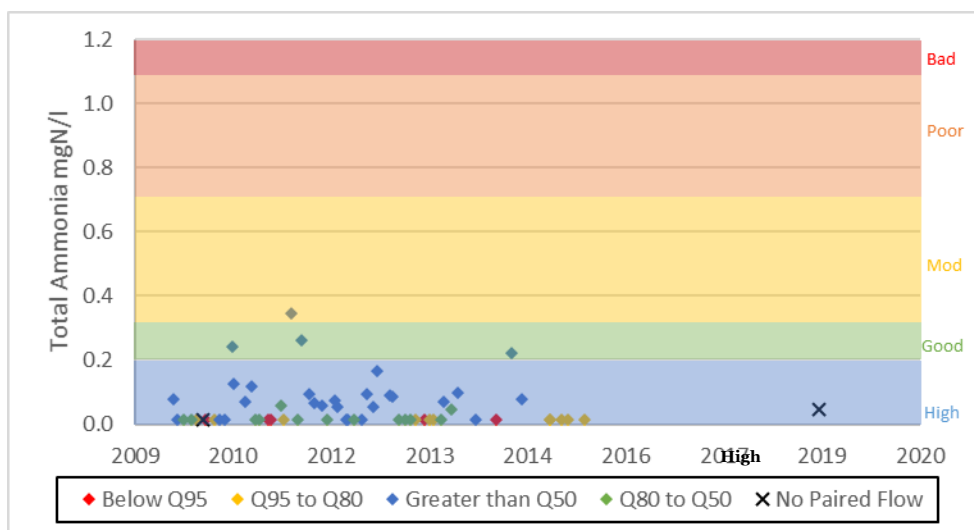
Total ammonia concentrations on the Afon Syfynwy at Stepside Bridge (see **Figure B3.4**) were all consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l).

Total ammonia concentration for the Afon Syfynwy at Gelli was reviewed and data presented in **Figure B3.5** against the relevant WFD standards for an upland low alkalinity river⁸.

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

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

Figure B3.5 Total Ammonia in the Afon Syfynwy at Gelli, above Slade Brook, Incorporating Appropriate WFD Status Bands

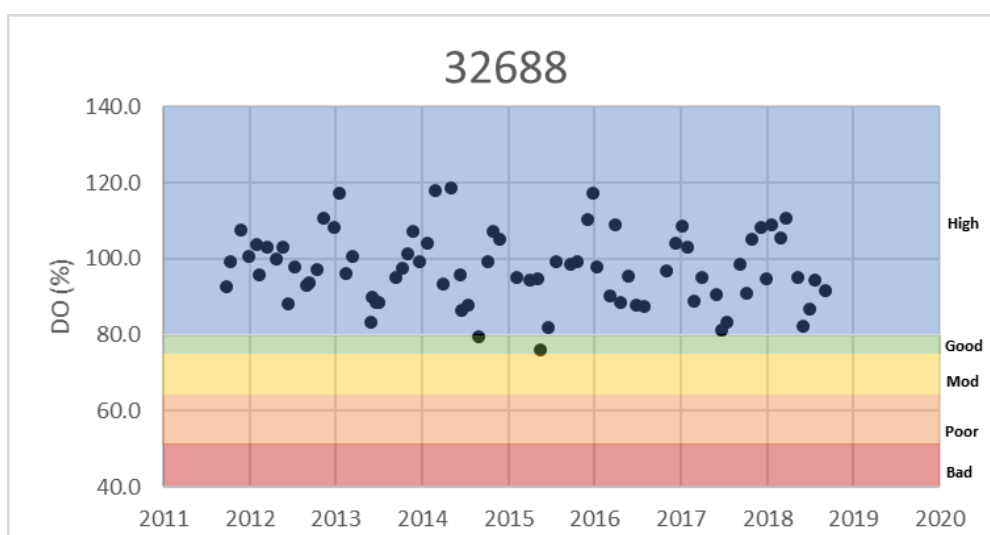


Total ammonia concentrations on the Afon Syfynwy at Gelli (see **Figure B3.5**) were predominantly consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). Good status is observed on three occasions:; 17/11/2010 at 0.24 mg/l; 03/11/2011 at 0.26 mg/l and 06/10/2014 at 0.22 mg/l. Moderate status is also noted once with 0.34 mg/l on 12/09/2011.

Dissolved oxygen saturation

Dissolved oxygen saturation for monitoring site 32688 on the Llys-y-Fran Reservoir at Boathouse was reviewed and data are presented in **Figure B3.6** against the relevant WFD standards for an upland low alkalinity river⁹.

Figure B3.6 Dissolved Oxygen Concentrations on the Llys-y-Fran Reservoir at Boathouse, Incorporating Appropriate WFD Status Bands

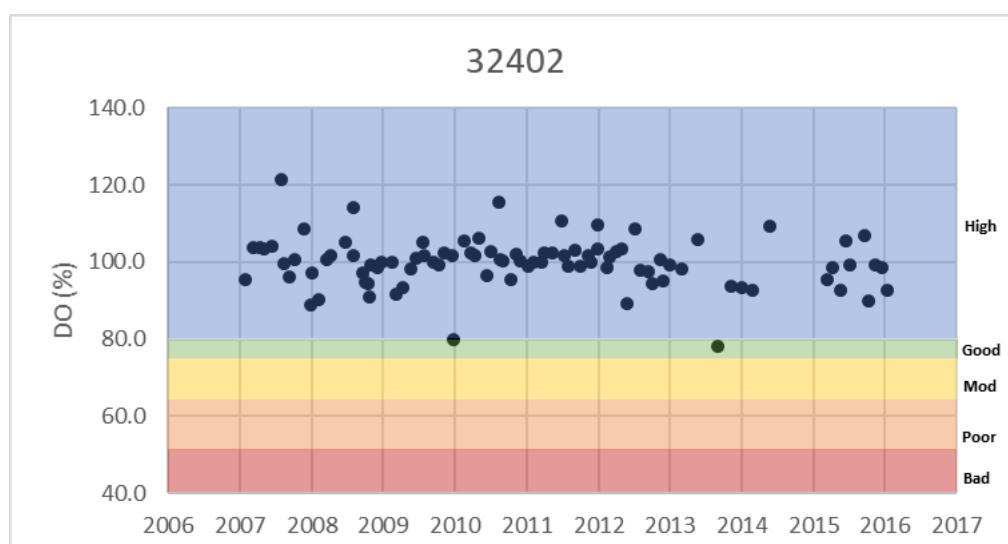


⁹ The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

Dissolved oxygen saturation measurements for Llys-y-Fran Reservoir at Boathouse (see **Figure B3.6**) were mostly consistent with the WFD standard to support high status for fish and invertebrates (80%). One exception is notable on 06.10.2015 with 76.1% resulting in Good WFD status. This appears to be an isolated incident.

Dissolved oxygen saturation at the Afon Syfynwy at Llys-y-Fran was reviewed and data are presented in **Figure B3.7** against the relevant WFD standards for an upland low alkalinity river¹⁰.

Figure B3.7 Dissolved Oxygen Concentrations on the Afon Syfynwy at Llys-y-Fran, Incorporating Appropriate WFD Status Bands



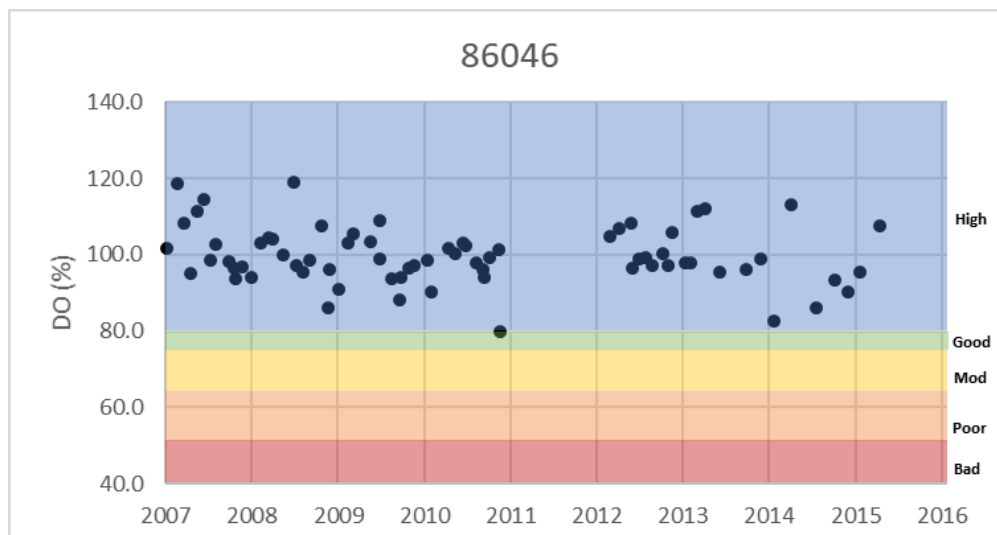
Dissolved oxygen saturation measurements at the Afon Syfynwy at Llys-y-Fran (see **Figure B3.7**) were mostly consistent with the WFD standard to support high status for fish and invertebrates (80%). In one instance Good WFD status is achieved on 30/07/2014 with 78% suggesting an isolated incident.

Dissolved oxygen saturation at the Afon Syfynwy at below Walton Mill Fish Farm was reviewed and data are presented in **Figure B3.8** against the relevant WFD standards for an upland low alkalinity river¹¹.

¹⁰ The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

¹¹ The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

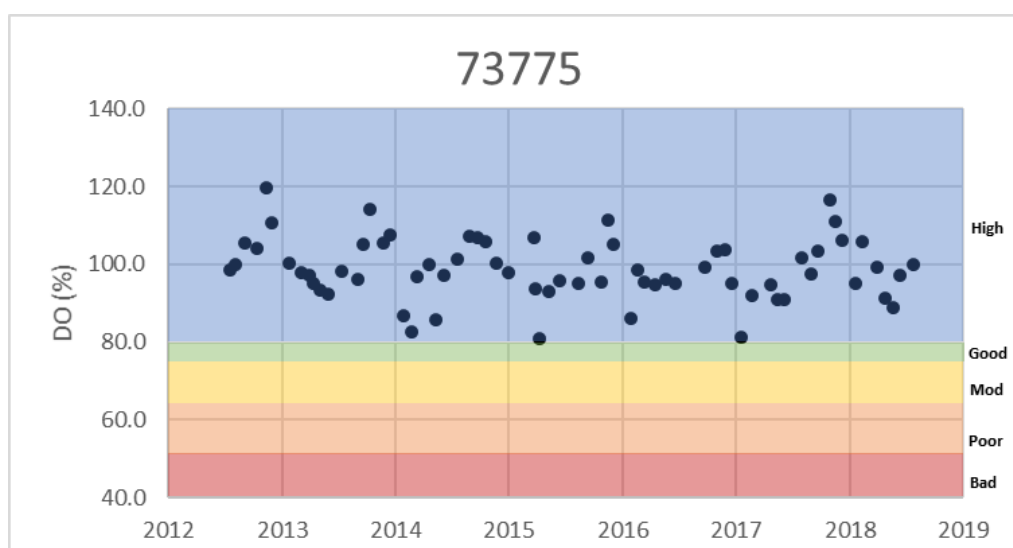
Figure B3.8 Dissolved Oxygen Concentrations on the Afon Syfynwy at below Walton Mill Fish Farm, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation measurements at the Afon Syfynwy below Walton Mill fish farm, above Slade Brook (see **Figure B3.8**) were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Dissolved oxygen saturation at the Afon Syfynwy at Stepside Bridge was reviewed and data are presented in **Figure B3.9** against the relevant WFD standards for an upland low alkalinity river¹².

Figure B3.9 Dissolved Oxygen Concentrations on the Afon Syfynwy at Stepside Bridge, Incorporating Appropriate WFD Status Bands

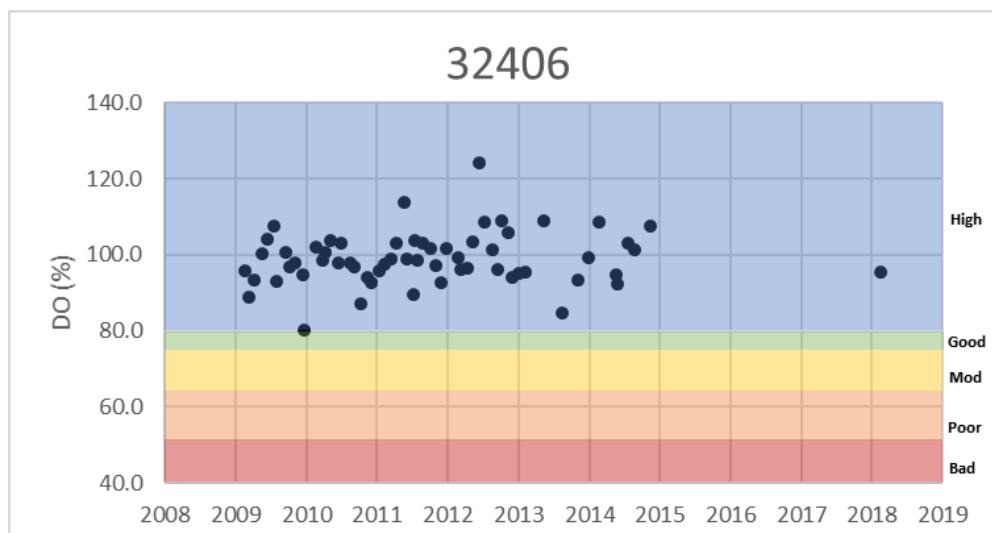


¹² The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

Dissolved oxygen saturation measurements at the Afon Syfynwy at Stepside Bridge (see **Figure B3.9**) were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Dissolved oxygen saturation on the Afon Syfynwy at Gelli was reviewed and data are presented in **Figure B3.10** against the relevant WFD standards for an upland low alkalinity river¹³.

Figure B3.10 Dissolved Oxygen Concentrations on the Afon Syfynwy at Gelli, Incorporating Appropriate WFD Status Bands



Dissolved oxygen saturation measurements on the Afon Syfynwy at Gelli (see **Figure B3.10**) were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

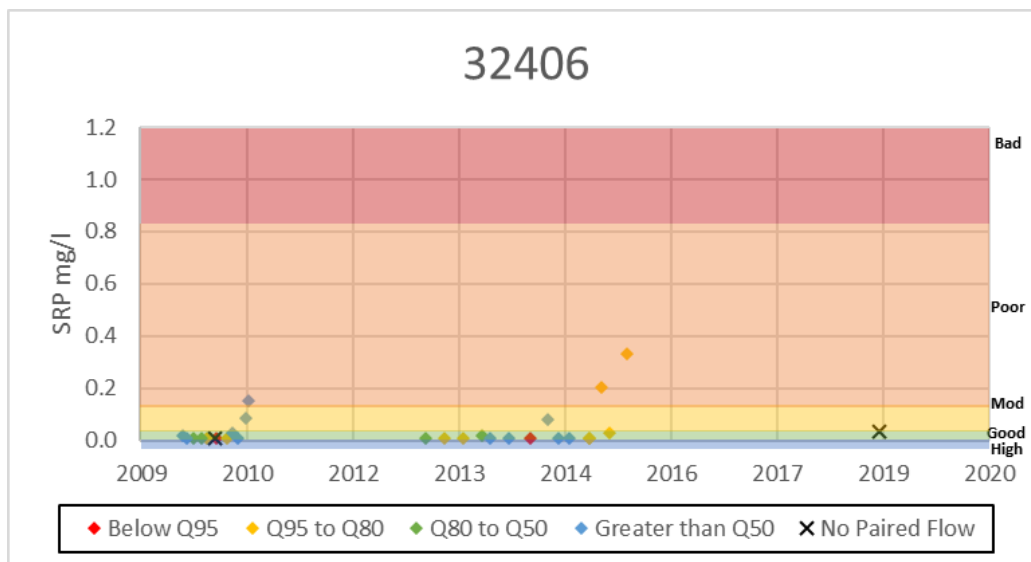
Soluble Reactive Phosphorus Concentration

Soluble Reactive Phosphorus (SRP) concentration for monitoring on the Afon Syfynwy at Gelli was reviewed and data are presented in **Figure B3.11** against the relevant site specific WFD standards¹⁴.

¹³ The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

¹⁴ 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 B3.11 Soluble Reactive Phosphorus on the Afon Syfynwy at Gelli, Incorporating Appropriate WFD Status Bands

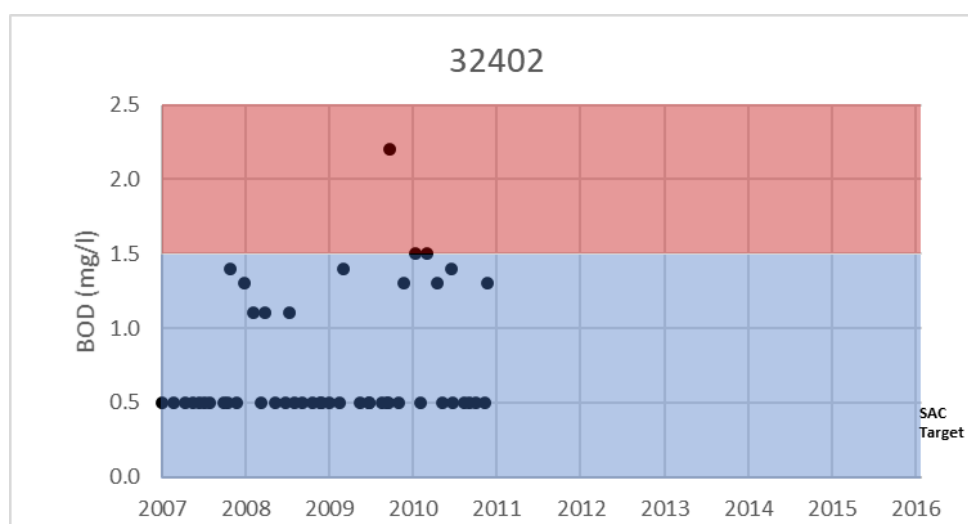


Soluble Reactive Phosphorus concentrations at Afon Syfynwy at Gelli (see **Figure B3.11**) were mostly consistent with the WFD standard to support good status for diatoms and macrophytes (0.04mgP/l). Values below good status were noted on 7 instances since 2009.

Biological Oxygen Demand

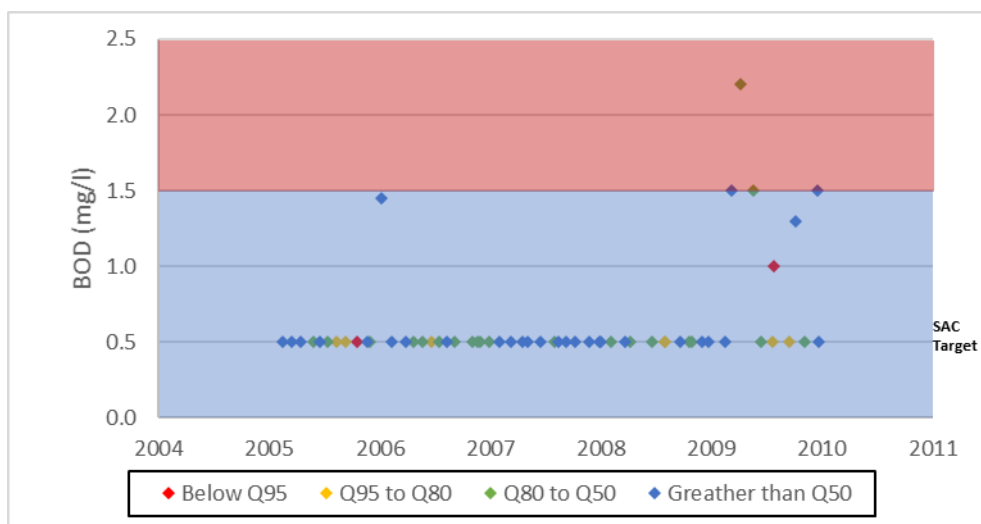
Biological Oxygen Demand (BOD) concentration in the Afon Syfynwy at Llys-y-fran was reviewed against the Cleddau SAC targets (**Figure B3.12**). BOD concentrations in the Afon Syfynwy were mostly compliant with the SAC BOD targets (1.5 mg/l) with only a single exceedance.

Figure B3.12 Biological Oxygen Demand in the Afon Syfynwy at Llys-y-fran, Incorporating Appropriate SAC Targets



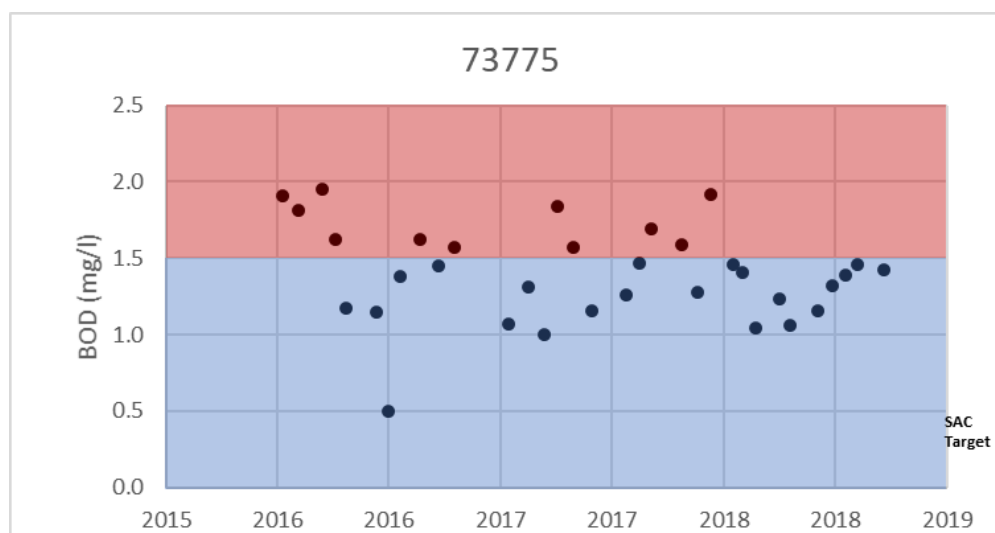
Biological Oxygen Demand (BOD) concentration in the Afon Syfynwy below Walton Mill Fish Farm was reviewed against the Cleddau SAC targets (**Figure B3.13**). BOD concentrations in the Afon Syfynwy were mostly compliant with the SAC BOD targets (1.5 mg/l) with only a single exceedance. Pairings with flow do not indicate a clear trend.

Figure B3.13 Biological Oxygen Demand in the Afon Syfynwy below Walton Mill Fish Farm, Incorporating Appropriate SAC Targets



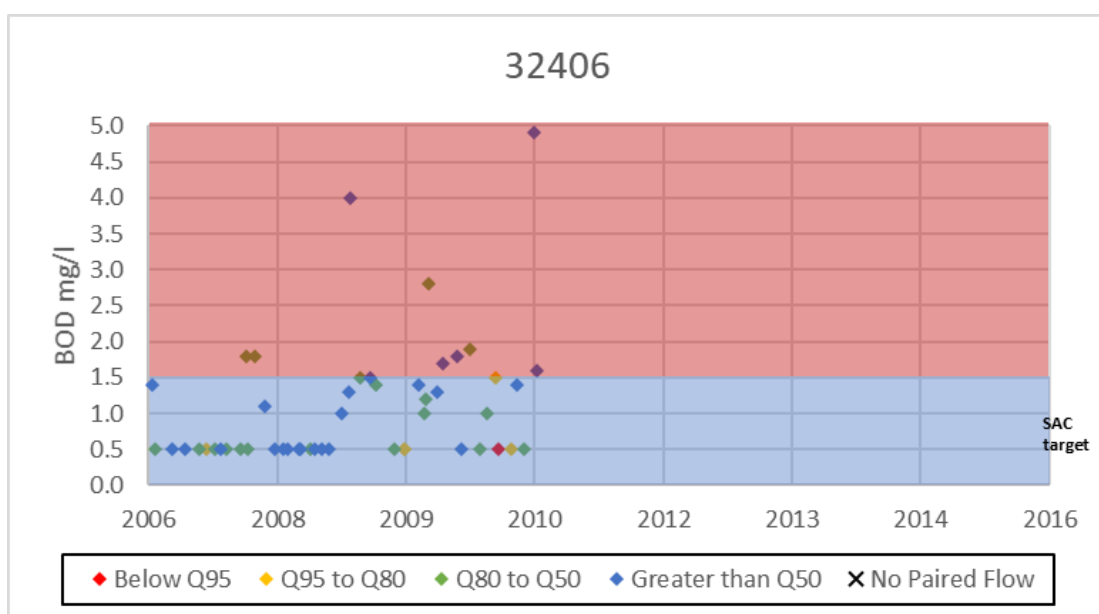
Biological Oxygen Demand (BOD) concentration in the Afon Syfynwy at Stepside Bridge Sample U/S of Bridge was reviewed against the Cleddau SAC targets (**Figure B3.14**). BOD concentrations in the Afon Syfynwy were variable with the SAC BOD targets (1.5 mg/l) 11 samples exceeding the target (32.4% of instances). Flow data for this period was not available however BOD peaks appear to correspond to winter and spring months suggesting possible rainfall influences.

Figure B3.14 Biological Oxygen Demand in the Afon Syfynwy at Stepside Bridge Sample U/S of Bridge, Incorporating Appropriate SAC Target



Biological Oxygen Demand (BOD) concentration in the Afon Syfynwy at Gelli was reviewed against the Cleddau SAC targets (**Figure B3.15**). BOD concentrations in the Afon Syfynwy were variable with the SAC BOD targets (1.5 mg/l) with 9 samples exceeding the target (15.3% of instances). Pairings with flow do not indicate a relationship however increases in BOD at this location are predominantly in the winter/spring period suggesting possible rainfall influences. BOD data were not available beyond 2010 at this location.

Figure B3.15 Biological Oxygen Demand on the Afon Syfynwy at Gelli, Incorporating Appropriate SAC Target



Reach 2 (Eastern Cleddau)

Water quality data are available for one NRW monitoring point on Reach 2 (negligible hydrological impact). Data are available for Eastern Cleddau at Canaston Road Bridge (site 88181) and represents the downstream section of Reach 2.

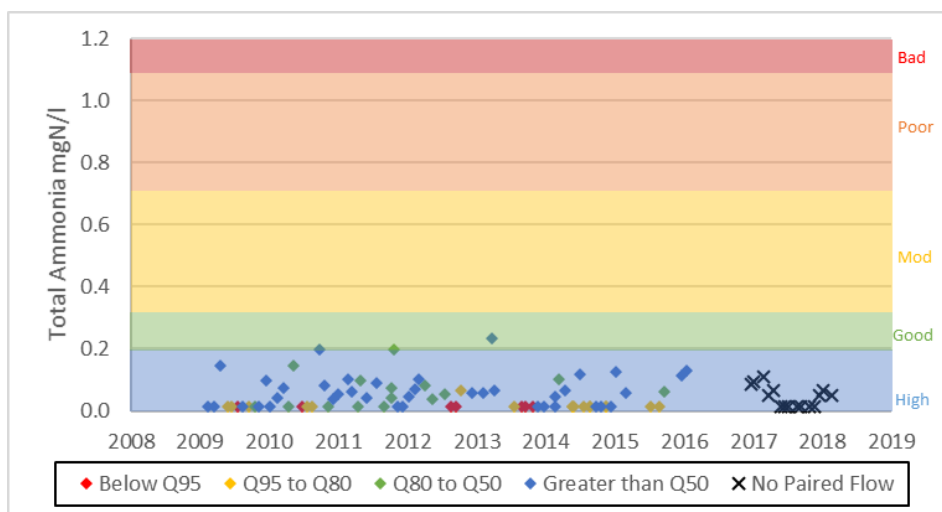
The average pH at Eastern Cleddau at Canaston Road Bridge over the ten year review period was 7.6 and the maximum water temperature was 17.7 °C.

Total ammonia concentration

Total ammonia concentration for the Eastern Cleddau at Canaston Road Bridge was reviewed and data presented in **Figure B3.16** against the relevant WFD standards for an upland low alkalinity river¹⁵.

¹⁵ 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 B3.16 Total Ammonia in the Eastern Cleddau at Canaston Road Bridge, Incorporating Appropriate WFD Status Bands

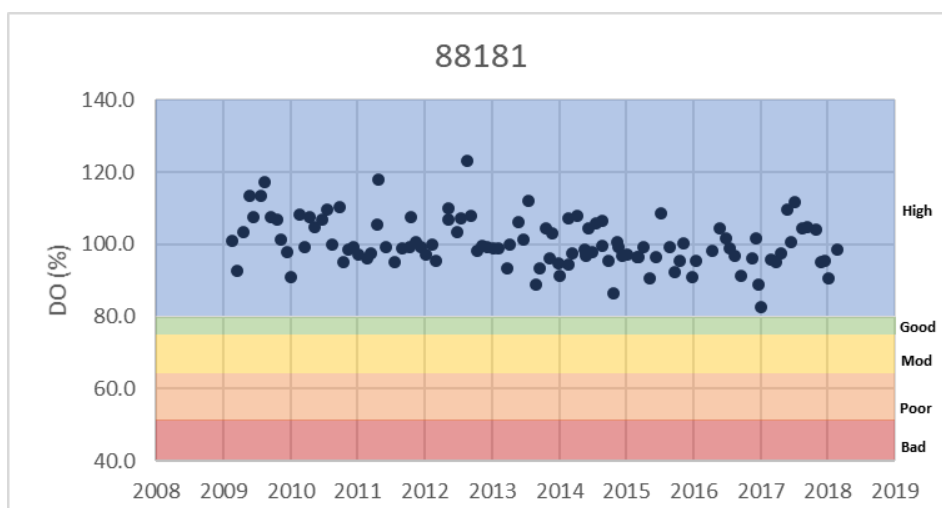


Total ammonia concentrations on the Eastern Cleddau at Canaston Road Bridge (see **Figure B3.16**) were predominantly consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). Two exceptions are noted: Good WFD status is noted on 24/02/2014 with 0.23 mg/l while Moderate WFD status was observed on 30/07/2008 measuring 0.5 mg/l.

Dissolved oxygen saturation

Dissolved oxygen saturation on the Eastern Cleddau at Canaston Road Bridge was reviewed and data are presented in **Figure B3.17** against the relevant WFD standards for an upland low alkalinity river¹⁶.

Figure B.17 Dissolved Oxygen Concentrations on the Eastern Cleddau at Canaston Road Bridge, Incorporating Appropriate WFD Status Bands



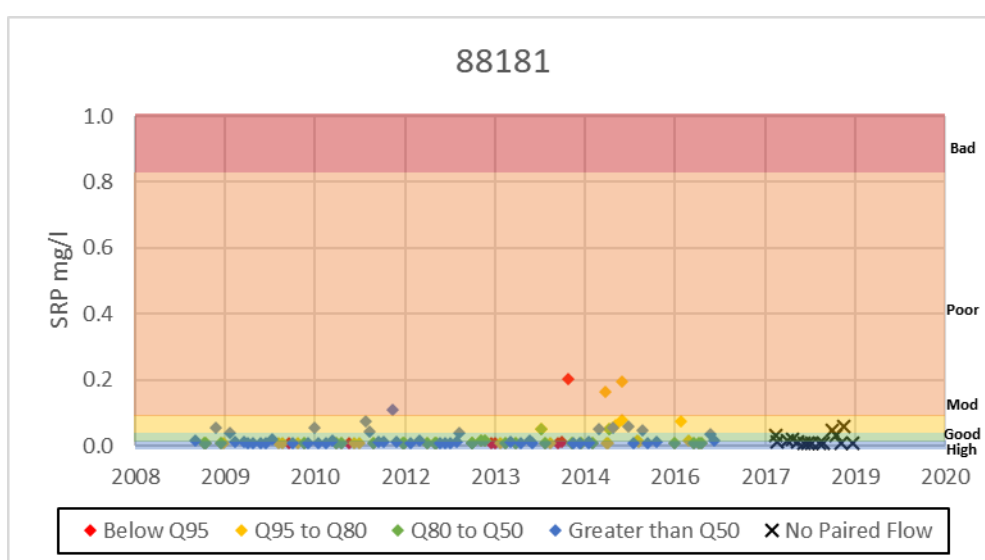
¹⁶ The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

Dissolved oxygen saturation measurements at the Eastern Cleddau at Canaston Road Bridge (see **Figure B3.17**) were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Soluble Reactive Phosphorus Concentration

Soluble Reactive Phosphorus concentration for monitoring on the Eastern Cleddau at Canaston Road Bridge was reviewed and data are presented in **Figure B3.18** against the relevant site specific WFD standards¹⁷.

Figure B3.18 Soluble Reactive Phosphorus on the Eastern Cleddau at Canaston Road Bridge, Incorporating Appropriate WFD Status Bands



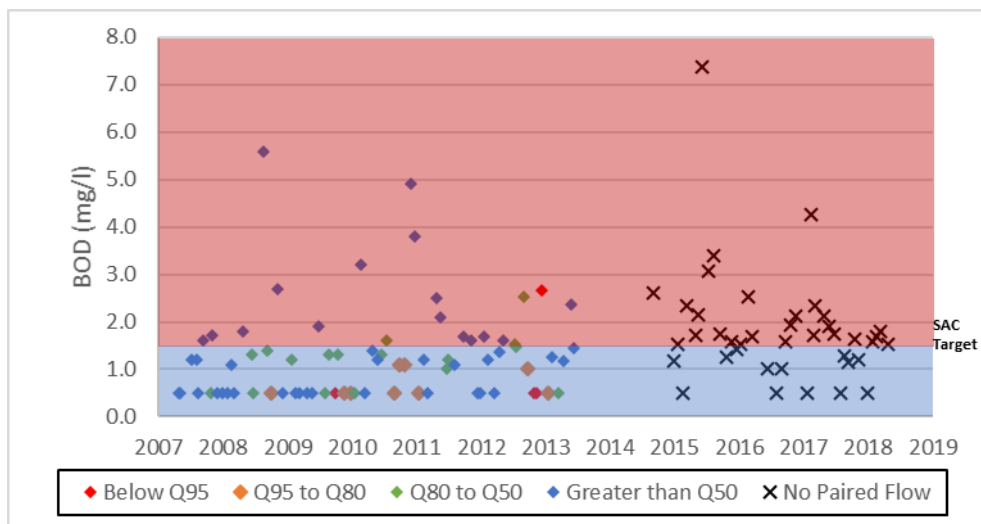
Soluble Reactive Phosphorus concentrations at Eastern Cleddau at Canaston Road Bridge (see **Figure B3.18**) were predominantly consistent with the WFD standard to support good status for diatoms and macrophytes (0.04mg/l). Values below Good status are noted on 21 occasions (13% of all results since 2009).

Biological Oxygen Demand

Biological Oxygen Demand (BOD) concentration in the Eastern Cleddau was reviewed against the Cleddau SAC targets (**Figure B3.19**). BOD concentrations in the Afon Syfynwy were variable with the SAC BOD targets (1.5 mg/l) with 47 samples exceeding the target (38.5% of instances). Pairings with flow do not indicate a relationship. Peaks in BOD concentration do not appear to be attributable to a particular season at this location.

¹⁷ 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 B3.19 Biological Oxygen Demand on the Eastern Cleddau at Canaston Road Bridge, Incorporating Appropriate SAC Targets



Reach 3 (Eastern Cleddau)

Water quality data are available for one NRW monitoring point on Reach 3 of the Eastern Cleddau (negligible hydrological impact) at Source (site 120010) and represents the downstream section of Reach 3.

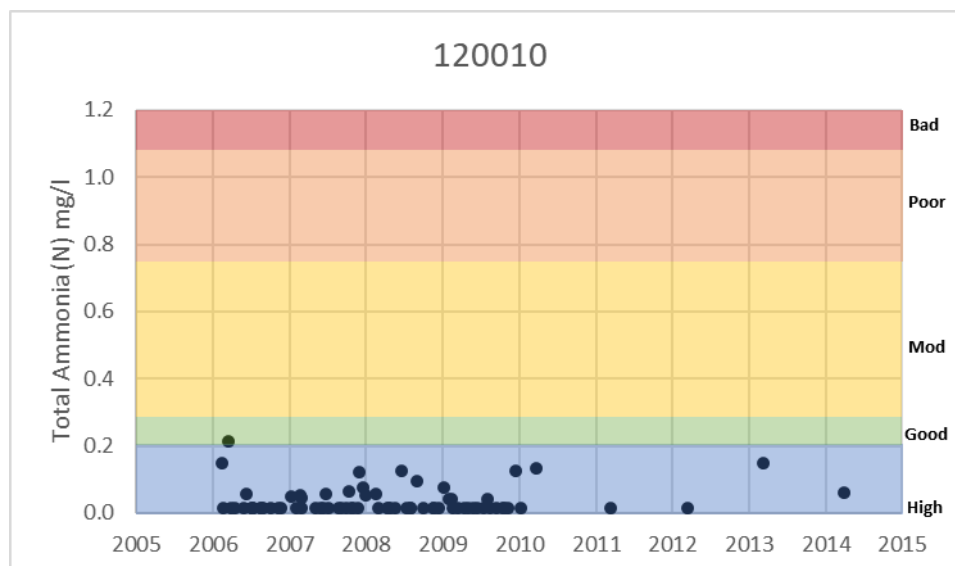
The average pH for the Eastern Cleddau site at Source over the ten year review period was 7.5 and the maximum water temperature was 19 °C.

Total ammonia concentration

Total ammonia concentration for the Eastern Cleddau at Source was reviewed and data presented in **Figure B3.20** against the relevant WFD standards for an upland low alkalinity river¹⁸.

¹⁸ 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 B3.20 Total Ammonia in the Eastern Cleddau at Source, Incorporating Appropriate WFD Status Bands

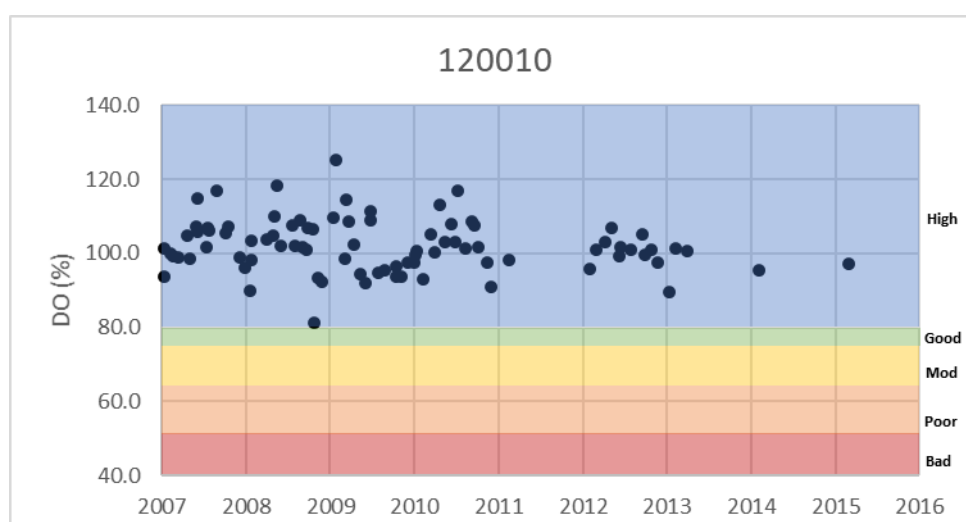


Total ammonia concentrations for the Eastern Cleddau at Source (see **Figure B3.20**) were predominantly consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). One exception is noted on 17/02/2007 with 0.22mg/l.

Dissolved oxygen saturation

Dissolved oxygen saturation for the Eastern Cleddau at Source was reviewed and data are presented in **Figure B3.21** against the relevant WFD standards for an upland low alkalinity river¹⁹.

Figure B3.21 Dissolved Oxygen Concentrations on the Eastern Cleddau at Source, Incorporating Appropriate WFD Status Bands



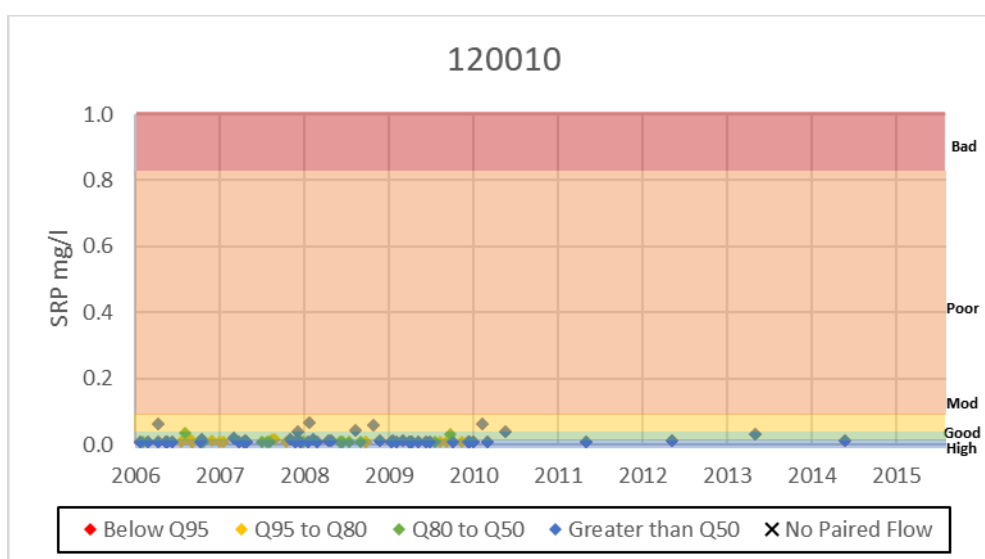
¹⁹ The River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. ISBN 978-0-85521-192-9.

Dissolved oxygen saturation measurements for the Eastern Cleddau at Source (see **Figure B3.21**) were all consistent with the WFD standard to support high status for fish and invertebrates (80%).

Soluble Reactive Phosphorus Concentration

Soluble Reactive Phosphorus concentrations at Eastern Cleddau at Source (see **Figure B3.22**) were predominantly consistent with the WFD standard to support good status for diatoms and macrophytes (0.04mg/l). Values below Good status are noted on 8 occasions (7% of all results since 2009).

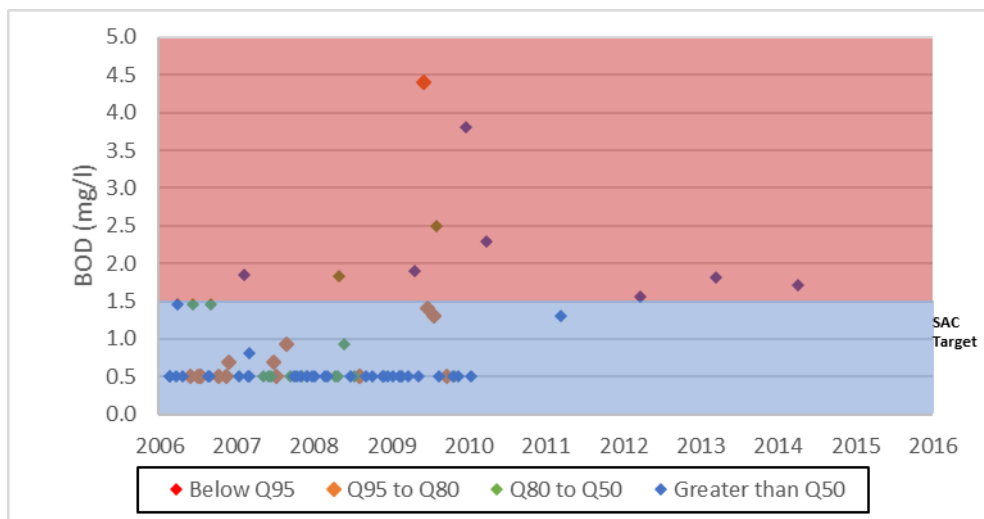
Figure B3.22 Dissolved Oxygen Concentrations on the Eastern Cleddau at Source, Incorporating Appropriate WFD Status Bands



Biological Oxygen Demand

Biological Oxygen Demand (BOD) concentration in the Eastern Cleddau at Source was reviewed against the Cleddau SAC targets (**Figure B3.23**). BOD concentrations in the Eastern Cleddau were variable with the SAC BOD targets (1.5 mg/l) with 10 samples exceeding the target (13.5% of instances). Pairings with flow do not indicate a clear relationship. Similarly, peaks in BOD concentration do not appear to be attributable to a season at this location.

Figure B3.23 Biological Oxygen Demand on the Eastern Cleddau at Source, Incorporating Appropriate SAC Targets



Water Quality Summary

Assessment of risk to water quality as a result of the Llys-y-Fran drought order is limited by the spatial and temporal extent of the data available. Data received from NRW cover the period January 2007 to December 2015.

Total ammonia concentrations were mostly consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Llys-y-Fran 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 assessed as **low** in all reaches.

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 Llys-y-Fran drought order. The risk of the drought order to dissolved oxygen saturation levels within the zone of influence is therefore assessed as **low** in all reaches.

Soluble Reactive Phosphorus concentration values were mostly consistent with the standard to support High status for fish and invertebrates throughout the zone of influence of the Llys-y-Fran drought order. The risk of the drought order to dissolved oxygen saturation levels within the zone of influence is therefore assessed as **medium** in all reaches.

These reaches fall within the Cleddau SAC and as such has been compared against the specific conservation objectives. Reaches 1 through 4 are compliant with the SAC targets for dissolved oxygen, un-ionised and total ammonia and pH. In Reach 1 BOD is predominantly compliant with the SAC objective however concentrations have exceeded it on 22 instances across all Reach 1 sample locations since 2006. It is therefore assumed that the risk to deterioration against the SAC targets is **medium** in Reach 1. In Reach 2 and 3 BOD exceeds the

conservation objective in 38.5% and 13.5% of instances suggesting a **medium** risk to the targets in these reaches during drought order implementation.

B.3.3 Environmental Pressures

B.3.3.1 Flow Pressures

No significant abstractions other than the Welsh Water abstraction at Canaston are located within the zone of influence of the drought order.

B.3.3.2 Water Quality Pressures

Two consented discharges have been identified as having a negligible or higher water quality pressure. A summary of these impacts are identified in **Table B3.2**.

Table B3.2 Summary of Water Quality Pressures

Discharge Name	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
Llys y Fan (Fish Farm)	0.003	Not specified	Not specified	Not specified	Not specified	Negligible
Llys-y-Fran STW	0.01	Not specified	Not specified	Not specified	Not specified	Minor
Walton East STW	Not specified	0.016	5	Not specified	Not specified	Minor
ST at Caffle Brewery	0.0044	Not specified	Not specified	Not specified	Not specified	Negligible
Clarebeston STW	0.005	Not specified	Not specified	Not specified	Not specified	Negligible
Llawhaden STW	0.005	Not specified	40	Not specified	Not specified	Negligible
Narberth West STW	2.39	1.1	50	25	Not specified	Minor (the discharge is close to tidal limit)
Ivy House, Llys-y-Fran, Clarbeston Road	0.0016	Not specified	20	Not specified	30	Negligible

B4 PHYSICAL ENVIRONMENT IMPACT SUMMARY

Potential impacts on the physical environment associated with the Llys-y-Fran Reservoir drought order are summarised in **Table B4.1**

Table B4.1 Summary of Potential Changes to the Physical Environment of the Impacted Reaches from Implementation of the Llys-y-Fran Reservoir Drought Order

Issue	Identified Impact
Afon Syfynwy (Reach 1)	
Flows in the Afon Syfynwy <i>Major impacts during the summer period August to September; moderate impacts during the winter period October to November</i>	<ul style="list-style-type: none"> Impacts to river flow (hydrology) in the reach downstream of Llys-y-Fran Reservoir have been assessed as potentially major during summer months (reduction in releases of up to 36.4Ml/d), but moderate during winter months (reduction in releases of up to 36.4Ml/d)
Water quality in the River Afon Syfynwy <i>Medium risk during period August-November</i>	<ul style="list-style-type: none"> Impacts to water quality in the reach downstream of Llys-y-Fran Reservoir have been assessed as medium risk for soluble reactive phosphorous, and low risk for ammonia and dissolved oxygen and.
Consented discharges <i>Negligible risk at any time of year</i>	<ul style="list-style-type: none"> These discharges are considered to have negligible pressure on the water environment during implementation of the drought order.
Eastern Cleddau (Reach 2)	
Flows in the Eastern Cleddau <i>Major impacts during the summer period August to September; moderate impacts during the winter period October to November</i>	<ul style="list-style-type: none"> Impacts to river flow (hydrology) in the reach downstream of the Afon Syfynwy confluence have been assessed as potentially major during summer months (reduction in releases of up to 36.4Ml/d), but moderate during winter months (reduction in releases of up to 36.4Ml/d)
Water quality in the Eastern Cleddau <i>Medium risk during period August-November</i>	<ul style="list-style-type: none"> Impacts to water quality in the reach downstream of Llys-y-Fran Reservoir have been assessed as medium risk for soluble reactive phosphorous, and low risk for ammonia and dissolved oxygen and.
Consented discharges <i>Minor risk at any time of year</i>	<ul style="list-style-type: none"> The Narberth West STW discharges are considered to exert a minor pressure on the water environment during implementation of the drought order.
Eastern Cleddau (Reach 3)	
Flows in the Eastern Cleddau <i>Major impacts during the summer period August to September; moderate impacts during the winter period October to November</i>	<ul style="list-style-type: none"> Impacts to river flow (hydrology) in the reach downstream of the Canaston abstraction intake have been assessed as potentially major during summer months (reduction in residual flow of up to 36.4Ml/d, from 68.2Ml/d to 34.1Ml/d), but moderate during winter months (reduction in residual flow of up to 36.4Ml/d).
Water quality in the Eastern Cleddau <i>Medium risk during period August-November</i>	<ul style="list-style-type: none"> Impacts to water quality in the reach downstream of Llys-y-Fran Reservoir have been assessed as medium risk for soluble reactive phosphorous, and low risk for ammonia and dissolved oxygen and.

B5 CUMULATIVE IMPACTS

The focus of this EAR is the Canaston 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 Canaston 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	8206-1 (Crowhill) – the hydrological influence of the Crowhill drought order has been assessed as being restricted to a reach of the Western Cleddau River from the Crowhill abstraction point to the tidal reach, and as such no in combination effects are anticipated. However while there are no cumulative hydrological effects both options impact the same European designated site.	Yes
Welsh Water - other drought options in the Eastern Cleddau catchment	8206-2 (Preseli) – the extent of any impact of the Preseli drought order extends until the upper end of Llys-y-Fran Reservoir. As the impacts of the Llys-y-Fran drought order extends from the outlet of the reservoir, the impacted areas of the two schemes do not coincide. There are no cumulative effects of these two drought orders on the downstream water environment (although the Preseli drought order could extend the duration of the two Llys-y-Fran drought orders through reduced inflows to the reservoir).	No
	8206-7 (Llys-y-Fran use of freshet bank) – 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 is limited to the fact that no more than 3 freshet releases would take place under the drought order. Therefore no further, cumulative effects are anticipated as a result of these two drought orders on the downstream water environment.	No
	In combination assessment of the Canaston drought order with 8206-7 (Llys-y-Fran use of freshet bank) and 8206-2 (Preseli) – the Preseli Reservoir drought order would affect the Afon Syfynwy reaches upstream of the Llys-y-Fran Reservoir whilst the Llys-y-Fran freshet bank drought order and Canaston drought order affect the Afon Syfynwy downstream of the reservoir. The only in-combination effect from the concurrent implementation of these three drought orders relates to the potential very small increase to the duration that the Llys-y-Fran freshet bank drought order and Canaston drought order may be required due to the upstream Preseli drought order reducing inflows to Llys-y-Fran reservoir. This potential impact has been assessed as equivalent to 2 days of additional implementation of both drought orders which would not lead to any in-combination adverse effects on site integrity.	No

Organisation	Potential In-combination Impacts	Further Consideration Required (Yes/No)
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)¹.

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

Continuously flowing watercourses

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

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

^a Standards are WFD high/good threshold for ammonia (N) of 0.2mg/l for upland low alkalinity rivers².

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

^b Standards are WFD high/good threshold for ammonia (N) of 0.3mg/l for lowland high alkalinity rivers³.

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

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

^c Standards are WFD high/good threshold for BOD of 3mg/l and good/moderate threshold of 4mg/l for upland low alkalinity rivers⁴.

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

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

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

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

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

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

alkalinity rivers⁵.

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

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

^e Standards are WFD high/good threshold for SRP of 0.02mg/l and good/moderate threshold of 0.04mg/l for upland low alkalinity rivers⁶.

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

^f Standards are WFD high/good threshold for SRP of 0.03mg/l and good/moderate threshold of 0.05mg/l for lowland low alkalinity rivers⁸.

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

^g Standards are WFD high/good threshold for SRP of 0.05mg/l and good/moderate threshold of 0.12mg/l for upland/ lowland high alkalinity rivers⁹.

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

Ephemeral watercourses

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

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

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

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

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

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

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

WATER FRAMEWORK DIRECTIVE STATUS: FISH

Potential Effects
For WFD river waterbodies within the zone of influence of the drought option, where screening of the drought option has identified that the fish element of biological status is <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.
Definition of Impacts
<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"> • Major: A major impact is one that results in deterioration in the WFD classification of the waterbody, or specifically the fish biological element of the classification. • Moderate: A moderate impact on fish status occurs when the fish population is predicted to be materially influenced, including effects on density, abundance or community composition, but where no deterioration in WFD classification is predicted. Consideration should be given to the scale of the impact and the potential for recovery of the populations. • Minor: A minor impact occurs when there is a predicted impact on fish abundance, density or community composition that is within the usual variability for the site and which will recover within a short timescale. • Negligible: A negligible impact is one where the predicted impact will not result in a detectable change in the fish population.
Data Requirements
<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"> • Relevant study area (as identified in the screening report) • Hydrology at or close to the monitoring sites to link to fish data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records • Meteorology (where flow data insufficient) from available NRW / Environment Agency rain gauges • Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys • Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.

Assessment Methodology and Uncertainty

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

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

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

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

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

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

The prediction of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or

surveillance data are used for impact assessment purposes. Lastly the environmental envelopes within which fish species can successfully exist, and the relationship between populations in stressed river conditions remains subject to debate. The assessment must therefore be undertaken in recognition that the outcome prediction will be subject to large potential variability. The study will therefore adopt a precautionary approach, with potential impact highlighted where doubt exists. Monitoring and mitigation proposals for the drought option can then be specified so that, should an option be enacted, the actual impact can be recorded and adaptive mitigation/management of the option undertaken to safeguard where possible the fish populations.

WATER FRAMEWORK DIRECTIVE STATUS: MACROINVERTEBRATES

Potential Effects

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

Definition of Impacts

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

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

Data Requirements

The baseline for macroinvertebrates will be established from existing data together with a comparison of species flow preference and taxon abundance. The analysis will provide an assessment of the community type and its sensitivity.

Macroinvertebrate status baseline assessment requires data from standard NRW / Environment Agency monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Macroinvertebrate data should include the LIFE and BMWP scores, together with abundance and density data where available. Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area (width and depth) and other environmental variables as follows:

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

rain gauges

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

Assessment Methodology and Uncertainty

Having established the baseline, the relative changes expected as a result of the drought actions (in relation to normal drought conditions) in river hydrology, geomorphology and water quality will be identified (see WFD fish assessment). An assessment will then 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) guidance¹⁰. The potential significance of the impacts is identified using the following:

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

Table 1 Value of Ecological Receptor

Ecological Value	Example
International	Existing or warranting designation as a e.g SPA and/or of significant conservation status for Europe (e.g European Protected Species (EPS)).
National	Existing or warranting designation as a SSSI and/or of significant conservation status for England (i.e. identified as a NERC / Environment Act (Wales) Section 7 species).
Regional	Habitats or species valuable at a regional level and/or of significant conservation status for the region (e.g viable breeding populations of Nationally Scarce species).
County	For example, existing or warranting designation as a County Wildlife Site (CWS) and/or of significant conservation status for the county (e.g viable breeding populations of species of county/metropolitan rarities).
District	For example, habitats or species of significant conservation status for the district (e.g viable breeding populations of species listed as rare in the district or borough).
Parish (local)	Species whose presence is considered to appreciably enrich biodiversity within the context of the parish or local neighbourhood, including as a local recreational/educational resource.
Site (within zone of influence only)	Species which are so low grade or widespread so as to be considered as not contributing to biodiversity value outside the boundaries of the site.

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

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

otherwise stated in the feature assessment.

- **Extent** – the extent of the impact is covered as part of the magnitude consideration.
- **Magnitude** – the magnitude of the impact is identified using the criteria identified in **Table 2**

Table 2 Magnitude of Impact

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

- **Duration** – the duration of impact is considered to be for 6 months, which is the duration for which a drought option is implemented, unless otherwise stated.
- **Reversibility** – all impacts are considered to be reversible unless they are identified to have a likely impact upon the overall integrity of the ecological receptor.
- **Timing and Frequency** – the drought option could be implemented at any point in the year, however the different life stages of the sensitive ecological features will be taken into account. The assessment is based upon the operation of a single drought permit, with subsequent applications for a drought permit required to consider cumulative effects of multiple drought permits.
- **Probability** – all impacts are considered to be probable, unless otherwise stated.

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

Data Requirements

Sensitive ecological features baseline review requires data from standard NRW / Environment Agency monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Data should include species presence, abundance and density. It is likely that most fisheries data will be for O and O+ lifestages, with some indication of older echelons. Environmental supporting data should include habitat availability, hydrology and water quality as follows:

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

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

Assessment Methodology and Uncertainty

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

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

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

Once the flow, habitat and water quality drought option predictions have been established, their implications for the sensitive ecological features will be assessed. The flow and habitat environmental preferences of the sensitive ecological features will be described. The predicted changes in supporting environmental variables (flow, depth, velocity, habitat quality, dissolved oxygen levels and/or temperature) due to the drought option should be assessed against the sensitive ecological features population data.

Where data are not available the assessment will be undertaken using expert judgement and

drawing on broad-scale evidence from other similar catchments.

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

Habitat Preferences

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	Description		
Atlantic salmon <i>Salmo salar</i> and Brown/Sea trout <i>Salmo trutta</i>			
Spawning	<ul style="list-style-type: none"> Clean and unconsolidated gravels typically in the transitional area between pools and riffles where the flow is accelerating and depth is decreasing 	-	Deposition of silt Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth
Nursery (fry and parr life stage)	<ul style="list-style-type: none"> Shallow areas with a low water velocity and pebble substrate, often at the margins of riffles 	<ul style="list-style-type: none"> Deep and/or high velocity habitats. 	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake Deterioration in water quality
Adults	Deep habitats that provide shelter including one or more of the following: <ul style="list-style-type: none"> submerged structures undercut banks overhanging vegetation <50cm above the water surface water surface turbulence causing a broken surface Deep pools downstream of obstacles and sufficient water quantity through structures to enable passage across obstacles. 	<ul style="list-style-type: none"> Open and shallow habitats, but will use these during migration to reach spawning gravels. Habitats upstream of significant obstructions. 	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake Increased significance of barriers to impede migration as a result of decreased flows Deterioration in water quality
Brook lamprey <i>Lampetra planeri</i>			
Spawning	<ul style="list-style-type: none"> Clean, unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing. 	-	Deposition of silt Reduction in velocity, depth or wetted width resulting in exposure of river bed Increased water velocity and depth
Nursery	<ul style="list-style-type: none"> Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content. 	-	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	Description		
Adults	<ul style="list-style-type: none"> Cover (stones and vegetation) in the vicinity of spawning gravels. 		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"> Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing. 	-	Deposition of silt Reduction in velocity, depth or wetted width resulting in exposure of river bed Increased water velocity and depth
Nursery	<ul style="list-style-type: none"> Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content. 	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake Deterioration in water quality
Adults	<ul style="list-style-type: none"> Suitable estuarine conditions, that is free from pollution and with suitable prey species available. Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers. 	<ul style="list-style-type: none"> Areas with significant pollution or limited prey availability. Habitats upstream of significant obstructions. 	Increased significance of barriers to impede migration as a result of decreased flows Increased risk of entrainment into water intake Deterioration in water quality
Sea lamprey, <i>Petromyzon marinus</i>			
Spawning	<ul style="list-style-type: none"> Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing. 	-	Deposition of silt Reduction in velocity, depth or wetted width resulting in exposure of river bed Increased water velocity and depth
Nursery	<ul style="list-style-type: none"> Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content. 	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake Deterioration in water quality
Adults	<ul style="list-style-type: none"> Suitable estuarine conditions, that is free from pollution and with suitable prey species available. Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers. 	<ul style="list-style-type: none"> Areas with significant pollution or limited prey availability. Habitats upstream of significant obstructions. 	Increased significance of barriers to impede migration as a result of decreased flows Increased risk of entrainment into water intake Deterioration in water quality
Bullhead, <i>Cottus gobio</i>			
Spawning	<ul style="list-style-type: none"> Coarse, hard substrate of gravel and stones. 	<ul style="list-style-type: none"> Deep, silty watercourses with high flow velocities and little or no cover. 	Deposition of silt Reduction in velocity, depth and/or wetted width Increased water velocity and depth

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	Description		
Nursery	<ul style="list-style-type: none">Shallow, stony riffles		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
Adult	<ul style="list-style-type: none">Sheltered sections created by woody debris, tree roots, leaf litter, macrophyte cover or larger stones.		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">Wetland habitats within 30km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.	<ul style="list-style-type: none">Low productivity watercourses with dominance of coarse substrates and low macrophyte cover and diversity.Habitats upstream of significant obstructions.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
			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">Deep, slow flowing watercourses and wetland habitats within 80km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.		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">Run/glide flowLess than 50cm deepVelocities greater than 0.5m/sSubstrate composed of clean and uncompacted gravel	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	<ul style="list-style-type: none">Marginal shallow bays set back from or within margins of main channelDepths between 1cm and 30cmNo discernible to minimal flowSubstrate composed of >30% gravel and sand with low silt contentLack of or very little riparian shading		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	<ul style="list-style-type: none">Commonly associated with stretches of clean gravel and macrophyte beds, showing a preference to relatively fast-flowing stretches in the middle reaches of large rivers.The species also occupies deep water habitats at the foot of weirs,		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Impedance to movement upstream
			Increased water velocity and depth
		Increased risk of entrainment into water intake	

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	Description		
	in the lee of large woody debris, rock ledges or other obstructions on the river bed.		Deterioration in water quality Increased water velocity and depth
Fine-lined pea mussel, <i>Pisidium tenuilineatum</i> and depressed river mussel <i>Pseudanodonta complanata</i>			
All life stages	<ul style="list-style-type: none"> Fine sediments of lowland rivers and canals, 	<ul style="list-style-type: none"> High velocity watercourses with coarse substrates. 	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
White-clawed crayfish <i>Austropotamobius pallipes</i>			
All life stages	<ul style="list-style-type: none"> Slow-flowing sections of stony rivers Boulder riffles in chalk or clay streams Submerged tree roots Debris dams Crevices in old or damaged submerged brickwork, stonework, cracked concrete or rotten wooden structures Un-mortared stone revetting which protects banks from erosion Stands of submerged and emergent aquatic plants Old gravel workings and chalk pits Good water quality 	<ul style="list-style-type: none"> Uniform clay channels Areas of deep or soft silt Dense filamentous algae Narrow fast-flowing channels Areas of sand and gravel, or bedrock, which are lacking in cobble or boulder (though they may feed in or commute through these areas) Pebble or cobble shingle regularly exposed by changing river levels Areas of armoured bed where the substrate is compacted by the river flow Acidic streams or ochreous drainage Poor water quality or salinity 	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed Increased water velocity and depth Increased risk of entrainment into water intake Transfer of non-native species or disease Deterioration in water quality

APPENDIX D

ENVIRONMENTAL FEATURES

ASSESSMENT

D1 INTRODUCTION

This appendix presents information regarding the environmental features associated with the Canaston 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 **Appendix D** 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)¹² and the Chartered Institute of Ecology and Environmental Management (CIEEM) study guidelines³. 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 reaches for the Canaston 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.

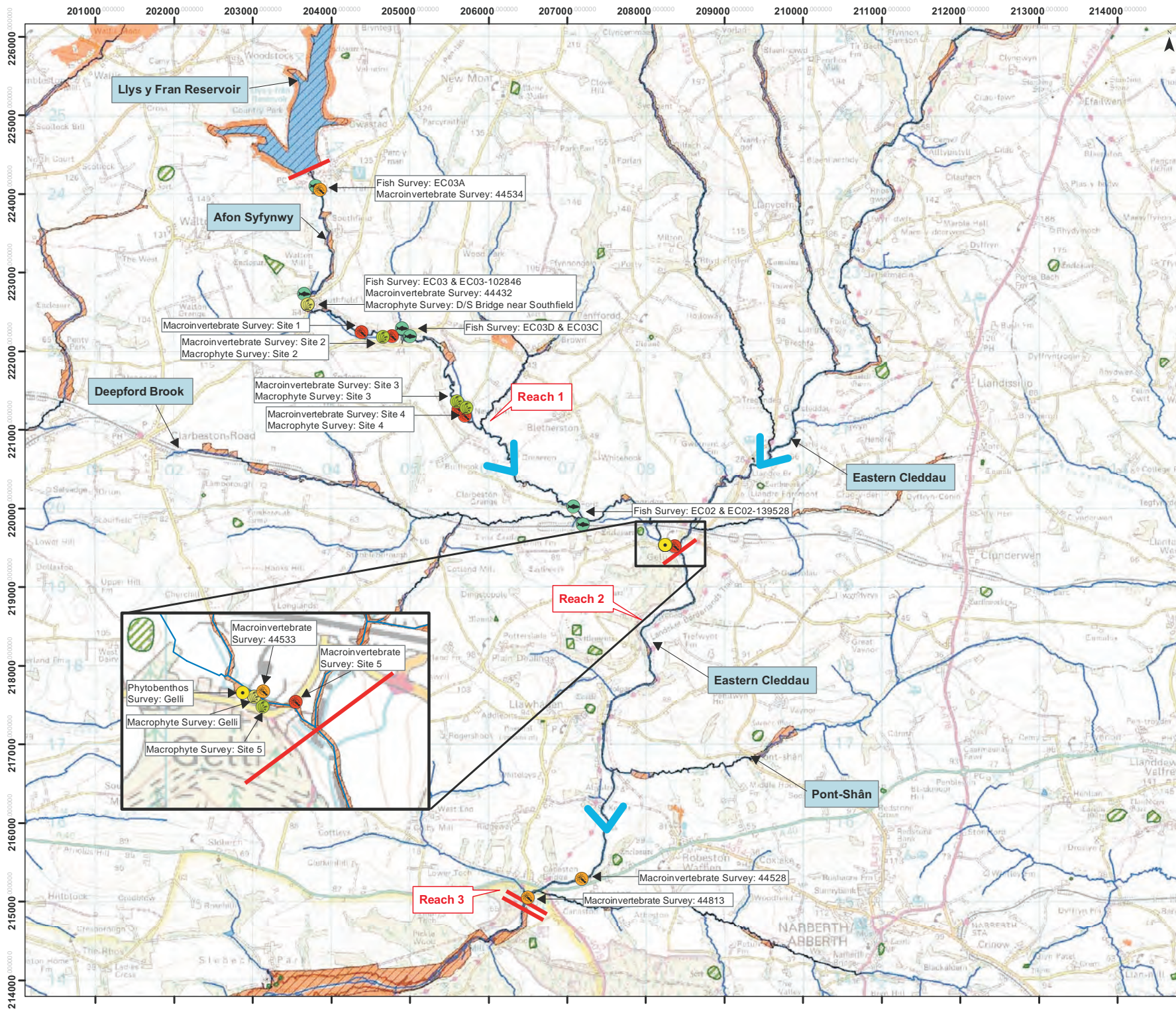
This appendix is set out in the following sections:

- Section D.2 Designated Sites
- Section D.3 WFD Status and Community Assessment / Notable Species
- Section D.4 Invasive Flora and Fauna
- Section D.5 Recreation and Archaeology

¹ IEMA (2004) Guidelines for Environmental Impact Assessment.

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

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



Legend

- Water Courses
- Reservoir
- Hydrological Reach
- Direction of Flow
- Special Area of Conservation
- Site of Special Scientific Interest
- Scheduled Ancient Monuments
- Fish Survey
- Phytobenthos Survey
- Macrophyte Survey (Welsh Water)
- Macrophyte Survey (NRW)
- Macroinvertebrate Survey (Welsh Water)
- Macroinvertebrate Survey (NRW)

1:45,000
 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:
 Environmental Features: 8206-8
 Canaston 50% reduction in HoF

Figure Number: Figure D1.1	Date: February 2019
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D2 DESIGNATED SITES

D.2.1 Cleddau Rivers SAC / Eastern Cleddau River SSSI

D.2.1.1 Baseline

The Llys y Fran Reservoir, the Afon Syfynwy and the Eastern Cleddau are designated as part of the Afonydd Cleddau / Cleddau Rivers SAC and Eastern Cleddau SSSI. The Annex I habitats for which the SAC has been designated are:

- Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* 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 Cleddau Rivers SAC Core Management Plan⁴ reports 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’.

The Eastern Cleddau Rivers SSSI includes the Eastern Cleddau and the Afon Syfynwy (including Llys y Fran Reservoir). The site is designated for the SSSI features described above for the SAC, as well as the aquatic plant *Potamogeton berchtoldii* x *P. polygonifolius* (cf).

The Afon Syfynwy within the zone of influence of the drought order is within SAC management units 11 and 12, and the Eastern Cleddau within the zone of influence of the drought order is in SAC management unit 10. The habitat feature ‘watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation’ is a feature of the Cleddau Rivers SAC. The Cleddau Rivers SAC Core Management Plan confirms that this habitat is present within the study reaches. The *Potamogeton berchtoldii* x *P. polygonifolius* (cf) feature of the Eastern Cleddau Rivers SSSI is reported to only be present in the Eastern Cleddau within the study area (SAC management unit 10).

The Eastern Cleddau River SSSI is primarily designated for important populations of otter

⁴ Countryside Council for Wales (2017) *Core Management Plan Including Conservation Objectives*, Cleddau Rivers SAC. September 2017.

Lutra lutra, bullhead *Cottus gobio*, river lamprey *Lampetra fluviatilis* and brook lamprey *Lampetra planeri*. It is also designated for: sea lamprey *Petromyzon marinus*; for its range of river habitats including beds of submerged aquatic plants often dominated by water-crowfoot *Ranunculus spp*; the aquatic plant *Potamogeton berchtoldii* x *P. polygonifolius* (cf.) as well as a variety of associated riverside habitats. The tributaries included within this site are the Afon Wern, Llanycefn, Rhyd-afallen, Afon Syfynwy, Rhyd-y-Brown Brook, Ty-llosg Brook, Deepford Brook, Cotland Brook, Afon Conin, Pont Shan and Narberth Brook.

D.2.1.2 Assessment

The hydrological assessment has identified a reduction of up to 73% in low and extreme low flows in Reach 1 during August – September. In addition, the drought order could result in a 48.5% and 62% reduction in low and extreme low flows in Reach 2 and a 63% and 86% reduction in low and extreme low flows in Reach 3 during this period. Between October and November, the drought order could result in a 73% reduction in low flows in Reach 1 and a 42.9% and 51% reduction in low flows in Reach 2 and Reach 3 respectively. This could lead to corresponding reductions in wetted width and depth of the river downstream of Llys y Fran Reservoir in Reach 1 up to the tidal limit below the Canaston abstraction (Reach 3). The hydrological impact of the drought order is considered to be major during the summer months and moderate during the autumn months with minor risks of impacts to water quality with regard to soluble reactive phosphorus, ammonia, and dissolved oxygen in Reach 1. Risks to water quality has been assessed as negligible in Reach 2 and 3 (see **Appendix B**).

The Annex 1 habitat ‘watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitriche-Batrachion* vegetation’ is present within the impacted reaches. The impacts of the drought order on the macrophyte community have been assessed as moderate – major (see Section D3.1). River lamprey, brook lamprey, and sea lamprey, and bullhead (Annex II species for which the SAC has been designated) are present within the impacted reach. Impacts on these fish species have been assessed as minor - major (see Section D3.3). Therefore the overall impact on the Cleddau Rivers SAC / Eastern Cleddau River SSSI is assessed as **major**.

The drought order will have no adverse effects on the Annex 1 habitats of alluvial forest and active raised bog, nor on the Annex II / SSSI species of otter. The former habitats are not dependent on flows in the Afon Syfynwy downstream of Llys y Fran reservoir or the reaches of the Eastern Cleddau upstream and downstream of the Canaston intake. and otter are mobile species that can adapt to changes in river levels and may potentially benefit from easier predation of fish species. These habitats and species are not considered further.

D.2.2 Pembrokeshire Marine SAC

D.2.2.1 Baseline

The zone of hydrological influence of the drought order does not extend below the tidal limit of the Eastern Cleddau, however, impacts associated with the implementation of the drought permit may affect the adjoining reach of the Eastern Cleddau estuary which is designated as

part of the Pembrokeshire Marine SAC.

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 (*Glaucopuccinellietalia 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*

The distribution of the habitats and species within this section of the SAC are not fully understood.

Based on available information (NRW designated sites website, SAC features map, SSSI citation), the Annex I habitats associated with this reach of the Eastern Cleddau primarily consist of the estuary feature, mudflats and sandflats not covered by seawater at low tide and Atlantic salt meadows. As described by the EU Habitat Interpretation Manual, river estuaries are coastal inlets where, unlike 'large shallow inlets and bays' there is generally a substantial freshwater influence. The mixing of freshwater and seawater and the reduced current flows in the shelter of the estuary lead to deposition of fine sediments, often forming extensive intertidal mud and sand-flats. The reduction in freshwater input during the implementation of the drought order may pose an adverse risk to the habitat and associated ecology.

Grey seals are among the rarest seals in the world, with the UK population representing around 50% of the world population and 95% of the EU population⁵. Grey seal are present within the SAC.

Shore dock is one of Europe's most threatened endemic vascular plants. It is most commonly found growing by the side of streams entering beaches, on oozing soft-rock cliffs, and in rock clefts where flushing occurs. It is considered to occur within a relatively narrow zone above the high water mark⁶. Whilst site specific data on the distribution of shore dock in this reach of the SAC is not currently available⁷, the plant is known to only occur where a constant source of freshwater, running or static, is available⁸.

Of the species of fish outlined above, only river lamprey are considered present within the hydrological zone of influence. Whilst there are no records of sea lamprey or shad species within or near to the hydrological zone of influence, these species are listed as qualifying features of the SAC and are assessed below. In terms of sea lamprey, whilst there is no data to confirm their presence in the Eastern Cleddau, they are considered to be present in the Cleddau rivers, and therefore the SAC. Whilst suitable habitat may be present, there are few records of shad species within the SAC, and the dynamics of any population which may be present unknown⁹.

Otter are present throughout the Cleddau rivers and estuarine environments associated with the Pembrokeshire Marine SAC¹⁰.

D.2.2.2 Assessment

It is anticipated that the reduction in flow and wider impacts associated with the implementation of the drought order are not anticipated to extend beyond the Eastern Cleddau estuary downstream of the confluence with the Western Cleddau.

Due to the high mobility of grey seal combined with an adaptable diet, and core habitat (based on SSSI citation for Milford Haven Waterway), they are most likely to move to unimpacted areas of the SAC during the drought permit implementation period. Impacts to grey seal are

⁵ Countryside Council for Wales (2009) Pembrokeshire Marine European Marine Site Advice Provided by The Countryside Council for Wales in Fulfilment of Regulation 33 Of The Conservation (Natural Habitats, &C.) Regulations 1994. Published February 2009

⁶ European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Second Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2001 to December 2006 Conservation status assessment for: S1441: *Rumex rupestris* - Shore dock

⁷ Joint Nature Conservation Committee - SAC selection – Pembrokeshire Marine
<http://jncc.defra.gov.uk/ProtectedSites/SACselection/sac.asp?EUcode=UK0013116>

⁸ Joint Nature Conservation Committee - Background to SAC selection - 1441 Shore dock
<http://jncc.defra.gov.uk/publications/JNCC312/species.asp?FeatureIntCode=s1441>

⁹ Countryside Council for Wales (2009) Pembrokeshire Marine European Marine Site Advice Provided by The Countryside Council for Wales in Fulfilment of Regulation 33 Of The Conservation (Natural Habitats, &C.) Regulations 1994. Published February 2009

¹⁰ Countryside Council for Wales (2009) Pembrokeshire Marine European Marine Site Advice Provided by The Countryside Council for Wales in Fulfilment of Regulation 33 Of The Conservation (Natural Habitats, &C.) Regulations 1994. Published February 2009

therefore assessed as **negligible**.

Based on the available information on the distribution of shore dock (SAC features map, Core Management Plan and SSSI citation for Milford Haven Waterway) , it is unlikely to occur in the impacted reach and therefore impacts are assessed as **negligible**.

Whilst the marine stage of the shad's life cycle is not well understood, literature suggests a suitable estuarine habitat is likely to be very important for adults and juveniles¹¹. Based on commercial bycatch data, both species of shad are predicted to occur near estuaries or coastal areas during January to February¹², coinciding with the drought permit implementation period. However, whilst suitable habitat may be present, there are few records of shad within the SAC, or specific to the Eastern Cleddau, with the dynamics of any population which may be present unknown¹³. In addition, impacts associated with the drought permit on estuarine habitat within the Eastern Cleddau estuary are not likely to result in a change of extent or composition of the feature, therefore limiting risks to shad within the SAC. Based on a precautionary approach, impacts associated with the drought permit on shad species which may be present within the Pembrokeshire Marine SAC are assessed as **negligible**.

The anadromous nature of the river lamprey means the species navigates from its spawning grounds in freshwater to feed in the estuarine reaches within the SAC which adjoin the lower reaches of the Eastern Cleddau. The drought permit is assessed as causing a reduction in flow in Reach 3 (Canaston intake to the Tidal limit) of up to 51% during winter (October to November) low flows (Q_{95}) and 86% during extreme summer (August to September) low flows (Q_{99}). A reduction in flow is likely to coincide with a reduction in freshwater inputs to the upper reaches of the Eastern Cleddau estuary. The anadromous spawning migration phase in the lamprey life cycle is a time of profound morphological and physiological change¹⁴. Physiological stress may increase as a result of river lamprey having to spend more time in the saline environment of the estuary, particularly if upstream passage is limited by barriers to migration, such as the Canaston weir located within the hydrological zone of influence. Cues for river lamprey migration may also be at risk from reduced flows, with adult lamprey not successfully migrating upstream into the Eastern Cleddau to spawn, ultimately impacting upon recruitment.

In terms of the downstream migratory life stage, a sudden change in salinity, which may occur as fish pass from the Eastern Cleddau into the tidal reaches, has been shown to have a limited impact¹⁵. Any further risks associated with water quality have been assessed as negligible in

¹¹ Joint Nature Conservation Committee. 2007. Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough: JNCC. Available from: www.jncc.gov.uk/article17

¹² ICES. 2015. Report of the Workshop on Lampreys and Shads (WKLS), 27–29 November 2014, Lisbon, Portugal. ICES CM 2014/SSGEF:13. 206 pp

¹³ Countryside Council for Wales (2009) Pembrokeshire Marine European Marine Site Advice Provided by The Countryside Council for Wales in Fulfilment of Regulation 33 Of The Conservation (Natural Habitats, &C.) Regulations 1994. Published February 2009

¹⁴ Ferreira-Martins, D., Coimbra, J., Antunes, C., & Wilson, J. M. (2016). Effects of salinity on upstream-migrating, spawning sea lamprey, *Petromyzon marinus*. Conservation physiology, 4(1), cov064. doi:10.1093/conphys/cov064

¹⁵ Potter I.C., Huggins R.J. (1973). Observations on the morphology, behaviour and salinity tolerance of downstream migrating river lamprey (*Lampetra fluviatilis*). J. Zool. 1973; 169: 365–379.

Reach 3.

River lamprey feed on marine species of fish such as herring, sprat and flounder. Impacts associated with the drought permit are unlikely to impact upon these prey species, and therefore is not considered a risk to river lamprey populations.

Impacts to the migration of river lamprey in Reaches 1-3 of the hydrological zone of influence are assessed as major adverse. Due to the presence of river lamprey in the other river systems associated with the Pembrokeshire Marine SAC, impacts on river lamprey populations associated with the Pembrokeshire Marine SAC are assessed as **moderate adverse**, short term, temporary and reversible.

Relatively little is known about the precise habitats occupied by adult sea lampreys, the precise conditions in which they occur at sea have not been described, nor is it certain which fish are the main prey species¹⁶, making assessment uncertain. However, the impacts described for river lamprey are likely to be similar to those described above for river lamprey. Impacts to sea lamprey in the Pembrokeshire Marine SAC are therefore assessed as **moderate adverse**.

Suitable prey (fish) habitat for otter is readily accessible throughout the SAC, including estuary shallows, accessible from freshwater habitat. The impacts associated with the drought permit are not considered to adversely impact upon the prey species of the otter, or their foraging ability, therefore impacts are assessed as **negligible**.

Overall, based on potential impacts to lamprey species, the impact on the Pembrokeshire Marine SAC is assessed as **moderate adverse**, short term, temporary and reversible.

Summary

The potential impacts of the Canaston drought order on SAC and SSSI designated sites and species 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 macroinvertebrate community. The impacts presented in **Table D2.1** are restricted to Reach 1 and 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 SAC and SSSI Designated Sites and Species

Feature	Impact	Significance of Impact
Reach 1 – Reach 3		
Cleddau Rivers SAC / Eastern Cleddau SSSI	<ul style="list-style-type: none"> The impacts of the drought order on the macrophyte habitats for which the sites are designated have been assessed as moderate-major 	Major

¹⁶ Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.

Feature	Impact	Significance of Impact
	<ul style="list-style-type: none">• 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 minor - major during the permit implementation period.• No adverse effects of the drought order are likely on alluvial forest and active raised bog habitats nor on otter.	
Pembrokeshire Marine SAC	<ul style="list-style-type: none">• Impacts on primary qualifying habitats and features are assessed as negligible.• Impacts on river and sea lamprey (qualifying feature of the SAC designation) have been assessed as major during the drought permit implementation period, however, the presence of populations in other rivers associated with the SAC reduce the impact significance.	Moderate

D3 WFD STATUS AND COMMUNITY ASSESSMENT / NOTABLE SPECIES

D.3.1 Macrophytes

D.3.1.1 Baseline

Baseline macrophyte monitoring information, received from the NRW, within Reach 1 consisted of two sites on the Afon Syfynwy at the Gelli and D/S Bridge near Southfield Villa sites (see **Figure D1.1**). The information consisted of two sampling occasions at Gelli in July 2004 and August 2007 plus one sampling occasion at the D/S Bridge near Southfield Villa site in August 2001. Data was also available for two surveys (2004 and 2007) for a site in Reach 2 (Canaston Gauging STN) and one survey in 2007 for the site, U/S Canaston Intake, also in Reach 2.

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

Macrophyte results were provided by the NRW using the standard LEAFACS2 methodology¹⁷ 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
- (iv) Percentage cover of all green filamentous algal taxa over the whole of the surveyed river sections (ALG).

In addition to the above scores, observed Mean Trophic Rank (MTR) and Macrophyte Flow Ranking (MFR) scores were also provided for samples taken in 2004 and 2007. **Table D3.1** provides a summary of RMNI, MTR and MFR scores recorded at sites within the study reach. **Table D3.2** and **Table D3.3** identify the interpretation of MFR and MTR scores.

RMNI and RMHI are biotic indices used to determine the nutrient preference and flow preference of macrophyte communities respectively and are updated versions of the MTR and MFR biotic indices. To calculate RMNI scores, macrophyte communities are identified and assessed on a scale of 1 to 10 based on individual species cover values and their combined

¹⁷ WFD-UKTAG (2014) UKTAG river assessment method – macrophytes and phytobenthos (River LEAFACS2).

preference for nutrient enrichment. High scores are associated with communities in eutrophic waters, low scores are associated with oligotrophic waters. Following the same premise communities with high RMHI scores are associated with low energy flow velocities and low scores are associated with high energy flow velocities.

Table D3.1 LEAFPACS and MTR Nutrient and Flow Scores for NRW Macrophyte Sampling Sites on the Afon Syfynwy

Site	Grid Reference	Year	MFR	MTR	RMNI
D/S BRIDGE NEAR SOUTHFIELD VILLA	SN-03700-22600	2001	3.0	68.2	5.32
GELLI	SN-08250-19540	2004	3.17	61.6	5.44
		2007	3.33	66.7	5.4
CANASTON GAUGING STN	SN-07188-15295	2004	3	58.3	5.65
		2007	2.93	57.4	6.09
U/S CANASTON INTAKE	SN-06500-15050	2007	2.91	52.6	6.56

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

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

Table D3.3 Interpretation of MTR Scores (from Holmes *et al.*, 1999¹⁸)

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

Eleven macrophyte species were recorded at the D/S Bridge near Southfield Villa site in 2001 (of which nine were hydrophytes). At the Gelli site, 29 macrophyte species were found in 2004

¹⁸ Holmes, N T H, Newman, J R, Chadd, S, Rouen, K J, Saint, L and Dawson, F H (1999) *Mean Trophic Rank: A Users Manual*. R&D Technical Report E38, Environment Agency, Bristol.

(of which 18 were hydrophytes); 17 were found in 2007 (of which 12 were hydrophytes). RMNI at the D/S Bridge near Southfield Villa site was 5.32, indicating mesotrophic conditions. The samples taken at the Gelli site indicated similar conditions, with RMNI scores of 5.44 and 5.40 in 2004 and 2007, respectively. The samples taken at the Canaston Gauging STN site on the Eastern Cleddau had RMNI scores of 5.65 and 6.09 in 2004 and 2007 respectively, indicating mesotrophic conditions. RMNI score was higher at the U/S Canaston Intake site with 6.56 recorded in 2007, indicating mesotrophic to eutrophic conditions.

The MFR score for the samples identified in the baseline data for the Afon Syfynwy was indicative of a plant community showing a preference to moderate flow velocity, with a score of 3 at the D/S Bridge near Southfield Villa sampling site and a score between 3.17 and 3.33 at the Gelli sampling site. The baseline data for the Eastern Cleddau was also indicative of a plant community showing a preference to slow to moderate flow velocity, with a score of 2.91 at the U/S Canaston Intake sampling site and a score between 2.93 and 3 at the Canaston Gauging Station sampling site. The MTR scores on the river Syfynwy are indicative of a sites which are unlikely to be impacted/eutrophic, with a higher MTR (68.2) at the upstream of D/S Bridge near Southfield Villa sampling site and a lower mean MTR (64.2) at the Gelli sampling site. The sampling sites on the Eastern Cleddau have MTR scores which are indicative of sites which are at risk of becoming eutrophic, with a higher mean MTR (57.9) at the upstream of D/S Bridge near Southfield Villa sampling site and a lower MTR (52.6) at the U/S Canaston Intake sampling site.

Macrophyte surveys were also undertaken in 2011 by Cascade Consulting for Welsh Water in support of the drought order assessment. Five sites were surveyed along the Reach 1 (see **Figure D1.1** and **Table D3.4**). Sampling was conducted following standard LEAFPACS survey methodology¹⁹. LEAFPACS EQR scores are given in **Table D3.4**.

Table D3.4 Macrophyte Monitoring in 2011: Locations and Results

Site	Watercourse	NGR	LEAFPACS EQR Score
1	Afon Syfynwy	SN0430722281	0.71
2		SN0466022187	0.65
3		SN0560121368	0.64
4		SN0571621254	0.62
5		SN0825419545	0.71

Typical species identified in the 2011 surveys include *Ranunculus penicillatus*, *Callitriche hamulata*, *Myriophyllum alterniflorum*, *Riccardia chamaedryfolia*, *Platyhypnidium riparioides* and *Hygroamblystegium fluviatile*. The data also indicated that the macrophyte communities in the hydrological zone of influence of the drought order are adapted to moderate flow conditions.

Plant species diversity and composition varied between sites depending upon shading and

¹⁹ UKTAG (2008) *UKTAG River Assessment Methods Macrophytes and Phytobenthos; Macrophytes (River Leafpacs)*. October 2008.

gradient, but overall the river sections surveyed contained a diverse, healthy macrophyte community in the open sections. In the shaded sections, channel macrophytes comprised bryophytes with higher plants being generally sparse.

River banks were predominantly semi-natural (except at Site 5). Exposed side bars were frequent and included herb species and grasses. The banks were generally tree-lined, although extensive Himalayan balsam (*Impatiens glandulifera*) was present throughout.

The river LEAFACS EQR for the whole section was 0.66 which places it towards the middle of the 'good-moderate' category indicating that nutrient pressures are relatively low and the reach is in good ecological status with regard to the macrophyte community component of WFD assessment.

In addition, monitoring was undertaken in 2017 by APEM²⁰ for a single site in Reach 1 (NGR SN 07138 19966) near Gelli. The result of the survey is provided in **Table D3.5**. The RMNI score observed during this survey is indicative of a community with a preference for moderate to fast flowing conditions. The low percentage of algal cover is also indicative of good water quality with limited eutrophication.

Table D3.5 Macrophyte results, 2017

Reach	Site Location (NGR, downstream extent))	Matrix				Environmental Variables	
		RMNI	NTAXA	NFG	ALG	Total Cover of Macrophytes	% of filamentous algae
1	SN 07138 19966	4.92	10.0	5.0	0.0	10	0

Notable Species

At the Gelli monitoring site, Batrachian *Ranunculus* sp. was noted in 2007 (2.5-5 % cover) and *Ranunculus penicillatus* subsp. *penicillatus* was noted in 2004 (2.5-5 % cover). In addition, *Myriophyllum alterniflorum* and *Fontinalis* sp. were also recorded in both 2004 and 2007 with *Callitriche hamulata* present in 2004; these species are also components of *Ranunculion fluitantis* and *Callitriche-Batrachion* vegetation ("Ranunculus communities"). No *Ranunculus* sp. were noted at the D/S Bridge near Southfield Villa site, with the channel plant community being bryophyte dominated (including *Fontinalis squamosa*. at 10-25% cover), although three *Callitriche* species were recorded in 2001. The data provided for the two sampling sites on the River Cleddau showed the presence of Batrachian *Ranunculus* sp. and *Myriophyllum alternifolium* at both sites, with *Ranunculus penicillatus* noted in 2004 at the Canaston Gauging Station site. The macrophyte communities recorded during surveys by Cascade Consulting in 2011 are considered to represent a good example of *Ranunculion*

²⁰ Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018 - Llys Y Fran - July 2018 (APEM)

fluitantis and *Callitricho-Batrachion* vegetation, subtype 3²¹.

No data were evident for the SSSI designated species *Potamogeton berchtoldii* x *P. polygonifolius* at any monitoring sites on the Afon Syfynwy or Cleddau.

D.3.1.2 Assessment

The assessment of impacts on the macrophyte community should be considered in the context of the watercourse under baseline conditions. Baseline data indicates that the macrophyte communities in the hydrological zone of influence of the drought order are adapted to moderate flow conditions. Reduction in 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. However, the hydrological regime in the zone of influence of the drought order is highly variable under normal operating conditions reflecting periods of reservoir spill, compensation and regulation releases (see **Appendix B**). Hence, macrophyte communities within the zone of influence of the drought order are likely to be adapted to a highly variable flow regime. However, significant decreases in volume of low flows could have the potential to have a negative effect on the macrophyte communities and subsequent WFD status of the Afon Synfynwy and Eastern Cleddau through:

- Proliferation of filamentous algae due to decreases in velocity/increases in water temperature/increases in nutrients;
- Shading of macrophyte stands by epiphytic algae, due to decreases in velocity/increases in water temperature/increases in nutrients;
- Desiccation of macrophyte beds due to reduced wetted width and water depth;
- Reduction in gaseous exchange in submerged species due to slower flow/ponding or increased epiphytic algae cover;
- Reduction in flowering and seed setting; and
- Encroachment of marginal emergent species into the channel.

Hydrological impacts as a result of drought order implementation in Reach 1 (Afon Syfynwy) are anticipated to be major adverse, with an associated reduction in wetted width, depth and bed exposure during this period. High flows which influence macrophyte community composition by scouring activities (particularly in autumn and winter after the growing season) would not be affected. Overall risk of the drought order to water quality as a result of reduced flows have been summarised as medium risk for soluble reactive phosphorus.

The drought order is likely to operate during August to November and would coincide with at least part of the main macrophyte growing season.

²¹JNCC(2016) <http://jncc.defra.gov.uk/protectedsites/sacselection/habitat.asp?FeatureIntCode=H3260>

The potential reduction in flow could affect macrophyte communities at the time when they are most vulnerable to impacts. Due to limited duration of the drought order, macrophyte communities are expected to recover within two to three seasons and the impacts are therefore considered to be short term and reversible.

Available information suggest that Reach 1 and Reaches 2 and 3 are considered different sub-types of the Annex 1 habitat; Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation. While the tributaries of the Eastern Cleddau could be considered to be typical of sub-type CB5: Atlantic bryophyte *Callitriche hamulate*/*Ranunculus penicillatus* spp *penicillatus*, the Eastern Cleddau would be considered a sub-type CB4: smaller meso-eutrophic rivers. In addition to the negative effects listed above, both sub-types are highly susceptible to increased silt deposition. An assessment of the geomorphological risks associated with the drought order determined that the risk to change in sediment dynamics as a result of the drought order is negligible. However, the implementation of the drought order during the autumn months could result in decreased “flushing of riffle areas which could impact on macrophyte cover in subsequent years.

Due to the sensitivity of the macrophyte communities, including *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation for which the Cleddau Rivers SAC is designated, and the major hydrological impact within all reaches during the growing season, the impact on macrophyte communities are considered **major**, adverse, short term and reversible. The impact is considered to be **moderate** during the months of October and November as a result of the decrease in flushing flows.

Summary

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

Table D3.5 Summary of Impacts on Macrophyte Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Syfynwy		
Macrophytes	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	<p>Major (August-September) Moderate (October-November)</p>
Notable and designated SAC and SSSI species, including <i>Ranunculus</i> communities	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	Major
Reach 2 – East Cleddau Syfynwy conf – Canaston intake		
Macrophytes	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	<p>Major (August-September) Moderate (October-November)</p>
Notable and designated SAC and SSSI species, including <i>Ranunculus</i> communities	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	Major
Reach 3 – Eastern Cleddau Canaston intake – tidal limit		
Macrophytes	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	<p>Major (August-September) Moderate (October-November)</p>
Notable and designated SAC and SSSI species, including <i>Ranunculus</i> communities	<ul style="list-style-type: none"> Reduction in late season growth as a result of major impacts on water levels and flows. Alteration to community composition as a result of minor changes in water quality. 	Major

As the macrophyte status element of the Syfynwy - Llys-y-fran to confluence with Eastern Cleddau (GB110061030700) and Eastern Cleddau – confluence with Syfynwy to tidal limit (GB110061030670) WFD waterbodies have not been classified, an assessment of the risk of deterioration in status is not applicable.

D.3.2 Macroinvertebrates

D.3.2.1 Baseline

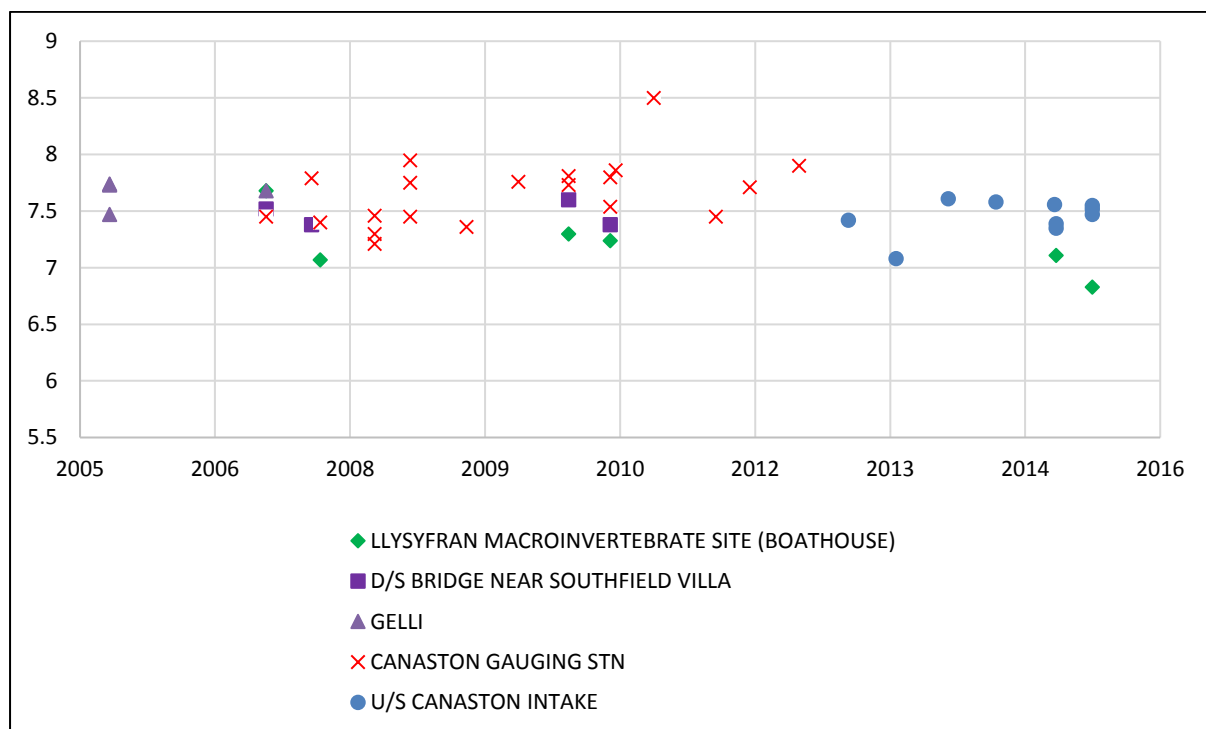
Within the study area, baseline data are available for macroinvertebrates at three NRW sampling locations on the Afon Syfynwy and two sampling locations on the Eastern Cleddau. Samples were collected in spring (March to May), summer (June to August) and autumn (September to November) in various years between 1990 and 2015 by NRW.

Sampling was conducted following the standard NRW protocol involving a three-minute kick / sweep sample encompassing all the available instream habitats in proportion to their occurrence²². For data collected between 1990 and 2000, animals were identified to family level and the abundance recorded in logarithmic categories; for the data collected after 2000 abundance was recorded as the actual values. These datasets were used to calculate a series of standard biotic indices: Biological Monitoring Working Party (BMWP) scores; Average

²² Environment Agency (1999) *Procedures for Collecting and Analysing Macroinvertebrate Samples* (Issue 2.0), Environment Agency BTO01.

Score Per Taxon (ASPT) scores; Lotic Invertebrate Flow Evaluation (LIFE); and number of taxa. There are no regulatory quality bands for BMWP scores and ASPT scores. However, as a guide, BMWP scores of 200 with ASPT values above 6 are indicative of rivers of exceptionally good quality, while BMWP scores of 100 with ASPT values of 5 are indicative of reasonably good water quality. LIFE scores around 6 represent a macroinvertebrate community that is primarily comprised of species favouring slow-flowing conditions and scores over 8 generally represent a community primarily comprised of species favouring faster-flowing conditions. The LIFE scores, ASPT and BMWP Scores are plotted in **Figures D3.1 to D 3.3**.

Figure D3.1 Observed Family LIFE Scores within the Afon Syfynwy and Eastern Cleddau



LIFE scores in the Afon Syfynwy range from 6.64 to 8.1: the Gelli site had the highest LIFE scores, in the range 7.2 to 8.1, while the Llysyfran Macroinvertebrate Site (Boathouse) had the lowest LIFE scores, in the range 6.64 to 7.68. The Eastern Cleddau LIFE scores range from 7.08 to 8.5, the scores were higher at Canaston Gauging Station, in the range 7.21 to 8.5, than at the U/S Canaston Intake site which scored in the range 7.08 to 7.61. The LIFE scores recorded for all sites are in the upper values of the range of scores obtained for rivers during studies as part of the development of the LIFE index (typical scores were 6-8)²³. The LIFE scores for predominately indicate the presence of invertebrate families that favour moderate velocity habitats.

²³ Extence, C., Balbi, D.M., Chadd, R.P. (1999). *River flow indexing using British benthic macro-invertebrates: a framework for setting hydro-ecological objectives*. Regulated Rivers Research and Management, 15: 543-74

Figure D3.2 Observed ASPT Scores within the Afon Syfynwy (and With the Canaston Site in the Eastern Cleddau Included for Reference)

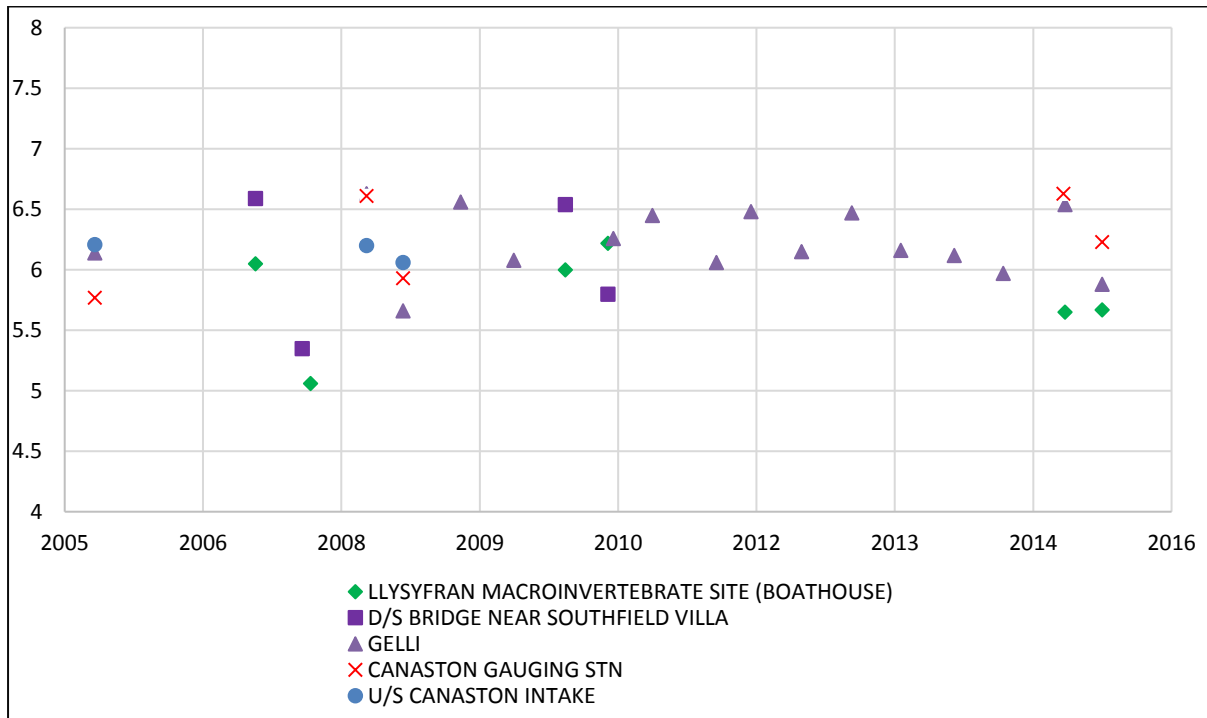
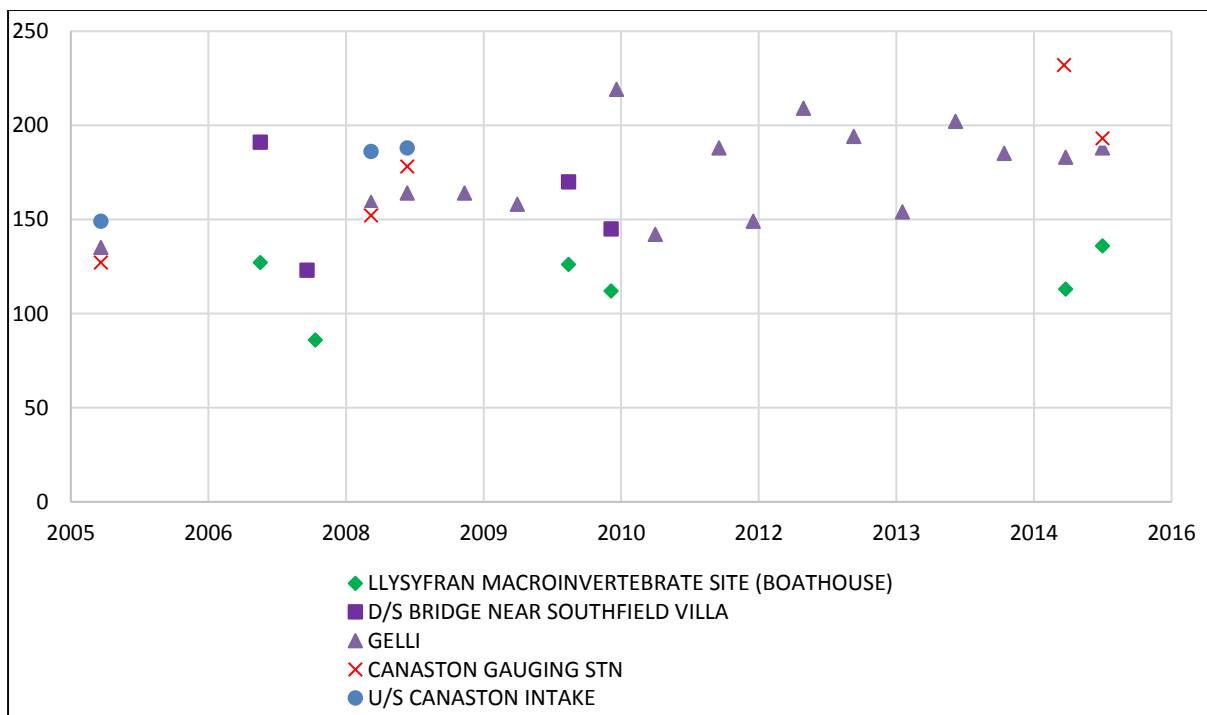


Figure D3.2 Observed BMWP Scores within the Afon Syfynwy (and With the Canaston Site in the Eastern Cleddau Included for Reference)



The ASPT scores in the Afon Syfynwy range from 4 to 6.83, which indicate a range of moderate to very good water quality. In the Eastern Cleddau, the range is 5.58 to 6.83, which is a range from good to very good water quality, with the presence of invertebrate families that favour clean water with high oxygen levels. In the Afon Syfynwy, there is a general increase in ASPT scores with distance downstream from the reservoir.

The composition and abundance of the macroinvertebrate communities at the sampling locations are indicative of moderate to high diversity. In the Afon Syfynwy, the Gelli site supported the highest BMWP scores and species diversity, with BMWP scores between 135 and 219, and with 22 to 35 scoring macroinvertebrate taxa identified. The species diversity is similar at D/S Bridge near Southfield Villa with BMWP scores between 110 and 198, along with between 18 and 33 scoring taxa present. The BMWP scores and macroinvertebrate diversity are lowest at the site closest to the reservoir (the Boathouse site) with BMWP scores between 52 and 136 along with between 13 and 24 scoring taxa recorded. The minimum and maximum values were recorded in the autumn 2000 and the autumn 2015 samples respectively.

BMWP and ASPT scores for the sites show some variation but scores at all of the sites are relatively high and are indicative of a macroinvertebrate community that have only been subject to minor anthropogenic impacts.

Macroinvertebrate kick sampling was also undertaken in 2011 by Cascade Consulting for Welsh Water in support of the drought order assessment. Five sites were surveyed along the Reach 1 (see **Figure D1.1** and **Table D3.6**) in summer and autumn 2011, following standard NRW protocol.

Animals were identified to species level and abundance recorded. These data were used to calculate BMWP and ASPT values that are graphically presented in **Figure D3.3**. LIFE scores have not been calculated, as this index is most representative when results from both spring and autumn samples are considered.

Table D3.6 Macroinvertebrate Monitoring 2011: Sample Locations

Site	Watercourse	NGR
1	Afon Syfynwy	SN0438522245
2		SN0472922188
3		SN0562721271
4		SN0570321190
5		SN0836819526

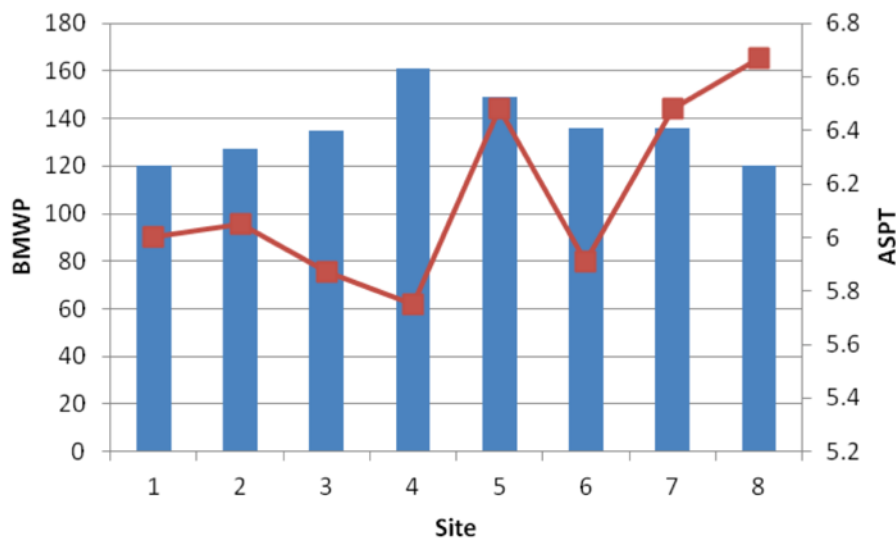
The calculated summer BMWP and ASPT scores are generally high, indicating relatively unimpacted conditions in terms of water pollution at all sites surveyed. Several species of stonefly, mayfly and caddisfly were recorded.

Autumn surveys were undertaken during a period of relatively high flow. Low amounts of

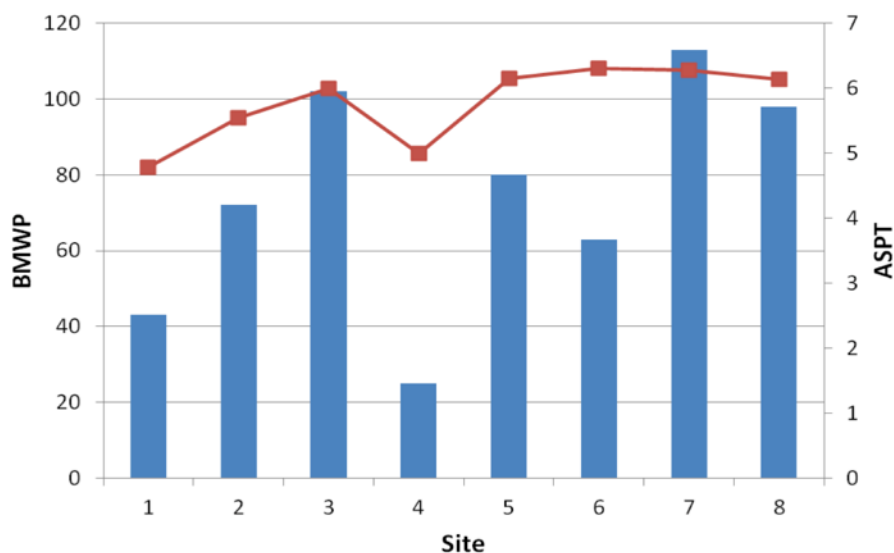
substrate were collected during the kick-sampling surveys at all the sites, and this was especially noticeable at control site 1, site 2, site 4 and site 6. Subsequently, the diversity of invertebrates identified at these sites was markedly lower in September than in the August samples. Due to the difficulties collecting substrate in the autumn surveys, these results are not considered to be representative of the macroinvertebrate community present at the sites and are not discussed further.

Figure D3.3 Indices for Macroinvertebrate Surveys Undertaken in Summer and Autumn 2011 in Afon Syfynwy (BMWP and ASPT graphically presented as blue bars and red squares respectively)

Spring



Autumn



Notable species

Two rare taxa were present within the data provided by NRW. One individual of the Nationally

Scarce riffle beetle *Oulimnius troglodytes* was found in the Syfynwy at Gelli on 02 September 2015. This species, typically found under stones, is smaller than the more common *Oulimnius tuberculatus*.

One individual of the Nationally Scarce caseless caddisfly *Metalype fragilis* was found at Canaston Gauging STN on the Cleddau on 15 April 2015. This species is associated with calcareous streams and lakes.

D.3.2.2 Assessment

Baseline macroinvertebrate data for the hydrological zone of influence indicate that the community present is indicative of good to high water quality conditions, and indicate improving water quality with distance downstream in Reach 1. The community includes several species which favour relatively high velocity habitats including stoneflies and mayflies and is considered to be susceptible to a decrease in flow

The potential reduction in wetted width and depth could result in a loss or fragmentation of habitats (e.g. riffle areas), and the loss of lateral, longitudinal and/or vertical connectivity. This would result in a reduction in the abundance or a loss of species utilising such habitats, ultimately resulting in a change in the macroinvertebrate community structure. Species with a spring emergence are also likely to be affected by the potential hydrological changes in October and November as these species would be present as early stage larvae overwintering within in the hydrological reaches. Impacts are also likely to include a reduction in the abundance and distribution of flow sensitive taxa.

Impacts on the macroinvertebrate community are anticipated to be of a medium to high magnitude, although short-term, temporary and reversible. Taking into account the potential for the drought order to affect macroinvertebrate communities at times of emergence , the overall impacts of the drought order on the macroinvertebrate community within all reach have been assessed as **major** adverse) adverse, short term, and reversible.

Notable species

The Nationally Scarce species *Oulimnius troglodytes* and *Metalype fragilis* were both detected at low densities at only one site in Reach 1. Both species form part of the in-stream benthic macroinvertebrate fauna and will therefore be affected in the same way as the overall macroinvertebrate community. Impacts of the drought order on these species are therefore assessed as **major** in Reach 1 (*Oulimnius troglodytes* only) and **major** in Reach 2-3 (*Metalype fragilis* only).

Summary

The potential impacts of the Canaston drought order on the macroinvertebrate community are summarised in **Table D3.7**. 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 D3.7** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.7 Summary of Impacts on Macroinvertebrate Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Syfynwy		
Macroinvertebrates	<ul style="list-style-type: none"> Reduction in species diversity as a result of the loss of flow-sensitive taxa Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats 	Major
Notable species - <i>Oulimnius troglodytes</i>	<ul style="list-style-type: none"> Reduction in velocity/area of preferred habitat. 	Major
Reach 2 – East Cleddau Syfynwy conf – Canaston intake		
Macroinvertebrates	<ul style="list-style-type: none"> Reduction in species diversity as a result of the loss of flow-sensitive taxa Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats 	Major
Notable species - <i>Metatype fragilis</i>	<ul style="list-style-type: none"> Reduction in velocity/area of preferred habitat. Disruption to emergence and recolonisation 	Major
Reach 3 – Eastern Cleddau Canaston intake – tidal limit		
Macroinvertebrates	<ul style="list-style-type: none"> Reduction in species diversity as a result of the loss of flow-sensitive taxa Loss of marginal habitats and reduction in abundance and distribution of species utilising such habitats 	Major
Notable species - <i>Metatype fragilis</i>	<ul style="list-style-type: none"> Reduction in velocity/area of preferred habitat. Disruption to emergence and recolonisation 	Major

There is a risk of short-term deterioration in status of the macroinvertebrate component of the Syfynwy waterbody (GB110061030700) and Cleddau waterbody (GB110061030670) due to the drought order. Impacts of drought order implementation on the macroinvertebrate communities of the impacted reaches have been summarised as - major adverse, short-term, temporary and reversible. Consequently, the macroinvertebrate component of the WFD waterbodies is considered to be at **major** risk of short-term deterioration.

D.3.3 Fish

D.3.3.1 Baseline

In recent years, Reach 1 (Afon Syfynwy), Reach 2 and 3 (Eastern Cleddau) have been subject to intensive fisheries monitoring as part of a programme of ecological surveys commissioned by Welsh Water to fulfil monitoring specified in the 2012 environmental assessment of the Llys y Fran and Afon Syfynwy (SW8) Drought Order²⁴. Further fisheries monitoring was commissioned and undertaken in 2013 (OHES)²⁵ and 2017 (APEM)²⁶. Routine fisheries

²⁴ Cascade (2012). Environmental Assessment of the Llys y Fran and Afon Syfynwy (SW8) Drought Order. A report for Dŵr Cymru Welsh Water. April 2012.

²⁵ OHES (2013). SW8 Llys y Fran and Afon Syfynwy: Fishery and Lamprey Surveys. September 2013. A report by OHES Environmental undertaken on behalf of Cascade Consulting Ltd and DCWW.

²⁶ Dwr Cymru Welsh Water Drought Plan Monitoring 2017 to 2018 - Llys Y Fran - July 2018 (APEM)

monitoring has also been undertaken on the Afon Syfynwy and the Eastern Cleddau by NRW, with the most recent surveys being undertaken in 2018. Relevant previous studies and the most recent fish survey data have been reviewed and analysed to provide an updated summary baseline.

The Eastern Cleddau catchment (including the hydrological zone of impact) is designated as part of the Cleddau Rivers SAC. The Annex II 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 are not a primary reason for site selection. Condition assessment of the River Cleddau SAC features carried out in 2008 by the Countryside Council for Wales (CCW)²⁷ revealed that all listed fish species were in unfavourable condition: unclassified (i.e. not enough survey data available to undertake an accurate assessment). It is noted that Atlantic Salmon *Salmo salar* is not a designated species for this SAC.

Existing Data

The most recent fish surveys were undertaken by NRW (2018) and APEM (on behalf of Welsh Water in 2017) and consisted of a single timed run survey in each of the three hydrologically impacted reaches. Due to the excessive width of the two watercourses, quantitative survey methodologies (allowing population estimates to be made) could not be employed. The fisheries monitoring undertaken by OHES between 2011 and 2013 consisted of a suite of surveys in a predicted extent of hydrological influence of the proposed drought order. Monitoring consisted of standard electric fishing surveys at four sites on the Afon Syfynwy as well as lamprey-specific electric fishing surveys at 10 sites on the Afon Syfynwy and Eastern Cleddau. Detailed methodologies are provided in the relevant reports²⁸.

Fish survey data from four sites²⁹ in Reach 1 on the Afon Syfynwy and one site³⁰ in Reach 2 and on the Eastern Cleddau was provided by NRW following a data request to inform this assessment. No NRW survey data was available for Reach 3. Relatively long-term datasets were provided for some sites in Reach 1, however, sites have not been sampled consistently either across years or in terms of methodology. However, the geographical coverage gives a useful insight into the likely species assemblage within the predicted zone of influence and complements the more detailed data collected by OHES and APEM in support of this study.

‘Principal’ Atlantic salmon *Salmo salar* rivers (numbering 64 in England and Wales) are assessed annually with the most recent report³¹, published in 2016. The Rivers Eastern and

²⁷ 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

²⁸ Cascade (2012). Environmental Assessment of the Llys y Fran and Afon Syfynwy (SW8) Drought Order. A report for Dŵr Cymru Welsh Water. April 2012.

²⁹ EC03A (Site ID 5032) SN0380024100, EC03 (Site ID 5026) SN0370022600, EC03C (Site ID 5037) SN0500022200 and EC02 (Site ID 5054) SN0720019800.

³⁰ EC19 (Site ID: 61083) SN0751317338

³¹ Cefas. 2015. Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2014. Preliminary assessment prepared for ICES, March 2015.

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 meeting the management objective) with a predicted classification of 'At risk' in 2020. 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 Syfynwy - Llys y Fran to confluence with Eastern Cleddau waterbody (GB110061030700) was assessed as achieving good status for fish in 2009, 2015 and 2018 (interim 2018 classification³²). The Eastern Cleddau – confluence with Syfynwy to tidal limit (GB110061030670) was assessed as achieving moderate status for fish in 2009. A classification status for fish was not available for 2015 or 2018 (interim) classifications.

Species Composition

Eleven fish species have been recorded within the hydrological zone of impact of the Canaston drought order: Atlantic salmon, brook and river lamprey, bullhead (all Environment Act (Wales) Section 7 and Habitats Directive Annex II species), brown/sea trout *Salmo trutta* (Environment Act (Wales) Section 7 species), European eel *Anguilla anguilla* (Environment Act (Wales) Section 7 species and IUCN Red List 'Critically Endangered'), gudgeon *Gobio gobio*, minnow *Phoxinus phoxinus*, roach *Rutilus rutilus*, three-spined stickleback *Gasterosteus aculeatus* and stone loach *Barbatula barbatula*. Rainbow trout *Oncorhynchus mykiss* have also been recorded but, as an introduced non-native species, are not considered further in this assessment.

Unidentified lamprey (*Lampetra* sp.) ammocoetes³³ have been recorded in surveys by OHES

³² Interim cycle 2 2018 status - Based on Natural Resources Wales 2018 Cycle 2 Interim Classification Data - https://drive.google.com/file/d/14w17jL05sNuToVELqMCK_yc6DdHU7STb/view

³³ Lamprey larvae are known as ammocoetes. When ammocoetes mature prior to migration (either to estuaries for river lamprey or upstream to spawn for brook lamprey) they are known as transformers.

and APEM, and incidental records in NRW surveys also refer only to 'Lamprey sp.'. This is due to the fact that brook and river lamprey ammocoetes are indistinguishable in the field³⁴. There are no records of sea lamprey within or near to the hydrological zone of impact.

OHES survey data from 2013 suggest a limited increase in species richness, fish density and biomass with distance downstream from the reservoir, however, Atlantic salmon, brown / sea trout and European eel dominate the fish assemblage at most sites. Roach (not native to the Eastern Cleddau) were present in relatively high densities in the upper reaches of the Afon Syfynwy and these fish are likely to have been carried out of Llys y Fran Reservoir by overflows or discharges and managed to persist in slower-moving, deeper sections of the river downstream. The APEM surveys in 2017 encompassed all three hydrologically impacted reaches, however only a single survey was undertaken in each. A total of seven species were recorded, with Reach 1 possessing the highest species richness compared to the two sites downstream in Reach 2 and 3. Atlantic salmon and European eel were present in Reach 1 only, whereas brown trout, river/brook lamprey and bullhead were present in all three reaches. Unlike previous surveys, coarse fish were absent.

The available data suggest that the Afon Syfynwy and Eastern Cleddau provide important spawning and nursery habitat for Atlantic salmon and brown / sea trout as well as good quality freshwater habitat for European eel.

Brook and River Lamprey

Lamprey habitat mapping was undertaken in 2011 and lamprey-specific electric fishing surveys were undertaken at 10 sites³⁵ in September 2012 and 2013 on the Afon Syfynwy and Eastern Cleddau. Both optimal and sub-optimal sites were surveyed quantitatively using a 1m² quadrat. A depletion survey was undertaken within this defined area following the 'Life in Rivers' protocol³⁶.

Mean lamprey densities (ammocoetes and transformers) of brook and river lamprey combined) across sites are provided in **Table D3.8** below. For perspective, a mean density threshold of >10 ammocoetes per m² is used to denote favourable condition status in SAC river and brook lamprey populations³⁷. The data suggest that 60% of sites assessed as consisting of optimal juvenile lamprey habitat exceeded this threshold in both years. Mean juvenile lamprey density values at optimal habitat sites also exceeded this threshold in both years (11.3 and 13.4 m⁻² respectively). This compares favourably with results from an APEM survey in 2004 which reported 47% of optimal sites met the favourable condition threshold with a mean density in optimal sites at 9.2 m⁻². There is variability in densities across sites and years, but the data does suggest that brook and river lamprey ammocoetes are present throughout the catchment

³⁴ 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.

³⁵ OHES lamprey monitoring locations: L3 (SN 057 212), L4a (SN 070 200), L4b (SN 070 200), L4c (SN 070 200), L5a (SN 083 194), L5b (SN 083 194), L5c (SN 083 194), L6a (SN 073 171), L6b (SN 073 171), L7a (SN 067 151) and L7b (SN 067 151).

³⁶ 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.

³⁷ 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.

albeit at low densities. Suitable habitat (i.e. silt with organic detritus in shallow, slow moving marginal areas) was found to be ‘present to frequent’ in the Afon Syfynwy and ‘frequent to extensive’ in the relevant reaches of the Eastern Cleddau²⁴ which suggests that habitat availability is not a particular environmental bottleneck to these species.

Table D3.8 Juvenile Lamprey densities in 2012 and 2013 in the Afon Syfynwy and Eastern Cleddau.

OHES lamprey monitoring location (ordered upstream to downstream)	Optimal/sub-optimal habitat	2012 density estimate (ammocoetes/transformers per m ²)	2013 density estimate (ammocoetes/transformers per m ²)
L3	Optimal	11*	27
L4a	Sub-optimal	46	3
L4b	Sub-optimal	0*	4
L4c	Sub-optimal	0*	1*
L5a	Optimal	11*	22
L5b	Sub-optimal	1*	2*
L5c	Optimal	n/a	0*
L6a	Optimal	7	4*
L6b	Sub-optimal	5	0*
L7a	Optimal	16	14*
L7b	Sub-optimal	2*	16

*Minimum estimate

All datasets refer to either ‘river/brook lamprey ammocoete’ or ‘Lamprey sp.’ for lamprey ammocoetes due to the difficulty in differentiating this life stage. There is therefore no information of the relative proportion of river versus brook lamprey in the sampled ammocoetes.

Whilst no lamprey specific surveys were undertaken in 2017, the APEM surveys recorded three river/brook lamprey ammocoetes in Reach 1 and one in Reach 3. In addition, a single river/brook lamprey transformer (transforming from juvenile to adult life stage) was recorded in Reach 2. This indicates their presence remains widespread throughout the predicted zone of impact.

Atlantic Salmon

Survey data suggests that juvenile salmon are present in variable densities in Reach 1 only. The most recent surveys by APEM in 2017 recorded just two salmon parr in Reach 1, whilst NRW surveys in 2018 did not record any. The low numbers of juvenile salmon, including a complete absence of fry life stages (young of the year) suggests recruitment in the Syfynwy has been low in recent years. Whilst OHES survey data from 2012 and 2013 also indicate limited recruitment occurred in previous years, NRW survey data from 2013³⁸ recorded a much higher raw abundances of salmon fry and parr life stages. Results therefore suggest recruitment is

³⁸ ECo2 and ECo3 survey sites

highly variable between years and maybe even on a very localised site scale within the Syfynwy. The only available survey data from Reach 2 and 3 carried out in 2017 did not record salmon. A single NRW survey in 2014 at EC19 in Reach 2 also recorded an absence of the species (note this survey may have been targeted at assessing eel abundance and therefore not entirely accurate for salmonid species).

The 2012 EAR³⁹ presented rod catch data from 1999 to 2010 (no new data have been made available by NRW for this study) which suggested only low levels of relatively stable returning adult salmon numbers. The NRW Cleddau Rivers Salmon and Sea Trout Catchment Summary Report for 2015⁴⁰ (the latest currently available) states reasonable salmon numbers are present in the Cleddau Rivers, with rod catches in 2015 below those of the peak years of 2007-2010. Numbers in 2015 were however slightly higher than the previous two years. The report also highlights the presence of salmon in the tributaries of the Eastern Cleddau outside of the predicted hydrological zone of impact, albeit in low densities in 2015. The most recent (2017) Annual Assessment of Salmon Stocks⁴¹ classified the Eastern and Western Cleddau as currently 'At risk' (<5% probability of 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. Overall, this highlights the importance of maintaining passage and suitable conditions for Atlantic salmon downstream within Reach 2 and 3 of the Eastern Cleddau to ensure the populations upstream are sustained.

Brown / Sea trout

Survey data indicates a self-sustaining population of brown trout is present throughout the predicted zone of impact. The most recent surveys undertaken by NRW (2018) and APEM (2017) recorded reasonably low numbers of brown trout throughout the predicted hydrologically impacted zone. Reach 1 contained a range of life stages, including fry, parr and adults, albeit in low numbers. The previous OHES and NRW surveys (not comparable with the 2017 surveys due to differing survey methodologies) also recorded self-sustaining brown trout populations in Reach 1. This indicates the habitats in the Afon Syfynwy can support the various life cycles of trout from spawning to adult life stages.

In terms of sea trout, the 2012 EAR presented sea trout rod catch data from 1999 to 2010 (no new data have been made available by NRW for this study) which suggested high levels of returning adult fish but a marked decline over that period. The 2015 NRW catchment summary for the Cleddau Rivers⁴² shows a continuing decline in rod catches, with the assessment classifying sea trout as 'Probably at Risk'. The 2015 NRW catchment summary for the Cleddau classifies juvenile trout as Grade A and B in 2015, indicating healthy abundances

³⁹ Cascade (2012). Environmental Assessment of the Llys y Fran and Afon Syfynwy (SW8) Drought Order. A report for Dŵr Cymru Welsh Water. April 2012.

⁴⁰ Natural Resources Wales. 2015. Know Your River – Cleddau Rivers Salmon and Sea Trout Catchment Summary

⁴¹ Cefas. 2017. Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2017. Preliminary assessment prepared for ICES, April 2018.

⁴² Natural Resources Wales. 2015. Know Your River – Cleddau Rivers Salmon and Sea Trout Catchment Summary

of young fish in the upper Cleddau and tributaries. Survey data for Reach 2 on the Eastern Cleddau was limited to a single survey undertaken by APEM in 2017. Due to the excessive width of the river channel in Reach 2, a timed electric fishing run of the wadeable margins recorded trout fry. The presence of this juvenile life stage suggests brown/sea trout spawned successfully in 2016 within Reach 2. It is therefore also considered likely that the deeper water habitats in Reach 2 contains adult fish. The same survey approach in Reach 3 recorded low numbers of brown trout parr, indicating suitable conditions are present for the developing juvenile life stages of the species.

Bullhead

Very little data are available on the population status of bullhead within the hydrological zone of impact as the species has not been formally recorded in the majority of surveys; OHES surveys and NRW data pre-2012 record log-abundance only. However, the available data do suggest that bullhead are present throughout the Eastern Cleddau catchment in low to medium densities and the Afonydd Cleddau SAC Condition Assessment⁴³ suggests that the species is widespread throughout the catchment. The most recent surveys undertaken by APEM in 2017 recorded bullhead in all three reaches, indicating the species are indeed present throughout the predicted zone of hydrological impact. The available data are not of sufficient quality to establish how bullhead densities compare against the 0.2 fish/m² SAC target for favourable conservation status in upland streams⁴⁴.

European Eel

Survey data indicates European eel inhabit or migrate throughout the predicted hydrological zone of impact.

The most recent surveys undertaken by APEM in 2017 recorded both juvenile and developing size classes of eel in Reach 1, indicating fish have successfully entered the Cleddau and passed upstream as far as the Syfynwy. OHES data from 2012 and 2013 also indicate that eel are present in relatively high densities throughout Reach 1. NRW surveys carried out in the upper Eastern Cleddau and its tributaries also contain eel, further highlighting the importance of the upper reaches of the catchment as a key habitat for their development into adults.

Whilst eel were absent in 2017 from the surveys carried out in Reach 2 and 3, they were recorded in 2014 by NRW in Reach 2 (Site name EC19⁴⁵). The abundance of eel in Reach 1 compared to Reach 2 and 3 suggests habitat is better suited to the species in the upper reaches of the catchment and/or difficulties in surveying the larger main river of the Eastern Cleddau/differences in survey approach result in eel not being fully represented in the survey catch.

⁴³ 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.

⁴⁴ Cowx IG & Harvey JP (2003). Monitoring the Bullhead, *Cottus gobio*. Conserving Natura 2000 Rivers Monitoring Series No. 4, English Nature, Peterborough. 16pp.

⁴⁵ EC19 (Site ID: 61083) SNO751317338

Ecological Value of Fisheries Receptors

Brook and river lamprey and bullhead are Environment Act (Wales) Section 7 species as well as Habitats Directive Annex II species that are a primary reason for selection of the Cleddau Rivers SAC and therefore are considered to be of international importance. Atlantic salmon (Environment Act (Wales) Section 7 and Habitats Directive Annex II species), brown / sea trout (Environment Act (Wales) Section 7) and European eel (Environment Act (Wales) Section 7 and IUCN Red List 'critically endangered' species) are considered to be of national importance in the context of this assessment. Gudgeon, minnow, roach, stone loach and three-spined stickleback are considered to be of local importance only.

D.3.3.2 Assessment

Hydrological variability in rivers can have a significant influence on the distribution of fish. When extreme low flows, or prolonged periods of low flow, are experienced, for example due to drought conditions and / or abstraction, the resultant changes in the hydrological regime can have significant impacts on resident fish communities. Reductions in flow often reduces the wetted area and volume with the potential for subsequent impacts on fish populations as a result of, for example, intra- and inter-specific interactions (e.g. increased competition for optimal habitat and food)^{46,47}, reduced water quality and reduced reproductive success, growth and condition⁴⁸.

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

Reach 1 (the Afon Syfynwy) is likely to experience a reduction in flow of up to 73% due to implementation of the drought order. This will increase the risk of fish mortality but fish species have evolved mechanisms in order to cope with low flow conditions, for example, avoidance behaviour (i.e. moving downstream as water levels drop) or the ability to persist in pooled areas of deeper water. However, flow sensitive species such as Atlantic salmon and bullhead are, nonetheless, susceptible to reduced flows.

The drought order is also expected to have a major impact on the functionality of the Canaston fish pass. This fish pass is currently not thought to fully function below approximately Q_{90} due to receding tailwater levels resulting in an exposed concrete apron below the pass. The hydrological assessment predicts a reduction of flow in Reach 3 of up to approximately 63% at Q_{95} during August and September and up to 51% of Q_{95} flows during October and November. This is expected to have a noticeable impact in terms of the functionality of the pass or the

⁴⁶ 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

⁴⁷ 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.

⁴⁸ 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.

duration of migration opportunity.

Brook and River Lamprey

Juvenile (ammocoete and transformer) lamprey and lamprey spawning habitat

There is the potential for reduced flow to result in a decrease in river levels and wetted width. This has particular significance for juvenile (ammocoetes and transformer) lamprey habitat which tends to consist of silt in shallow, marginal areas. Gravel spawning habitat may also be affected. There is therefore the potential for a loss or degradation of this habitat. Juvenile lamprey are likely to be able to relocate to areas of suitable habitat as river levels decrease, however, competition and stress would likely increase. The major reduction in low and extreme low flows is expected to have a significant effect on marginal habitats. Gravels containing nests and / or eggs are likely to be present from March to June and will not be affected by the drought order. The impact on juvenile lamprey and lamprey spawning habitat is therefore considered to be **major adverse** (compensation only) in all reaches due to potential habitat loss.

Water Quality

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

Migration of River Lamprey

Mature river lamprey migrate upstream into freshwater in the autumn (from October to December⁴⁹). River lamprey ammocoetes metamorphosise after three to five years in freshwater and then descend to estuarine and marine environments between July and September in smaller rivers^{Error! Bookmark not defined.}. Both life stages of the river lamprey coincide with the drought permit implementation periods of August to September and October to November. Upstream migration requires a reasonable flow of water to aid passage past natural and non-natural in-channel barriers. Low flows may limit upstream passage and hinder downstream passage, leaving both migratory life stages exposed to higher risks of predation and ultimately a reduction in recruitment. The impact on river lamprey migration is therefore considered to be **major adverse** in all reaches for the duration of the drought permit.

Bullhead

Bullhead are present throughout the hydrological zone of influence. The species is flow sensitive, with spawning and egg incubation occurring from March to May and young-of-the-year fish reliant on flows to distribute to other areas between July and September. Particularly

⁴⁹ Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No.5. English Nature, Peterborough

susceptible juvenile life stages may therefore be impacted by reduced flows (and likely reduced water quality) associated with implementation of the drought order. A reduction in flow of up to 73% is likely to have a significant impact on bullhead populations in Reach 1. The impact on bullhead is therefore considered to be **major adverse** for in Reach 1 and moderate adverse in Reaches 2 and 3 for the duration of the drought permit.

Atlantic Salmon

Atlantic Salmon Migration

Juvenile Atlantic salmon populations in the Eastern Cleddau appear fairly limited to the upper reaches and tributaries, highlighting their importance as spawning and juvenile nursery grounds. The Afon Syfynwy / Eastern Cleddau is therefore also an important migratory corridor for the species, including the lower reaches of the river (Reach 2 and 3). It is likely that the majority of migrating Atlantic salmon would enter the river from October to December and there is the potential for drought order-related impacts on flow to affect the timing of this migration. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature, and will not be affected by the drought order. Periods of increased flow are considered to be a primary cue in initiating adult and smolt life stage Atlantic salmon migration and very low flows are likely to delay and/or limit migration, thereby increasing the risk of mortality due to increased predation and stress. The impact on adult Atlantic salmon migration is therefore considered to be **major adverse** in all reaches during the months of October and November and minor adverse during the months of August and September.

Water Quality

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in habitat to increase stress and subsequent loss of condition. Atlantic salmon are susceptible to poor water quality and particularly low dissolved oxygen and extremes of water temperature however, water quality impacts have been assessed as minor in Reach 1 and negligible in Reaches 2 and 3. The impact on Atlantic salmon is therefore considered to be **minor** adverse in Reach 1, due to a potential reduction in water quality (predominately dissolved oxygen) and **negligible** in Reaches 2 and 3.

Spawning and Juvenile Atlantic Salmon Habitat

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Atlantic salmon parr tend to use water depths exceeding 0.2m. Provided minimum low flows remain available from the compensation flow releases, juvenile Atlantic salmon are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. Atlantic salmon parr are territorial and will defend areas of the stream associated with feeding stations on or just above the substrate, from where

they intercept drifting particles and forage the surrounding benthos. The impact on spawning and juvenile Atlantic salmon habitat is therefore considered to be **major** adverse in all reaches.

Brown / Sea Trout

Sea Trout Migration

The Cleddau rivers catchment is known to host a locally important sea trout population, with the Afon Syfynwy and upper Eastern Cleddau considered to provide spawning and juvenile nursery habitat. The Afon Syfynwy and Eastern Cleddau are also an important migratory corridor for the species. The available information suggests the number of sea trout returning to the catchment is currently in decline and probably at risk of not meeting its management objectives as a fishery. It is likely that sea trout would enter the river from May to October and there is the potential for drought order-related impacts on flow to affect the timing of this migration. The majority of out-migrating smolt would be likely to migrate downstream between mid-March and mid-May depending on water temperature, and will not be affected by the drought order. Periods of increased flow are considered to be a primary cue in initiating both up and downstream sea trout migration and very low flows are likely to delay/prevent migration, thereby increasing mortality due to increased predation and stress. The impact on adult sea trout migration is therefore considered to be **major adverse** in all reaches during both the summer and autumn months

Water Quality

Brown / sea trout are susceptible to poor water quality, particularly dissolved oxygen and elevated water temperature. The impacts on water quality have been assessed as minor and impacts on brown/sea trout are expected to be limited. The impact on brown / sea trout is therefore considered to be **minor adverse** in Reach 1, due to a potential reduction in water quality (predominately dissolved oxygen) and **negligible** in Reaches 2 and 3.

Spawning and Juvenile Brown / Sea Trout Habitat

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Provided minimum low flows remain available from the compensation flow releases, juvenile brown / sea trout are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. The impact on juvenile brown / sea trout is therefore considered to be **major adverse** (compensation only) in all reaches for the duration of the drought permit.

European Eel

Elver enter rivers in early spring and a general upstream migration occurs throughout the year. Elver migration is not linked to periods of increased flow and low flow conditions are unlikely to impact migration except where habitat fragmentation occurs. The downstream migration of

mature (silver) eel tends to occur between September and December in most rivers and there is the potential for drought order-related impacts on flow to effect the timing of this migration. Juvenile European eel of a wide age range are likely to be present in low densities throughout the Eastern Cleddau catchment but the species is tolerant of high temperatures and relatively poor water quality and is considered resilient to drought conditions. The impacts on European eel are expected limited to silver eel migration in September to December and are considered to be **moderate adverse** in Reach 1 in all reaches

Other Fish Species

Gudgeon, minnow, roach, stone loach and three-spined stickleback spawning and egg incubation occurs within late spring and summer months which are encompassed by the predicted period for drought order implementation. There is the potential for significant impacts on populations of these species associated with habitat loss arising from implementation of the drought order. The impact on other fish species is considered to be **moderate adverse** in all reaches.

Summary

The potential impacts of the Canaston drought order on the fish community are summarised in **Table D3.9**. 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 D3.9** represent the worst-case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.9 Summary of Impacts on Fish Community

Feature		Impact	Significance of Impact
Reach 1 – Afon Syfynwy			
Environment Act (Wales) Section 7 Species	Brook and river lamprey	• Loss of juvenile habitat as a result of reduced river levels.	Major
		• Reduced water quality.	Negligible
	River lamprey	• Migration of adult river lamprey affected or halted by a reduction in flow.	Major
	Bullhead	• Increase in mortality due to habitat loss.	Major
	Atlantic salmon	• Delays and potential cessation of adult migration due to reduced flows.	Major
		• Reduced water quality.	Minor
		• Delays and potential cessation of smolt migration due to reduced flows.	Major
		• Reduction in spawning and juvenile survival due to habitat loss.	Major
	Brown/sea trout	• Delays and potential cessation of smolt migration due to reduced flows.	Major
		• Delays and potential cessation of adult sea trout migration due to reduced flows.	Major
		• Reduced water quality.	Minor
		• Reduction in spawning and juvenile survival due to habitat loss.	Major

	European eel	<ul style="list-style-type: none"> Delays and potential cessation of silver eel migration due to reduced flows. 	Moderate
Other fish species		<ul style="list-style-type: none"> Habitat loss and reduced water quality. 	Moderate
Reach 2– Eastern Cleddau			
Environment Act (Wales) Section 7 Species	Brook and river lamprey	<ul style="list-style-type: none"> Loss of juvenile habitat as a result of reduced river levels. 	Major
		<ul style="list-style-type: none"> Reduced water quality. 	Minor
	River lamprey	<ul style="list-style-type: none"> Migration of adult river lamprey affected or halted by a reduction in flow. 	Major
	Bullhead	<ul style="list-style-type: none"> Increase in mortality due to habitat loss. 	Moderate
	Atlantic salmon	<ul style="list-style-type: none"> Delays and potential cessation of adult migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Reduced water quality. 	Minor
		<ul style="list-style-type: none"> Delays and potential cessation of smolt migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Reduction in spawning and juvenile survival due to habitat loss. 	Major
	Brown / sea trout	<ul style="list-style-type: none"> Delays and potential cessation of adult sea trout migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Delays and potential cessation of smolt migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Reduced water quality. 	Minor
		<ul style="list-style-type: none"> Reduction in spawning and juvenile survival due to habitat loss. 	Major
	European eel	<ul style="list-style-type: none"> Delays and potential cessation of silver eel migration due to reduced flows. 	Moderate
Other fish species		<ul style="list-style-type: none"> Habitat loss and reduced water quality. 	Moderate
Reach 3– Eastern Cleddau			
Environment Act (Wales) Section 7 Species	Brook and river lamprey	<ul style="list-style-type: none"> Loss of juvenile habitat as a result of reduced river levels. 	Major
		<ul style="list-style-type: none"> Reduced water quality. 	Minor
	River lamprey	<ul style="list-style-type: none"> Migration of adult river lamprey affected or halted by a reduction in flow. 	Major
	Bullhead	<ul style="list-style-type: none"> Increase in mortality due to habitat loss. 	Moderate
	Atlantic salmon	<ul style="list-style-type: none"> Delays and potential cessation of adult migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Reduced water quality. 	Minor
		<ul style="list-style-type: none"> Delays and potential cessation of smolt migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Reduction in spawning and juvenile survival due to habitat loss. 	Major
	Brown / sea trout	<ul style="list-style-type: none"> Delays and potential cessation of adult sea trout migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Delays and potential cessation of smolt migration due to reduced flows. 	Major
		<ul style="list-style-type: none"> Reduced water quality. 	Minor
		<ul style="list-style-type: none"> Reduction in spawning and juvenile survival due to habitat loss. 	Major
	European eel	<ul style="list-style-type: none"> Delays and potential cessation of silver eel migration due to reduced flows. 	Moderate
Other fish species		<ul style="list-style-type: none"> Habitat loss and reduced water quality. 	Moderate

There is a risk of short-term deterioration in status of the fish component of the Syfynwy - Llys y Fran to confluence with Eastern Cleddau (GB110061030700) and the Eastern Cleddau – confluence with Syfynwy to tidal limit (GB110061030670) waterbodies due to the drought order. Impacts of drought order implementation on the fish communities of the impacted reaches in the Syfynwy - Llys y Fran to confluence with Eastern Cleddau (GB110061030700) have been summarised as minor to major adverse, short-term, temporary and reversible.

Consequently, the fish component of the Syfynwy - Llys y Fran to confluence with Eastern Cleddau (GB110061030700) is considered to be at **major risk** of short-term deterioration. Impacts of drought order implementation on the fish communities of the impacted reaches in the Eastern Cleddau – confluence with Syfynwy to tidal limit (GB110061030670) have been summarised as minor to moderate adverse, short-term, temporary and reversible. Consequently, the fish component of the Eastern Cleddau – confluence with Syfynwy to tidal limit (GB110061030670) is considered to be at **major risk** of short-term deterioration.

D.3.4 Phytobenthos

D.3.4.1 Baseline

Baseline phytobenthos monitoring information, received from NRW, within the reach subject to hydrological impact consisted of one site on the Afon Syfynwy at Gelli and one site on the Eastern Cleddau at Canaston Gauging Station (see **Figure D1.1**). Data are available for two seasons during 2015 only.

These data shows a community typical of middle reaches of rivers with circumneutral pH and moderate nutrient levels. Communities are relatively diverse, with samples showing there is no over dominance of one or two species that could indicate particular environmental pressures, other than a common decrease from relatively high numbers species tolerant to colder temperatures (e.g. *Navicula lanceolata*, *Navicula gregaria*) from spring moving to autumn. TDI4 scores of 52 and 54 (Syfynwy) and 53 and 45 (Eastern Cleddau) in spring and autumn respectively suggest mesotrophic conditions.

D.3.4.2 Assessment

Impacts on the phytobenthos assemblages of the Afon Syfynwy 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; possible local increases in water temperature; and increases in filamentous algae smothering the substrate.

Due to the short lifecycle of algal species, phytobenthos communities can respond to rapidly to environmental change and a response in phytobenthos community composition to the reduction in flows due to the drought order would be expected.

WFD EQR metrics for phytobenthos (TDI4 in DARLEQ)⁵⁰ 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 phytobenthos community and associated WFD status. However, due to the rapid response of phytobenthos communities to environmental variables, this effect is expected to be short lived, with communities recovering rapidly (i.e. within one season) following return to the normal hydrological regime. Therefore, any such impacts on the phytobenthos community in Reaches 1, 2 and 3 are likely to be **minor**.

⁵⁰ WFD-UKTAG (2014) Phytobenthos: Phytobenthos for Assessing River and Lake Ecological Quality (River DARLEQ2)

Summary

The potential impacts of the Canaston Reservoir drought order on the phytobenthos community are summarised in **Table D3.10**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Section 4.3 of the main report) and the sensitivities of the phytobenthos community. The impacts presented in **Table D3.10** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D3.10 Summary of Impacts on Phytobenthos Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Syfynwy Reach 2 – East Cleddau Syfynwy conf – Canaston intake Reach 3 – Eastern Cleddau Canaston intake – tidal limit		
Phytobenthos	<ul style="list-style-type: none"> Changes to community composition due to changes in velocity Changes to community composition and TDI4 scores due to increases in SRP 	Minor

As the phytobenthos status element of the Syfynwy - Llys-y-fran to confluence with Eastern Cleddau (GB110061030700) and Eastern Cleddau – confluence with Syfynwy to tidal limit (GB110061030670) WFD waterbodies have not been classified, an assessment of the risk of deterioration in status is not applicable.

D4 INVASIVE FLORA AND FAUNA

D.4.1 Dugesia tigrina.

D.4.1.1 Baseline

A single example of the invasive non-native flatworm species *Dugesia tigrina* was noted at the Llys y fran boathouse site on the Syfynwy and 15 individuals at the Canaston Gauging Station site on the Eastern Cleddau on the 9th September 2015. A North American species, it is increasing in range and numbers and has been noted to displace native triclad *Polycelis* species due to competition for food in lakes in North Wales⁵¹.

D.4.1.2 Assessment

It is unlikely that exacerbated drought conditions as a result of the drought order will favour the proliferation of this species over native species. The impacts of the drought order implementation on the spread or growth of invasive species has been assessed as **negligible**.

Summary

The potential impacts of the Canaston drought order on invasive species are summarised in **Table D4.1**. The impacts, and their magnitude, have been based on the hydrological impacts

⁵¹ Gee, H.; Young, J. O. (1993). The food niches of the invasive *Dugesia tigrina* (Girard) and indigenous *Polycelis tennisi* Ijima and *P. nigra* (Müller) (Turbellaria; Tricladida) in a Welsh lake. *Hydrobiologia* 254 (2): 99

(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). The impacts presented in **Table D4.1** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D4.1 Summary of Impacts on Invasive Species

Species	Impact	Significance of Impact
Reach 1 – Afon Syfynwy Reach 2 – East Cleddau Syfynwy conf – Canaston intake Reach 3 – Eastern Cleddau Canaston intake – tidal limit		
Invasive Species – <i>Dugesia tigrina</i>	<ul style="list-style-type: none"> Implementation of the drought order will do nothing to favour proliferation of this species. 	Negligible

D5 RECREATION AND ARCHAEOLOGY

D.5.1 Recreation

D.5.1.1 Baseline

The Afon Syfynwy provides numerous recreational opportunities including angling, walking, cycling and bird watching. The popularity of the area has resulted in the development of good recreation facilities: there is a visitor centre located at the reservoir itself with a café, shop, toilets, trails, picnic areas and parking for over 300 cars.

D.5.1.2 Assessment

In the event of a drought order implementation, flows in the Afon Syfynwy and Eastern Cleddau would already be low due to the natural drought conditions. Non-water dependent recreation is not anticipated to be materially affected by implementation of the drought order and impacts on walking and cycling have been assessed as **negligible** throughout the year. .

The only water dependent activity to take place in the impacted reaches is angling. Angling in the reach is predominantly associated with fly fishing. The salmon and sea trout fishing season starts at the beginning of April and ends on the 17th October. The brown trout fishing season starts in March and ends at the beginning of October. Fly fishing for rainbow trout can take place year round, however, this is associated with Llys y Fran Reservoir rather than river reaches.

The assessment of impacts on migratory salmonids has been assessed as major adverse. Impacts on angling are anticipated during October, when impacts of the drought order may coincide with the end of the fishing season. Overall impacts on angling have been assessed as **major** adverse (direct impacts constrained to October-November only, but indirect impacts due to adverse effects on fish recruitment could extend into subsequent angling seasons).

D.5.2 Archaeology

D.5.2.1 Baseline

There are a number of Scheduled Ancient Monuments in the study area in proximity to the zone of hydrological influence of the drought order including: Llawhaden Castle and Bridge and a number of defence enclosures (Walton Mill Rath, Knock Rath, Drim Camp and Gelly Earthworks).

No non-statutory archaeological features have been identified in proximity to the zone of hydrological influence of the drought order.

D.5.2.2 Assessment

None of the known designated assets are in sufficient proximity to the hydrological reaches to result in adverse effects to their setting. There is the potential for impacts on previously undiscovered paleo-environmental remains due to anticipated reductions in wetted width and depth and resulting bed exposure. However, as such remains have yet to be identified, impacts have been summarised as **negligible**.

Summary

The potential impacts of the Canaston Reservoir drought order on recreation and archaeology community are summarised in **Table D5.1**. 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 phytobenthos community. The impacts presented in **Table D5.1** represent the worst case impacts of implementing a drought order, over and above the impacts potentially caused by a natural drought.

Table D5.1 Summary of Impacts on Recreation and Archaeology

Feature	Impact	Significance of Impact
Reach 1 – 3		
Recreation – cycling, walking, birdwatching	<ul style="list-style-type: none"> Impacts on non- water dependant activities are not anticipated over and above the impacts of the baseline drought conditions. 	Negligible
Recreation – angling	<ul style="list-style-type: none"> Impacts on angling are anticipated during October and November, when impacts of the drought order may coincide with the end of the fishing season 	Major (October-November only)
Archaeology	<ul style="list-style-type: none"> None of the known designated assets are in sufficient proximity to the Afon Syfynwy result in impacts to their setting. 	Negligible