



Ricardo
Energy & Environment

Dŵr Cymru Welsh Water

Environmental Assessment of Ffynnon Llugwy Drought Permit (8001-4)

Final

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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 permit at Ffynnon Llugwy Reservoir, over and above those arising due to natural effects of drought and those which would occur under "normal" abstraction licence conditions.

Ffynnon Llugwy Reservoir is located in Welsh Water's North Eryri Ynys Môn WRZ (8001) includes the mainland adjacent to the Menai Straits (North Eryri) and Ynys Môn (Anglesey).

The assessment also considers how the proposed drought permit 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 Natural Resources Wales (NRW) for a drought permit at Ffynnon Llugwy, which may be required by Welsh Water in the future.

PROPOSED DROUGHT PERMIT DETAILS

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

If granted, this drought permit would involve a reduction in the compensation flow release from Ffynnon Llugwy to the Afon Llugwy from 4.5Ml/d to 2.5Ml/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill. The drought permit will influence the downstream Afon Llugwy as far as the Llyn Cowlyd stream capture leat, and potentially further downstream depending on the abstraction and compensation

arrangements at the leat.

The timing of the reduction in the compensation flow release is most likely to occur during the late summer / early autumn period, and is not considered to extend outside the period July to December. This has been confirmed by Welsh Water's water resources modelling.

The revised abstraction arrangements would be authorised for 6 months but would be removed sooner if water resources have returned to adequate levels to safeguard future water supplies, as agreed with Natural Resources Wales.

NEED FOR THE DROUGHT PERMIT

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

The justification for the drought permit 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 permit application.

ALTERNATIVE SOURCES CONSIDERED

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

POTENTIAL IMPACTS OF DROUGHT PERMIT IMPLEMENTATION

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

Summary of the Hydrological Assessment for the Afon Llugwy

The assessment has concluded that there are **major** impacts on river flows as a result of implementing the drought permit. There are **moderate** impacts on the physical environment of the river, including minor impacts for water quality.

Summary of the Environmental Features Screening for the Afon Llugwy

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

Screening identified the Eryri SAC / SSSI, Afon Llugwy SSSI, WFD status and Community Assessment / Environment (Wales) Act Section 7 species, landscape and recreation as environmental features for which an environmental assessment was

required. The assessment has concluded that there are **major** impacts on Eryri SSSI, aquatic ecology, specifically: **major** impacts on fish and bryophytes, **moderate** to minor impacts on macrophytes and macroinvertebrates, as well as **minor** impacts for phytobenthos.

Cumulative Impacts

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

MITIGATION AND MONITORING

The environmental assessment has identified significant impacts of implementation of a drought permit at Ffynnon Llugwy. 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 permit at Ffynnon Llugwy, 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**.

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Appendix B – Hydrology and Physical Environment Assessment

Appendix C – Environmental Features Assessment Methodologies

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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 permit by Dŵr Cymru Welsh Water (Welsh Water) to temporarily modify the abstraction conditions to allow a temporary decrease in compensation flow from Ffynnon Llugwy reservoir. Water abstracted at Ffynnon Llugwy is used to provide public water supplies to Welsh Water's North Eryri Ynys Môn Water Resource Zone (WRZ)¹ (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 permit at Ffynnon Llugwy. A drought permit 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 permit 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 permit over the period July to December. The purpose of the assessment is to determine the environmental impacts of the drought permit over and above any effects arising from natural drought conditions.

The study area and focus of this environmental assessment of the Ffynnon Llugwy drought permit, covers the following waterbodies:

- Nant gwryd to Ffynnon Llugwy (GB110066054870)
- Conwy to Nant gwryd (GB110066054850)

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 permit (**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**)

¹ UKWIR/Environment Agency define a WRZ as: 'The largest possible zone in which all resources, including external transfers, can be shared, and hence, the zone in which all customers will experience the same risk of supply failure from a resource shortfall.'

- recommendations for baseline, in-drought and post-drought permit 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 Guideline² (DPG); specifically Section 5 and Appendices I and J, and Welsh Government / Defra / NRW / Environment Agency guidance on drought permits and drought orders³.

Consideration has been given to the potential impacts of drought permit 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 permit 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 permit 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 permits / orders where there is certainty that there are no such impacted sensitive features.

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

² 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 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.

permit). 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 permit at Ffynnon Llugwy, 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 also be undertaken at the time of any future applications for the drought permit.

1.4 STRUCTURE AND CONTENT OF THE REPORT

This EAR comprises the following sections:

Section 1: Introduction

Section 2: Background to the Drought permit

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 PERMIT

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**).

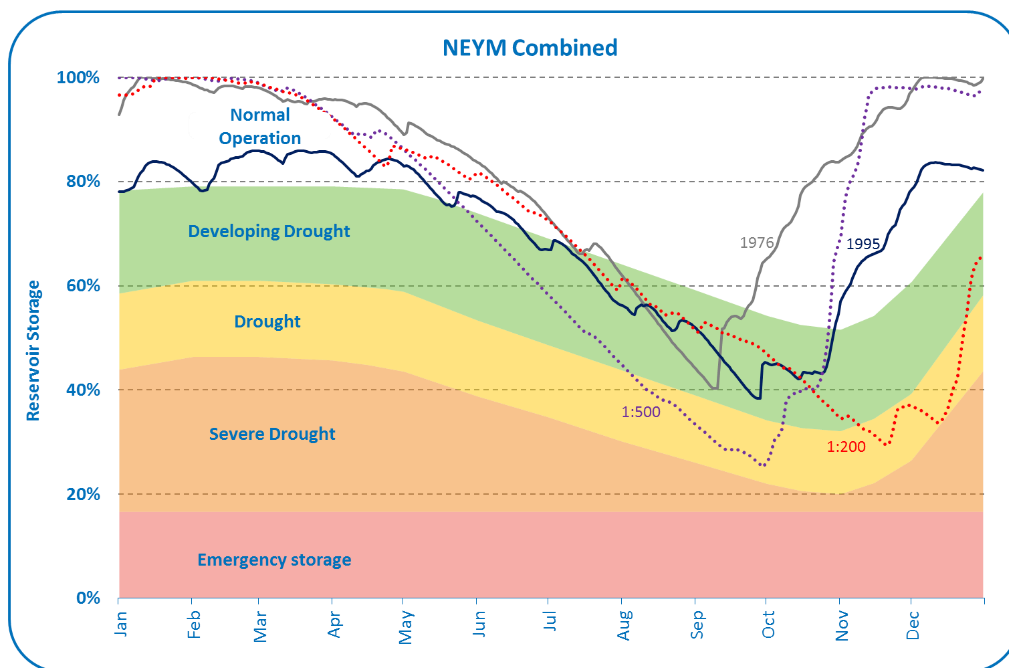
Figure 2.1 Welsh Water Water Resource Zones



The area of North Eryri Ynys Môn WRZ includes the mainland adjacent to the Menai Straits (North Eryri) and Ynys Môn (Anglesey). Water is supplied from five impounding reservoirs (Ffynnon Llugwy, Llyn Cwellyn and Llyn Marchlyn Bach on the mainland and Llyn Alaw and Llyn Cefni on Ynys Môn). The resources are operated conjunctively with the ability to feed water from the mainland to parts of Ynys Môn from the gravity resources of Llyn Cwellyn, Ffynnon Llugwy and Llyn Marchlyn Bach when reservoir storage allows. There are no exports or imports of water relating to North Eryri Ynys Môn WRZ.

The trigger levels for applying for a drought permit at Ffynnon Llugwy are based on the combined reservoir storage in Llyn Cwellyn, Llyn Cefni, Llyn Alaw and Ffynnon Llugwy falling below a defined level; this is shown in **Figure 2.2** (orange shading labelled as ‘severe drought’). Welsh Water’s assessment in its draft Drought Plan 2020 indicates that drought conditions severe enough to require an application for this drought option are unlikely to occur more frequently than at a return period of around once every 200 to 500 years. Fuller details of the work undertaken to assess this risk are provided in Annex 1 to the draft Drought Plan 2020.

Figure 2.2 North Eryri Ynys Môn WRZ Drought Action Zones and Historic Droughts



2.2 DESCRIPTION OF EXISTING ARRANGEMENTS AT FFYNNON LLUGWY DROUGHT PERMIT

Welsh Water’s licence (number 23/66/8/10) to abstract water under the Water Resources Act 1991 at Ffynnon Llugwy Reservoir includes the following conditions:

- 2,827 million litres (Ml) authorised to be abstracted per annum
- At an abstraction rate not exceeding 7.7282Ml/d⁴

Compensation flow releases provisions from the reservoir are included in the associated impounding licence (number 23/66/8/14), and also detailed in the North Wales Hydro Power Act 1973:

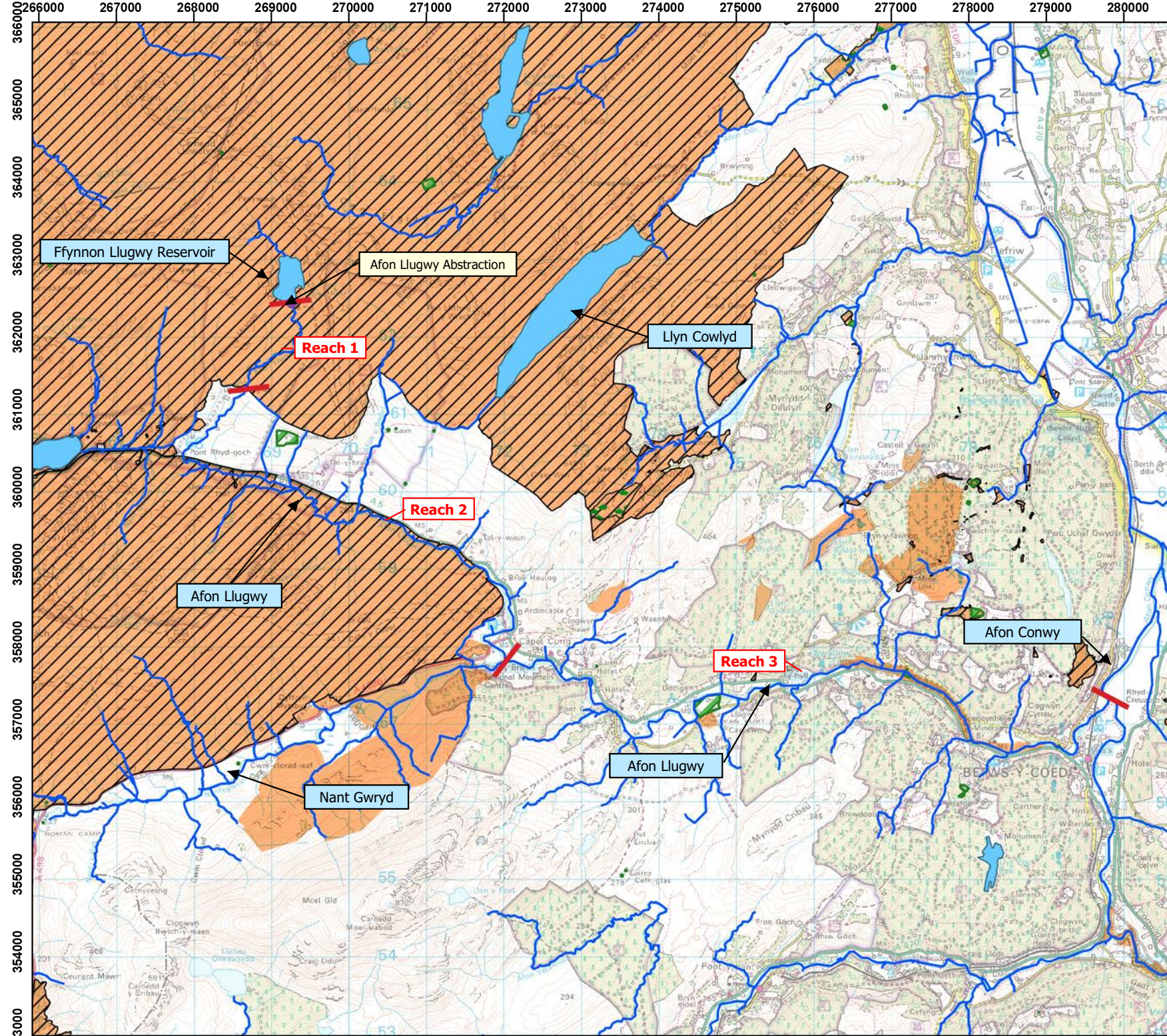
⁴ 1Ml/d is 1 million litres per day.

- Provision of a uniform statutory compensation water discharge of 4.5Ml/d at all times to the downstream Afon Llugwy.

The abstraction for potable supply is made directly from the reservoir and piped by gravity to Mynydd Llandegai Water Treatment Works (WTW) and Capel Curig WTW for treatment.

Approximately 1.4km downstream of Ffynnon Llugwy Reservoir, part of the Afon Llugwy flow is diverted by a stream capture system into the Llyn Cowlyd West Leat which transfers water to Llyn Cowlyd Reservoir for hydro-power generation. The stream capture system is licensed separately (held by RWE Innogy plc, licence number 23/66/10/0003). The licence authorises maximum abstraction of 132,392 Ml/yr at a rate not exceeding 1,300 Ml/d for the purposes of hydro-electric generation and 41.82 Ml/yr for domestic, industrial and agricultural purposes. Natural Resources Wales (NRW) have advised that the leat has no compensation flow or Hands Off Flow requirement associated with it.

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



- Legend**
- Abstraction
 - Hydrological Reach
 - Waterbody
 - Watercourse
 - Special Area of Conservation
 - Site of Special Scientific Interest
 - 🌿 National Nature Reserve
 - 🏛️ Scheduled Ancient Monument



1:65,000
 Note all locations are approximate
 This drawing incorporates Ordnance Survey Information
 © Crown copyright and database rights 2019

Project Title:
**Welsh Water Drought Plan
 Environmental Assessment**

Figure Title:
**Study Area: 8012_2
 Reduction in Ffynnon Llugwy Compensation**

Figure Number: Figure 2.3	Date: February 2019
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2.3 WELSH WATER'S DROUGHT PLANNING PROCESS

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

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

2.5 DROUGHT PERMIT – 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 permit, 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 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 permit, setting out the alternative options to the drought permit that Welsh Water has considered in addressing the risks to essential public water supplies due to drought.

2.7 PROPOSED DROUGHT PERMIT DETAILS

The drought permit involves a proposed reduction in the compensation flow release from Ffynnon Llugwy to the Afon Llugwy from 4.5Ml/d to 2.5Ml/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill. The drought permit will influence the downstream Afon Llugwy as far as the Llyn Cowlyd stream capture leat, and potentially further downstream depending on the abstraction and compensation arrangements at the leat.

Details of the existing and proposed drought permit abstraction at Ffynnon Llugwy are presented in **Table 2.1**.

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

The compensation release from Ffynnon Llugwy Reservoir sustains flow in the upper Afon Llugwy year round by 4.5Ml/d. From photographs provided by NRW, the design of the downstream leat intake structure appears to be such that low flows continue past the flow diversion weir. Only when flow is above a certain level does the leat start to capture water directly at the crossing point (however the flow at which this occurs is not known). Consequently, at low flows when reservoir outflow is limited to compensation flow releases only, the impacts of the drought permit will likely extend downstream of the leat until catchment flow accretion has significantly increased flows in the Afon Llugwy.

Table 2.1 Ffynnon Llugwy Existing and Proposed Drought Permit Abstraction

Abstraction Water Source	NGR	Normal Abstraction	Proposed Drought Permit Abstraction	Benefit ML/d
Ffynnon Llugwy Reservoir	SH 69260 62410	<p>Welsh Water's licence (23/66/88/10) to abstract water under the Water Resources Act 1991 at Ffynnon Llugwy Reservoir includes the following conditions:</p> <ul style="list-style-type: none"> • 2,827 million litres (ML) authorised to be abstracted per annum • At an abstraction rate not exceeding 7.7ML/d <p>Compensation flow releases provisions from the reservoir are included in the associated impounding licence (number 23/66/8/14), and also detailed in the North Wales Hydro Power Act 1973:</p> <ul style="list-style-type: none"> • Provision of a uniform statutory compensation water discharge of 4.5ML/d at all times to the downstream Afon Llugwy. <p>The abstraction for public water supply is made directly from the reservoir and piped by gravity to Mynydd Llandegai Water Treatment Works (WTW) and Capel Curig WTW for treatment.</p>	<p>The drought permit involves a proposed reduction in the compensation flow release from Ffynnon Llugwy to the Afon Llugwy from 4.5ML/d to 2.5ML/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill.</p>	2.00 ML/d

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

2.8 DROUGHT PERMIT PROGRAMME

The drought permit may remain in force for a period of up to six months, and it can be extended for up to a further six months. The period of implementation for this drought permit is restricted to July to December, 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. A permit may be granted but not actually implemented if weather conditions improve or, equally, the permit may only be partially implemented.

2.9 DROUGHT PERMIT 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 permit being implemented. For the purposes of this assessment, the "without drought permit" baseline includes the continuation of abstraction and statutory rate of compensation flow release (4.5ML/d) under the existing abstraction licence from Ffynnon Llugwy Reservoir. This represents normal operating arrangements during a typical summer/autumn period. The assessed drought permit assumes a temporary reduction in the compensation rate of 2ML/d (from 4.5 ML/d to 2.5ML/d), to conserve storage in Ffynnon Llugwy Reservoir.

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 for the drought permit assessment 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 permit during the worst environmental conditions (natural drought) that the permit could be implemented in.

In accordance with the DPG and the Habitats Regulations, the assessment considers how the proposed drought permit 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 permit 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.

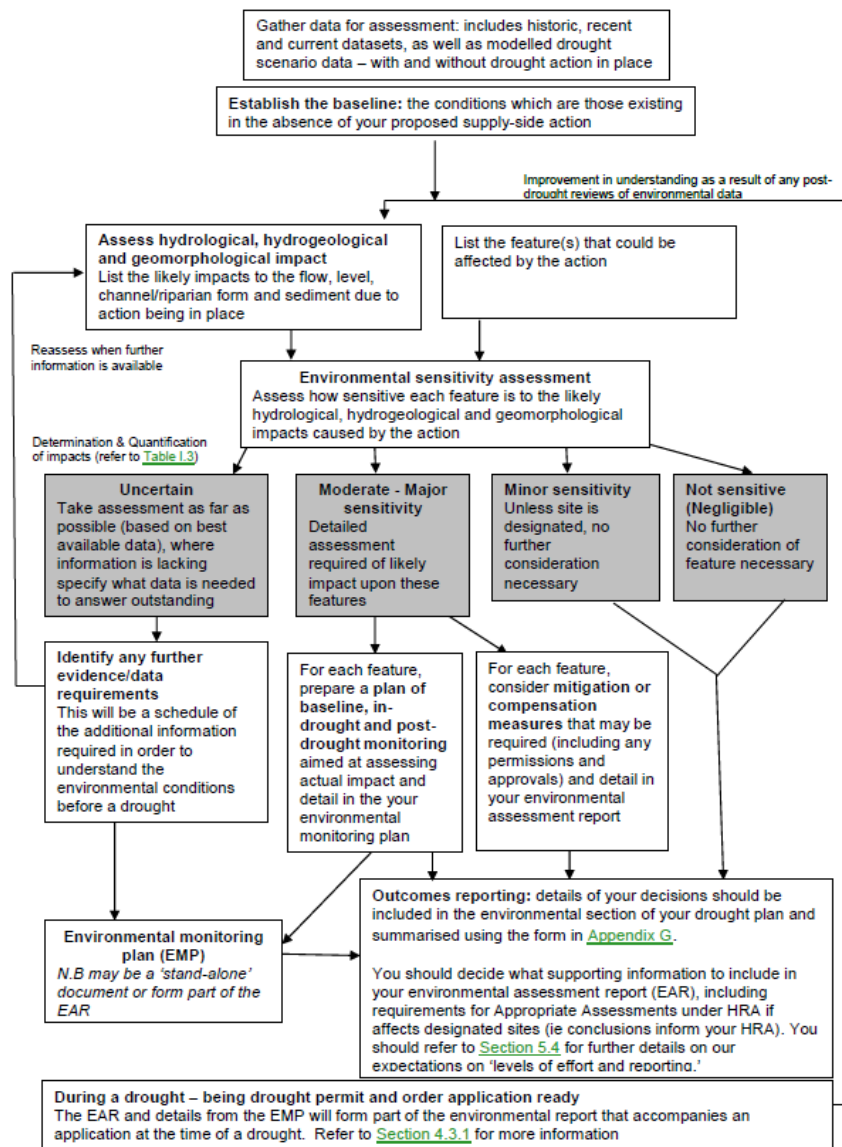
This is discussed further in Section 7.

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 Error! Reference source not found. 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 permit implementation should be considered in the context of what would occur without drought permit 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 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 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 permit. 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 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.

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 permit at Ffynnon Llugwy Reservoir.

Stage 2 - Environmental Sensitivity

With the extent and level of flow impact mapped, using GIS and other data sources, potentially sensitive receptors (sites / features) located within the extents of impact

have been identified. Potentially sensitive features investigated in the screening have been drawn from Box 1 in Appendix I of the DPG. These include:

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

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

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

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 Ffynnon Llugwy drought permit together with identification of relevant, sensitive environmental features within those study areas (based on the risk of them being impacted by the drought permit 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.

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 Ireland⁵
- 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

⁵ CIEEM, Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal. September 2018.

- The Convention on Wetlands of International Importance especially as Waterfowl Habitat , December 1975
- Conservation of Habitats and Species Regulations 2017
- The Countryside and Rights of Way Act 2000.

All aspects of the drought permit 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 permit 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 permit 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 permit 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 permit against baseline operating conditions of Welsh Water's abstraction licence in advance of drought permit implementation. Environmental sensitivity has been assessed considering the context of the timing of drought permit implementation. **It is important to acknowledge the basis of the assessment; i.e. impacts of drought permit implementation are assessed against what would occur without drought permit 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 Institute of Environmental Management and Assessment (IEMA)^{6,7} and the Chartered Institute of Ecology and Environmental Management (CIEEM) study guidelines⁸. 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 permit.

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 permit.

⁶ IEMA (2004) Guidelines for Environmental Impact Assessment.

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

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

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

3.4 LIMITATIONS OF THE ASSESSMENT AND UNCERTAINTIES

The 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 and 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 FFYNNON LLUGWY DROUGHT PERMIT - 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 permit. **Appendix B** sets out an assessment of the potential impacts on the physical environment of Ffynnon Llugwy drought permit during the period of implementation of the drought permit. The “without drought permit” 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 permit impacts, identifying the likely changes in flow/ level regime due to implementing the drought permit. The specific requirements of the DPG are summarised as:

- identify any changes that the drought permit 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 permit;
- describe how the likely conditions would differ with the drought permit in place compared to the same (or analogous) watercourse under natural conditions; and
- identify the extent of the area affected by your planned actions.

These requirements are addressed in the following sections.

1. The perceived extent of potential impact:

The study area (see **Figure 2.3**) is identified as the Afon Llugwy from downstream of Ffynnon Llugwy Reservoir to the confluence of the Afon Conwy at Betws-y-coed.

2. The nature and duration of the potential impact:

A description of the likely conditions with the drought permit 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 permit, the key areas for the assessment of the physical environment have been identified as:

- Change in river flows downstream of Ffynnon Llugwy Reservoir.

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

3. The length of the potential impact:

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

4.3 SUMMARY OF POTENTIAL EFFECTS ON THE PHYSICAL ENVIRONMENT

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

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

Ffynnon Llugwy	
Reservoir levels <i>Minor beneficial impacts</i>	<ul style="list-style-type: none"> The impact on Ffynnon Llugwy Reservoir would be a marginal increase in levels/storage, relative to the position without the drought permit, due to the reduced outflow which would help to conserve water in storage.
Afon Llugwy (Reach 1 & 2)	
Flows in the Afon Llugwy <i>Major impacts during the period July to December inclusive</i>	<ul style="list-style-type: none"> Reductions of up to 44% in river flows with corresponding reductions in wetted depths/wetted widths (potential marginal habitats), during the summer and autumn period
Water quality in the Afon Llugwy <i>Moderate (uncertain) risk during the period July to December inclusive</i>	<ul style="list-style-type: none"> WFD waterbodies indicates High status for Ammonia, DO and phosphorus and therefore at greater risk of deterioration under major hydrological impacts. However the lack of water quality monitoring data means there is a level of uncertainty.
Surface water abstractions and risk to abstractors <i>Moderate (uncertain) risk during the period July to December inclusive</i>	<ul style="list-style-type: none"> Potential impact on HEP abstraction through the Llyn Cowlyd West Leat, which may need to be reduced or discontinued during the implementation of the drought permit.
Consented discharges <i>Negligible risk</i>	<ul style="list-style-type: none"> No consented discharges
Geomorphology <i>Moderate (uncertain) risk during the period July to December inclusive</i>	<ul style="list-style-type: none"> Major hydrological impacts will likely result in a significant reduction in wetted width and flow velocity below those normally observed in the upper Afon Llugwy.
Afon Llugwy (Reach 3)	
Flows in the Afon Llugwy <i>Moderate/major impacts during the period July to September inclusive; negligible impacts during the period October to December inclusive</i>	<ul style="list-style-type: none"> Reductions of up to 19% in river flows (27% based on Afon Lledras donor gauge), with corresponding reductions in wetted depths/wetted widths (potential marginal habitats), during the summer and autumn period
Water quality in the Afon Llugwy <i>Moderate (uncertain) risk during the period July to September inclusive</i>	<ul style="list-style-type: none"> WFD waterbodies indicates High status for Ammonia, DO and phosphorus and therefore at greater risk of deterioration under minor hydrological impacts. However the lack of water quality monitoring data means there is a level of uncertainty.
Surface water abstractions and risk to abstractors <i>Negligible risk</i>	<ul style="list-style-type: none"> No surface water abstractions
Consented discharges <i>Negligible risk</i>	<ul style="list-style-type: none"> No consented discharges
Geomorphology <i>Moderate (uncertain) risk during the period July to September inclusive</i>	<ul style="list-style-type: none"> Moderate hydrological impacts may lead to a reduction in wetted width and flow velocity below those normally observed in the upper Afon Llugwy.

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 permit impacts and the baseline condition without a drought permit 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 FFYNNON LLUGWY DROUGHT PERMIT ENVIRONMENTAL FEATURES ASSESSMENT

5.1 INTRODUCTION

As set out in **Box 1** above, environmental sensitivity screening of the drought permit 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 permit. Susceptibility to the flow / level impacts resulting from the drought permit (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 Ffynnon Llugwy Drought Permit

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)
Reach 1 – (Afon Llugwy - Outflow of Ffynnon Llugwy to Llyn Cowlyd take off leat), Reach 2 (Afon Llugwy - Llyn Cowlyd take off leat to Capel Curig)				
Eryri/Snowdonia SAC	Major	Designated for important annex 2 species – Slender green feather-moss (recorded up to 450m) and floating water-plantain.	Major	Yes
Eryri SSSI	Major	Designated for important species such as floating water plantain and aquatic and marginal plant assemblages	Major	Yes
Notable species – Fish Brown trout <i>Salmo trutta</i>	Major	Reductions in flow is anticipated to reduce the availability of habitat for fish, and increase the risk of predation. Changes to velocity, depth, wetted width may reduce or dry out spawning gravels.	Major	Yes
Notable species – Mammals Otter <i>Lutra lutra</i>	Major	These species are not expected to be significantly impacted by drought permit implementation as habitat and availability and quality is not anticipated to be significantly altered. The reduction in river level may even be beneficial to otter with prey more easily accessible	Negligible	No
Notable species – Invertebrates Freshwater pearl mussel <i>Margaritifera margaritifera</i>	Major	The changes to river flow following initial onset of environmental drought is not anticipated to significantly alter habitat availability and quality for freshwater pearl mussel.	Moderate	Yes
Benthic macroinvertebrate communities	Major	The major hydrological impact is anticipated to reduce the availability of habitats or lead to exposure of benthic macroinvertebrate habitats.	Moderate	Yes
Landscape and visual amenity	Major	Ffynnon Llugwy and the Afon Llugwy are within Snowdonia National Park – the overall landscape and visual amenity of this area is appealing. Land use around the study zone is part of a wider area of acid sensitive geology and soils which are extensively grazed by sheep. The reduction of the compensation release may affect the landscape and visual amenity value of the site by reducing the quantity of water cascading down the mountainous stream. This will only be temporary and will be ameliorated once the drought has passed.	Uncertain	Yes
Recreation	Major	Recreational activities include angling, rock climbing, canoeing and fell walking. Ffynnon Llugwy is a game fishery and Afon Llugwy holds wild trout populations. Any reduction in wetted width and depth may influence water-dependent recreational activities. However, water levels will be naturally low in times of drought and impacts will be temporary in nature.	Uncertain	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)
Reach 3 – (Afon Llugwy - Capel Curig to the confluence with the Afon Conwy)				
Llugwy – Nant gwryd to Ffynnon Llugwy SSSI	Minor	Afon Llugwy is designated for its geomorphology and its assemblage of moss and liverwort species. The site supports an assemblage of oceanic and nationally scarce mosses and liverworts which depend on the river flows and damp, shaded conditions along the river's edge. The geographical location of the site also contributes to the flora due to the Atlantic, temperate climate which ensures infrequent desiccation and frost.	Minor	Yes
Notable species – Fish Bullhead <i>Cottus gobio</i> Brown/sea trout <i>Salmo trutta</i> Brook and river lamprey <i>Lampetra planeri</i> and <i>Lampetra fluviatilis</i> Atlantic salmon <i>Salmo salar</i> European eel <i>Anguilla anguilla</i>	Minor	A number of notable species occur within Reach 3. Reductions in flow is anticipated to reduce the availability of habitat for fish, and increase the risk of predation. Changes to velocity, depth, wetted width may restrict the access of migratory fish to spawning tributaries or to dry out spawning gravels.	Minor	Yes
Notable species – Mammals Otter <i>Lutra lutra</i>	Minor	These species are not expected to be significantly impacted by drought permit implementation as habitat and availability and quality is not anticipated to be significantly altered. The reduction in river level may even be beneficial to otter with prey more easily accessible	Negligible	No
Notable species – Invertebrates Freshwater pearl mussel <i>Margaritifera margaritifera</i>	Minor	The changes to river flow following initial onset of environmental drought is not anticipated to significantly alter habitat availability and quality for freshwater pearl mussel.	Minor	Yes
Benthic macroinvertebrate communities	Minor	The major hydrological impact is anticipated to reduce the availability of habitats or lead to exposure of benthic macroinvertebrate habitats.	Minor	Yes
Landscape and visual amenity	Minor	Ffynnon Llugwy and the Afon Llugwy are within Snowdonia National Park – the overall landscape and visual amenity of this area is appealing. Land use around the study zone is part of a wider area of acid sensitive geology and soils which are extensively grazed by sheep. The reduction of the compensation release may affect the landscape and visual amenity value of the site by reducing the quantity of water cascading down the mountainous stream. This will only be temporary and will be ameliorated once the drought has passed.	Uncertain	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)
Recreation	Minor	Recreational activities include angling, rock climbing, canoeing and fell walking. Ffynnon Llugwy is a game fishery and Afon Llugwy holds wild trout populations. Any reduction in wetted width and depth may influence water-dependent recreational activities. However, water levels will be naturally low in times of drought and impacts will be temporary in nature.	Uncertain	Yes

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 permit. 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	Llugwy - Nantygwryd to Ffynnon Llugwy (GB110066054870)		Llugwy - Conwy to Nantygwryd (GB110066054850)	
	Hydrological Impact at Location (Major, Moderate, Minor, Negligible)	Major		Moderate
Heavily Modified Waterbody (Y/N)	Yes		Yes	
RBMP Cycle	RBMP2 (2015) ⁹	2018 Cycle 2 Interim Classification	RBMP2 (2015) ¹⁰	2018 Cycle 2 Interim Classification
Ecological	Moderate	Moderate	Moderate	Moderate
Fish	Good	Good	Not assessed	Not assessed
Macrophytes	Not assessed	Not assessed	Not assessed	Not assessed
Phytobenthos	Not assessed	Not assessed	Good	Good
Macro-invertebrates	Not assessed	Not assessed	Good	Good
Total P/ Phosphate	High	High	High	High
Ammonia	High	High	High	High
Dissolved Oxygen	High	High	High	High
pH	Moderate	Moderate	High	Moderate
Sensitivity (Uncertain, Moderate/ Major, Minor, Not sensitive)	Moderate		Moderate	
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 permit.

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

⁹ NRW (2017) <https://drive.google.com/file/d/0B2hsDbbdxzZtZHItRU9lNkg1YWs/view>.

¹⁰ NRW (2018) https://drive.google.com/file/d/14w17jL05sNuT0VELqMCK_yc6DdHU7STb/view

the magnitude of impact in the relevant reservoir / river reaches for the Ffynnon Llugwy drought permit. Each feature assessment describes the analyses carried out and a statement of the assessed impact. All impacts are considered to be negative / adverse unless otherwise stated in the feature assessment. The approach is described in Section 3.3.

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






5.3.2 Summary of Features Assessment

Table 5.3 presents the overall summary of the significance of potential impacts of the drought permit 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 Permit Implementation Pre-Mitigation

Month			J	F	M	A	M	J	J	A	S	O	N	D	
Reaches 1 and 2 – Afon Llugwy															
Ery ri SAC			N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	
Ery ri SSSI			N/A	N/A	N/A	N/A	N/A	N/A							
Macrophytes	Macrophyte community		N/A	N/A	N/A	N/A	N/A	N/A							
	<i>Oceanic bryophyte</i>		N/A	N/A	N/A	N/A	N/A	N/A							
Risk to WFD water body macrophyte status			N/A	N/A	N/A	N/A	N/A	N/A	N/A						
Macroinvertebrates	Overall		N/A	N/A	N/A	N/A	N/A	N/A	N/A						
	Freshwater pearl mussel		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
Risk to WFD water body macroinvertebrate status			N/A	N/A	N/A	N/A	N/A	N/A	N/A						
Fish	Atlantic salmon	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N				
		Smolt migration	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	
		Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
		Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
	Brown trout	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
		Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
		Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N				
		Smolt migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
	Brook and river lamprey	Adult river migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
		Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
	European eel		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
	Other fish species - Minnow		N/A	N/A	N/A	N/A	N/A	N/A	N/A						
Risk to WFD water body fish status			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							
Risk to WFD water body phyto benthos status			N/A	N/A	N/A	N/A	N/A	N/A							
Landscape			N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	
Recreation			N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	
Reach 3 – Afon Llugwy															
Afon Llugwy SSSI			N/A	N/A	N/A	N/A	N/A	N/A							
Macrophytes	Macrophyte community		N/A	N/A	N/A	N/A	N/A	N/A					N	N	N
	<i>Oceanic bryophyte</i>		N/A	N/A	N/A	N/A	N/A	N/A					N	N	N
Risk to WFD water body macrophyte status			N/A	N/A	N/A	N/A	N/A	N/A							
Macroinvertebrates	Overall		N/A	N/A	N/A	N/A	N/A	N/A					N	N	N
	Freshwater pearl mussel		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
Risk to WFD water body macroinvertebrate status			N/A	N/A	N/A	N/A	N/A	N/A							
Fish	Brook and river lamprey	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A							
		Spawning and egg survival	N/A	N/A	N/A	N/A	N/A	N/A							
		Juvenile habitat	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							
	Atlantic salmon	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N			
		Smolt migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
		Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
		Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
	Brown trout, sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N				
		Smolt migration	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
		Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
		Spawning and juvenile habitat	N/A	N/A	N/A	N/A	N/A	N/A	N/A					N	N
European eel	Habitat loss and water quality		N/A	N/A	N/A	N/A	N/A	N/A	N	N					
Other fish species - Minnow		N/A	N/A	N/A	N/A	N/A	N/A	N/A							
Risk to WFD water body fish status			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	N	N	N	N	N	
Risk to WFD water body phyto benthos status			N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	
Landscape			N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	
Recreation			N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N	

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 permit 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 Permit Implementation on Designated Sites

Feature	Impact	Significance of Impact
Reach 1 and 2 – Afon Llugwy		
Eryri SAC	<ul style="list-style-type: none"> No water dependant habitats or species located in the units in which the Afon Llugwy occurs. Impacts of the drought permit on the are assessed as negligible 	Negligible
Eryri SSSI	<ul style="list-style-type: none"> Implementation of the drought permit has potential to have a limited effect on wetted widths, splash zone and humidity within the river reach, thereby potentially impacting the bryophyte assemblage of the SSSI. 	Major
Reach 3 – Afon Llugwy		
Afon Llugwy SSSI	<ul style="list-style-type: none"> Implementation of the drought permit has potential to have a limited effect on wetted widths, splash zone and humidity within the river reach, thereby potentially impacting the bryophyte assemblage of the SSSI. 	Minor

5.3.4 WFD and Community Assessment

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

WFD Definitions

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

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

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

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

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

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

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 Agency¹¹ 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 permit 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**.

¹¹ 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 permit identified from the assessment of macrophytes. The assessment has been made on a precautionary basis in the absence of any reliable data (see **Appendix D**). Collection of baseline data may provide the basis for a revised conclusion.

Table 5.5 Summary of Impacts of Drought Permit Implementation on Macrophytes

WFD Waterbody		Significance of Impact
Llugwy - Nantgwryd to Ffynnon Llugwy waterbody (GB110066054870) Current status: Not assessed	<ul style="list-style-type: none"> There is a risk of short-term deterioration in status of the macrophyte component due to the drought permit. 	Moderate
Llugwy - Conwy to Nantgwryd waterbody (GB110066054850) Current status: Not assessed	<ul style="list-style-type: none"> There is a risk of short-term deterioration in status of the macrophyte component due to the drought permit. 	Minor
Feature	Impact	Significance of Impact
Reach 1 – (Afon Llugwy - Outflow of Ffynnon Llugwy to Llyn Cowlyd take off leat), Reach 2 (Afon Llugwy - Llyn Cowlyd take off leat to Capel Curig)		
Macrophytes	<ul style="list-style-type: none"> Reduction in growth as a result of major impacts on water levels and flows. Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity 	Moderate (July to September only)
Bryophytes	<ul style="list-style-type: none"> Changes to community composition due to changes in splash and humidity. Reduction in growth as a result of major impacts on water levels and flows. Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity. 	Major (July to September) Minor (October to December)
Reach 3 – (Afon Llugwy - Capel Curig to the confluence with the Afon Conwy)		
Macrophytes	<ul style="list-style-type: none"> Reduction in growth as a result of major impacts on water levels and flows. Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity 	Minor (July to September only)
Bryophytes	<ul style="list-style-type: none"> Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity. Reduction in growth as a result of moderate (July to Sept) impacts on water levels and flows. Changes to community composition due to changes in splash and humidity. 	Minor (July to September only)

Macroinvertebrates

Table 5.6 presents a summary of the potential impacts of the drought permit identified from the assessment of macroinvertebrates. The assessment has been made on a precautionary basis in the absence of any reliable data (see **Appendix D**). Collection of baseline data may provide the basis for a revised conclusion.

Table 5.6 Summary of Impacts of Drought Permit Implementation on Macroinvertebrates

WFD Waterbody		Significance of Impact
Llugwy - Nantgwryd to Ffynnon Llugwy' (GB110066054870) Current status: Not assessed	<ul style="list-style-type: none"> • There is a risk of short-term deterioration in status of the macroinvertebrate component due to the drought permit. 	Moderate
Llugwy - Conwy to Nantgwryd waterbody (GB110066054850) Current status: Good	<ul style="list-style-type: none"> • There is a risk of short-term deterioration in status of the macroinvertebrate component due to the drought permit. 	Minor
Feature	Impact	Significance of Impact
Reach 1 – (Afon Llugwy - Outflow of Ffynnon Llugwy to Llyn Cowlyd take off leat), Reach 2 (Afon Llugwy - Llyn Cowlyd take off leat to Capel Curig)		
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 • Reduction in species diversity and abundance as a result of reduced recruitment. 	Moderate (July to November)
Freshwater pearl mussel	<ul style="list-style-type: none"> • Reduction in habitat area and suitability • Potential for mortality due to reduced flows and wetted width. 	Negligible
Reach 3 – (Afon Llugwy - Capel Curig to the confluence with the Afon Conwy)		
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 	Minor (July to September only)
Freshwater pearl mussel	<ul style="list-style-type: none"> • Reduction in habitat area and suitability 	Negligible

Fish

Table 5.7 presents a summary of the potential impacts of the drought permit identified from the assessment of fish. The assessment has been made on a precautionary basis in the absence of any reliable data (see **Appendix D**). Collection of baseline data may provide the basis for a revised conclusion.

Table 5.7 Summary of Impacts of Drought Permit Implementation on Fish

WFD Water body		Significance of Impact
Llugwy - Nant gwryd to Ffynnon Llugwy' (GB110066054870) Current status: Good	<ul style="list-style-type: none"> • There is a risk of short-term deterioration in status of the fish component due to the drought permit. 	Major
Llugwy - Conwy to Nant gwryd waterbody (GB110066054850) Current status: Not assessed	<ul style="list-style-type: none"> • There is a risk of short-term deterioration in status of the fish component due to the drought permit. 	Minor
Feature	Impact	Significance of Impact
Brook and river lamprey	<ul style="list-style-type: none"> • Delays and potential cessation of adult river lamprey migration due to reduced flows. 	Minor
	<ul style="list-style-type: none"> • Reduction in river flow resulting in increased siltation and suffocation of spawning gravels and eggs. • Reduction in spawning and juvenile survival due to habitat loss. 	
Atlantic salmon	<ul style="list-style-type: none"> • Delays and potential cessation of adult upstream migration due to reduced flows. 	Major (Reach 2)
	<ul style="list-style-type: none"> • Delays and potential cessation of smolt migration due to reduced flows. 	Moderate (Reach 3)
	<ul style="list-style-type: none"> • Reduced water quality. 	Moderate (Reach 2 & 3)
	<ul style="list-style-type: none"> • Loss of spawning and juvenile habitat as a result of reduced river levels. 	Major (Reach 2)
Brown/sea trout	<ul style="list-style-type: none"> • Delays and potential cessation of adult upstream sea trout migration due to reduced flows. 	Minor (Reach 3)
	<ul style="list-style-type: none"> • Delays and potential cessation of smolt migration due to reduced flows. 	Major (Reach 1 & 2)
	<ul style="list-style-type: none"> • Reduced water quality 	Moderate (Reach 3)
	<ul style="list-style-type: none"> • Reduction in spawning and juvenile survival due to habitat loss. 	Moderate (Reach 1-2)
		Minor (Reach 3)
		Major (Reach 1 & 2)

		Moderate (Reach 3)
European eel	<ul style="list-style-type: none"> Delays and obstruction to upstream juvenile migration 	Negligible
	<ul style="list-style-type: none"> Increased risk of stress and predation during downstream migration of a dult life stage (silver eel) 	Negligible (Reach 1 & 2) Minor (Reach 3)
Other fish species	<ul style="list-style-type: none"> Minor species are present in Reaches 2 and 3 only. Spawning and egg incubation of the minor species recorded occurs within the likely July to November period for drought permit implementation. These species are therefore susceptible to impacts associated with low flows. 	Moderate (Reach 2)
		Minor (Reach 3)

Phytobenthos

Table 5.8 presents a summary of the potential impacts of the drought permit identified from the assessment of phytobenthos. The assessment has been made on a precautionary basis in the absence of any reliable data (see **Appendix D**). Collection of baseline data may provide the basis for a revised conclusion.

Table 5.8 Summary of Impacts of Drought Permit Implementation on Phytobenthos

WFD Water body		Significance of Impact
Llugwy - Nantgwryd to Ffynnon Llugwy' (GB110066054870) Current status: Not assessed	<ul style="list-style-type: none"> There is a risk of short-term deterioration in status of the phytobenthos component due to the drought permit. 	Minor (uncertain)
Llugwy - Conwy to Nantgwryd waterbody (GB110066054850) Current status: Good	<ul style="list-style-type: none"> There is a risk of short-term deterioration in status of the phytobenthos component due to the drought permit. 	Minor (uncertain)
Reach 1 – (Afon Llugwy - Outflow of Ffynnon Llugwy to Llyn Cowlyd take off leat)		
Reach 2 (Afon Llugwy - Llyn Cowlyd take off leat to Capel Curig)		
Feature	Impact	Significance of Impact
Phytobenthos	<ul style="list-style-type: none"> Decrease in flow affecting phytobenthos community composition through changes to grazing pressure, increases in water temperature, and increases in filamentous algae smothering the substrate. Minor increase in SRP affecting phytobenthos community composition and TDI score. Communities are expected to recover rapidly following return to the normal hydrological regime. 	Minor
Reach 3 – (Afon Llugwy - Capel Curig to the confluence with the Afon Conwy)		
Phytobenthos	<ul style="list-style-type: none"> Decrease in flow affecting phytobenthos community composition through changes to grazing pressure, increases in water temperature, and increases in filamentous algae smothering the substrate. Minor increase in SRP affecting phytobenthos community composition and TDI score. Communities are expected to recover rapidly following return to the normal hydrological regime. 	Negligible

5.3.5 Landscape and Recreation

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

Table 5.9 Summary of Impacts of Drought Permit Implementation on Landscape and Recreation

Feature	Impact	Significance of Impact
Landscape	<ul style="list-style-type: none"> • Landscape and visual amenity impacts may be visible from public rights of way, footpaths, cycle routes and river crossings. However the impact on flows will only be temporary and will be ameliorated once the drought has passed. • Flows during drought conditions will naturally be low therefore the implementation of the drought permit is not expected to lead to any material additional landscape and visual amenity impacts 	Negligible
Recreation	<ul style="list-style-type: none"> • Any reduction in wetted width and depth may influence water-dependent activities such as angling and canoeing. • However, water levels will already be naturally low in times of drought and will already have curtailed these recreational activities prior to the drought permit implementation. • Any impacts will be temporary in nature and will be ameliorated once the drought has passed. 	Negligible

5.3.6 Supplementary Baseline Monitoring

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

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

The available data are not sufficient to adequately describe the potential impacts of a drought permit over and above a natural drought and gaps in the baseline have been identified in the features assessment in **Appendix D**.

Specifically there are spatial and temporal constraints on the baseline information for macroinvertebrates, macrophytes and phytobenthos with no monitoring data available. The existing baseline data is not considered to be sufficient to characterise the whole watercourse. There is no baseline information or specific surveys for white-clawed crayfish although they have been reported to be present with the catchment and there is limited baseline information on the presence of freshwater pearl mussels in the impacted reaches. Baseline information for fish is also limited where previous fish surveys have a number of key constraints such as including lamprey-specific monitoring and HABSCORE analysis. Consequently there is considerable uncertainty surrounding the status of existing fish populations present including protected species

(particularly sea lamprey *Petromyzon marinus*).

The impact assessment has therefore used the precautionary principle where data are lacking and uncertainty exists. A conservative approach has been used which assumes that, in the absence of definitive data, significant populations of the relevant species are present in the hydrological zone of impact and that worst-case impacts would occur.

Monitoring of Physical Environment and Key Receptors

A number of gaps have been identified in the baseline information provided whilst undertaking the environmental assessment of the Ffynnon Llugwy drought permit. It is, therefore, recommended that any outstanding and available data are obtained, where possible. A review of this and the findings of the walkover surveys described above will inform further monitoring requirements of habitats, sensitive communities and / or species to support the development of the environmental assessment of the Ffynnon Llugwy drought permit.

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

- Hydrology – hydrological cross-section and spot flow surveys at times of low flow in Reaches 1-2; accompanied by walkover of tributaries to north of Reach 2 to clarify effective catchment during low flows
- Hydrology - gauging station validation, including at low flows, from which to develop a rating equation and enable calculation of daily river flow for the Cwmlanerch river flow gauge
- Water quality – monitoring of water quality (dissolved oxygen, ammonia, phosphorous, temperature) in Reaches 1 and 2.
- Macrophytes – LEAFPACS survey, in June- September, at least one year, ideally two year baseline, ideally encompassing 1 x “normal” flow year and 1 x “dry” flow year in Reaches 1-3
- Macroinvertebrates – Baseline survey in spring, summer and autumn, three three minute kick/sweep samples and a one-minute hand search in Reaches 1-3
- Bryophytes - survey of up to 3 x areas within each reach (e.g. high gradient reach, open section, gorge/shaded section). Survey method uses quadrats to sample bryophytes from 2 x substrate types (wood & bark, and rock) within 3 x

zones (stream channel, stream bank, riparian corridor). 20 x 0.2 m quadrats are surveyed on each substrate type within each zone in each reach¹².

- Freshwater pearl mussels – baseline survey using a bathyscope to determine presence/absence and classify age of population in Reaches 1-3.
- Fish - baseline surveys to determine fish species presence and abundance.
 - To be confirmed following initial walkover but likely to be:
 - Reach 1 – 1 quantitative and 2 semi-quantitative surveys
 - Reach 2 - 1 quantitative and 4 semi-quantitative surveys
 - Reach 3 - 1 quantitative and 3 semi-quantitative surveys upstream of Swallow Falls and 1 quantitative and 3 semi-quantitative surveys downstream.
 - In addition, a limited number of control sites outside of the hydrological zone of influence.
 - Brook and river lamprey: One suite of lamprey-specific electric fishing surveys undertaken in September. Surveys to target known optimal and sub-optimal habitat including identification of juvenile habitat low in the catchment to establish whether sea lamprey are present.
 - Atlantic salmon, brown / sea trout, bullhead and European eel: One suite of three run and single run electric fishing surveys and HABSCORE assessments to be undertaken in August / September.

¹² Demars, B. O. L. and Britton, A. (2011). Assessing the impacts of small scale hydroelectric schemes on rare bryophytes and lichens. Scottish Natural Heritage and Macaulay Land Use Institute Funded Report. Scottish Natural Heritage Commissioned Report No.421

6 FFYNNON LLUGWY DROUGHT PERMIT – MITIGATION

The environmental assessment has identified some significant impacts, including **major** to **moderate** hydrological impacts, **major** impacts on Eryri SSSI and aquatic ecology, specifically: **major** impacts on fish and bryophytes, **moderate** to minor impacts on macrophytes and macroinvertebrates, as well as **minor** impacts for phytobenthos.

For those receptors with a potential impact or risk identified as being significant as a result of implementation of the drought permit, 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 permit 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 permit 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 permit 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/reservoir
- 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 permit is required to safeguard 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 permit and post-drought permit implementation are

listed in **Table 6.1**.

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

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 ¹³ 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 Ffynnon Llugwy drought permit are given in **Table 10.2**. For these features, a range of precautionary monitoring and triggers leading to enabling of appropriate mitigation measures are also described.

¹³ 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 permit 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 the NRW Review of Consents reports
- Assessment of cumulative impacts of the drought permit with other Welsh Water supply-side and drought order / permit 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 other neighbouring water company Drought Plans and NRW Drought Plans.
 - National Policy Statements for Wastewater and Renewable Energy Infrastructure.
- Environmental monitoring before, during and after drought permit implementation (see Section 10).

If a drought permit 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 permit 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 permit may affect the environment in combination with the effects of existing licences and consents. Therefore no relevant licences or consents have been identified as relevant for assessment of cumulative effects.

Other relevant Welsh Water drought permit / orders

No cumulative effects of implementing the Ffynnon Llugwy drought permit with other drought order / permit schemes have been identified. However, this should be reviewed at the time of any future application for a drought permit at Ffynnon Llugwy

Reservoir.

Welsh Water WRMP schemes

No WRMP schemes identified with cumulative impacts.

NRW Drought Plans

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

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 permit 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 FFYNNON LLUGWY DROUGHT PERMIT - 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 permit 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 permit impacts.

9 HABITATS REGULATIONS ASSESSMENT: STAGE 1 SCREENING

9.1 INTRODUCTION

Under Regulation 63 of the Habitats Regulations, the competent authority 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 permit 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 permit 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 option is likely to have significant effects on European designated site, and requires Appropriate Assessment.

Stage 2 – Appropriate Assessment

Drought options that are identified during HRA Screening (Stage 1) as having LSEs (either alone or in combination) will be taken forward to Appropriate Assessment. The Appropriate Assessment will consider the impacts of the drought permit, 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 permit, 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 FFYNNON LLUGWY RESERVOIR DROUGHT PERMIT

The objective of this section is to bring together all relevant information to enable a HRA to be undertaken of the impacts of the Ffynnon Llugwy reservoir drought permit on relevant European designated sites. In addition, this section will assess the likely impact of the drought permit on the designated features of any relevant SSSIs.

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

This section considers the designated features of Eryri SAC and discusses the potential for the drought permit at Ffynnon Llugwy 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 Eryri 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 permit, possible pathways to the designated sites and the effects on possible sensitive receptors in the sites. Only if there is an identifiable pathway between the impacted reaches and the designated sites, or individual receptors, is there likely to be an impact and where this is absent those sites have been screened out. The screening assessment has also considered the Eryri 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.

The following designated features of the Eryri SAC have been screened out as due to the lack of hydrological connectivity the implementation of a drought permit has no potential to result in likely significant effects on these terrestrial montane habitats and populations:

- Siliceous alpine and boreal grasslands
- Alpine and Boreal heaths
- Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
- Calcareous rocky slopes with chasmophytic vegetation
- Alpine and subalpine calcareous grasslands
- Siliceous rocky slopes with chasmophytic vegetation

- Siliceous scree of the montane to snow levels (*Androsacetalia alpinae* and *Galeopsietalia ladani*)
- Northern Atlantic wet heaths with *Erica tetralix*
- European dry heaths
- Blanket bogs
- Depressions on peat substrates of the Rhynchosporion
- Species-rich *Nardus* grassland, on siliceous substrates in mountain areas (and submountain areas in continental Europe)
- Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles
- Petrifying springs with tufa formation (Cratoneurion)
- Alkaline fens
- Alpine pioneer formations of the Caricion bicoloris-atrofuscae
- Slender green feather-moss *Drepanocladus (Hamatocaulis) vernicosus*

Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoëto-Nanojuncetea

This habitat is characteristic of waterbodies such as the Ffynnon Llugwy Reservoir, though there is no evidence to indicate it is present in this specific location. In addition, **Appendix B** notes that the impact of a drought permit on Ffynnon Llugwy Reservoir would “be a marginal increase in levels / storage, relative to the position without the drought permit, due to the reduced outflow which would help to conserve water in storage.” As the drought permit has been assessed as having a minor positive impact on the reservoir there is no evidence to suggest that it could have an adverse impact on this SAC feature.

As a result, it can be concluded that implementation of a drought permit would not result in any likely significant effects on this habitats within Eryri / Snowdonia SAC.

Floating water-plantain Luronium natans

In north Wales this species is found predominantly in waterbodies such as the Ffynnon Llugwy reservoir, though there is no evidence to indicate it is present in this location. In addition, **Appendix B** notes that the impact of a drought permit on Ffynnon Llugwy Reservoir would “be a marginal increase in levels / storage, relative to the position without the drought permit, due to the reduced outflow which would help to conserve water in storage.” As the drought permit has been assessed as having a minor positive impact on the reservoir there is no evidence to suggest that it could have an adverse impact on this SAC feature.

This species is not found in streams and rivers in north Wales and would therefore not be impacted by any changes to the Afon Llugwy.

As a result, it can be concluded that implementation of a drought permit would not result in any likely significant effects on this species within Eryri SAC.

Table 9.1 Summary of Likely Significant Effects of Ffynnon Llugwy Drought Permit Implementation Against Conservation Objectives for the Eryri SAC

Feature	Attribute (taken directly from Natural Resources Wales Conservation Objectives document)	Site Specific Target range and Measures	Impact of Drought Permit and level of certainty	Potential impact on achievement of objective
Eryri/Snowdonia SAC				
Oligotrophic to mesotrophic standing waters with vegetation of the <i>Littorelletea uniflorae</i> and/or of the <i>Isoëto-Nanojuncetea</i>	Extent of Oligotrophic to mesotrophic standing waters	Lower limit: no losses of extent other than due to climatic conditions	No risk to achievement of conservation objective; probable.	No
	Condition of Oligotrophic to mesotrophic standing waters	Each of the lakes meets CSM attributes All of the water quality parameters must be met Any indication of former acidification must be showing improvement	No risk to achievement of conservation objective; probable.	No
	Abstraction	Abstraction should not exceed limits of any abstraction licence and should not expose macrophyte communities of the shallow water close to the shore.	No risk to achievement of conservation objective; probable.	No
	Recreational activity	No stocking with non-native fish and any stocking with native species must be strictly controlled.	No risk to achievement of conservation objective; probable.	No
Floating water plantain <i>Luronium natans</i>	Extent of floating water plantain	Presence in Llyn Cwmffynnon	No risk to achievement of conservation objective; probable.	No
	Condition of floating water plantain		No risk to achievement of conservation objective; probable.	No
	Water quality	No limits set. These need to be set up for the individually relevant lakes.	No risk to achievement of conservation objective; probable.	No

9.2.2 Summary

In summary, no likely significant effects have been identified for the Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea* or Floating water-plantain *Luronium natans* features of the Eryri SAC as a result of the implementation of the drought permit.

9.3 IN-COMBINATION EFFECTS

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

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

10 ENVIRONMENTAL MONITORING PLAN (EMP)

10.1 INTRODUCTION

The overall scope of the EMP for the Ffynnon Llugwy drought permit meets the requirements of Section 5.2 (Monitoring) and informs the requirements of Section 5.3 (Mitigation) of 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 permit monitoring describes the prevailing environmental conditions prior to drought permit implementation. This will inform the implementation and management of any mitigation actions during the drought.
- During-drought permit 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 permit monitoring describes the recovery of environmental conditions following the cessation of a drought permit, and establishes whether the affected ecosystems have recovered to conditions prevailing in the pre-drought permit period.

The basis of the development of the EMP and monitoring recommendations are set out in Section 10.2.

10.2 BASIS OF THE EMP

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

The guidance states that:

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

- The level of monitoring needed should be risk-based. Not all sites will require in-drought and post-drought monitoring.
- Surveys may be needed to support/inform the decisions on environmental sensitivity and likely impact or to ascertain baseline conditions.
- In-drought permit 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 permit 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 permit 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 permit.

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 permit.

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

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

drought;

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

Table 10.1 Baseline, Pre, Onset, During and Post Drought Monitoring and Mitigation Recommendations

Feature reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
N/A		Walkover survey during low flow conditions - Mapping of sensitive habitats, communities, species and any monitoring sites that are required in order to improve understanding of the baseline communities.	N/A				Welsh Water
		Spot flow gauging surveys	One site per hydrological reach. Three occasions.	One site per hydrological reach. Three occasions.	N/A	One site per hydrological reach. Three occasions.	Welsh Water
		Biochemical water quality sampling.	One site per hydrological reach. Monthly. Consider continuous monitoring.	One site per hydrological reach. Weekly. Consider continuous monitoring.	N/A	One site per hydrological reach. Monthly, until recovery to pre-drought levels. Consider continuous monitoring.	Welsh Water
Macrophytes Reach 1 & 2	<ul style="list-style-type: none"> Reduction in growth as a result of major impacts on water levels and flows. Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width Increase in filamentous algae levels due to increased nutrients/water 	<p>The macrophyte community in the impacted reach is reasonably well understood as a result of monitoring carried out by Welsh Water¹⁴. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites are located at:</p> <ul style="list-style-type: none"> SH 6871361473 (Reach 1) SH 7107459321 (Reach 2) 	<p>Survey to be undertaken and macrophytes identified (if drought order likely to be implemented in the plant growing season). Follow LEAFPACS2 standard methodology¹⁵.</p> <p>Walkover survey to identify any key sources of nutrient loading.</p> <p>Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.</p>	<p>Walkover of key sections known to be susceptible to lower flows, informed by pre-drought survey.</p> <p>If drought order implementation occurs in the plant growing season, carry out macrophyte surveys at baseline sites. Follow LEAFPACS2 standard methodology for assessing macrophyte communities.</p>	<p>Consider measures to address identified point sources of nutrient loading.</p> <p>Consider scope for addressing any identified sources of nutrient loading from walkover survey, if this would help address water quality risks.</p>	<p>In the two years following drought order implementation and in June to September monitoring period carry out LEAFPACS2 macrophyte surveys at the baseline monitoring sites. To be extended if recovery has not occurred in two years.</p> <p>Significant alteration to macrophyte community composition (as informed by expert judgement,</p>	Welsh Water

¹⁴ Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Ffynnon Llugwy Reservoir, July 2018

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

Feature reach and	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	temperature/decreased velocity	<ul style="list-style-type: none"> SH 7955057060 (Reach 3) 				based on baseline data and multivariate statistical analyses) triggers post drought mitigation actions: If existing macrophyte community has significantly deteriorated, consider reseeded /replanting where possible to promote recovery. Replanting of macrophyte community composition to be informed by pre-drought community.	
Bryophytes Reach 1 & 2	<ul style="list-style-type: none"> Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity Reduction in growth as a result of moderate to major impacts on water levels and flows. Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width 	The bryophyte community in the impacted reach is well understood as a result of recent monitoring carried out by Welsh Water ¹⁶ . Surveys to be repeated every five years. Monitoring methodology should follow that used for the 2016 survey and reported in 'Averis (2016) Bryophyte Monitoring Baseline at Afon Llugwy, North Wales'.	Survey during summer. Monitoring methodology should follow that used for the 2016 survey and reported in 'Averis (2016) Bryophyte Monitoring Baseline at Afon Llugwy, North Wales'.	No additional mitigation measures.	Survey during summer. Monitoring methodology should follow that used for the 2016 survey and reported in 'Averis (2016) Bryophyte Monitoring Baseline at Afon Llugwy, North Wales'.	Survey during summer following drought permit implementation. Monitoring methodology should follow that used for the 2016 survey and reported in 'Averis (2016) Bryophyte Monitoring Baseline at Afon Llugwy, North Wales'. To be repeated has not occurred. Timescales and frequency to be agreed with NRW. Significant alteration to bryophyte community composition (as informed by expert judgement,	

¹⁶ Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Ffynnon Llugwy Reservoir, July 2018

Feature reach and	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
						<p>based on baseline data and multivariate statistical analyses) triggers post drought mitigation actions:</p> <p>If existing bryophyte community has significantly deteriorated, consider if it is feasible to re-locate unimpacted specimens from cobble/boulder features at sites with similar substrate/flow conditions where possible to promote recovery. Relocation of bryophyte community composition would need to be informed by pre-drought community and biosecurity constraints.</p>	
<p>Macroinvertebrates</p> <p>Reach 1 & 2</p>	<ul style="list-style-type: none"> Reduction in species diversity and abundance as a result of reduced recruitment. Reduction in species diversity as a result of the loss of flow-sensitive taxa. Loss of marginal habitats and reduction 	<p>The macroinvertebrate community in the impacted reach is well understood as a result of monitoring carried out by Welsh Water¹⁷. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites are located at the following sites:</p> <ul style="list-style-type: none"> Reach 1 - FL1-1 	<p>Seasonal monitoring of macroinvertebrates at the baseline survey sites (spring and autumn). Samples to be collected and identified to species level.</p> <p>Carry out water quality surveys at same time.</p> <p>In severe drought conditions, no in stream monitoring is advised during environmental</p>	<p>Seasonal monitoring of macroinvertebrates at the baseline survey sites (spring and autumn). Samples to be collected and identified to species level.</p> <p>Carry out water quality surveys at same time.</p>	<p>Mitigating impacts to the macroinvertebrate community as a result of lowered flow and water level is not feasible during drought or order implementation.</p> <p>Mitigating this impact should be triggered by post drought macroinvertebrate community</p>	<p>In the two years following drought order implementation, 3-minute kick sampling and mixed taxon level analysis at the three routine monitoring sites. To be extended if recovery has not occurred in two years.</p> <p>Significant alteration to macroinvertebrate</p>	Welsh Water

¹⁷ Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Ffynnon Llugwy Reservoir, July 2018

Feature reach and	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	in abundance and distribution of species utilising such habitats.	<ul style="list-style-type: none"> Reach 2 - FL2-1 Reach 3 - FL3-1 	drought to prevent further harm to the invertebrate community through kick/sweep sampling.	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>assessments to implement post drought mitigation measures.</p> <p>Consider possible in-stream measures or adjustments to improve habitat conditions.</p> <p>Consider the removal of fine silt by manual raking of small areas.</p>	<p>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> <p>If recovery of the community does not occur within two years, consider the installation of fly boards at unimpacted sites during egg laying season, before transferring the boards to the impacted reach for eggs to hatch and repopulate.</p>	

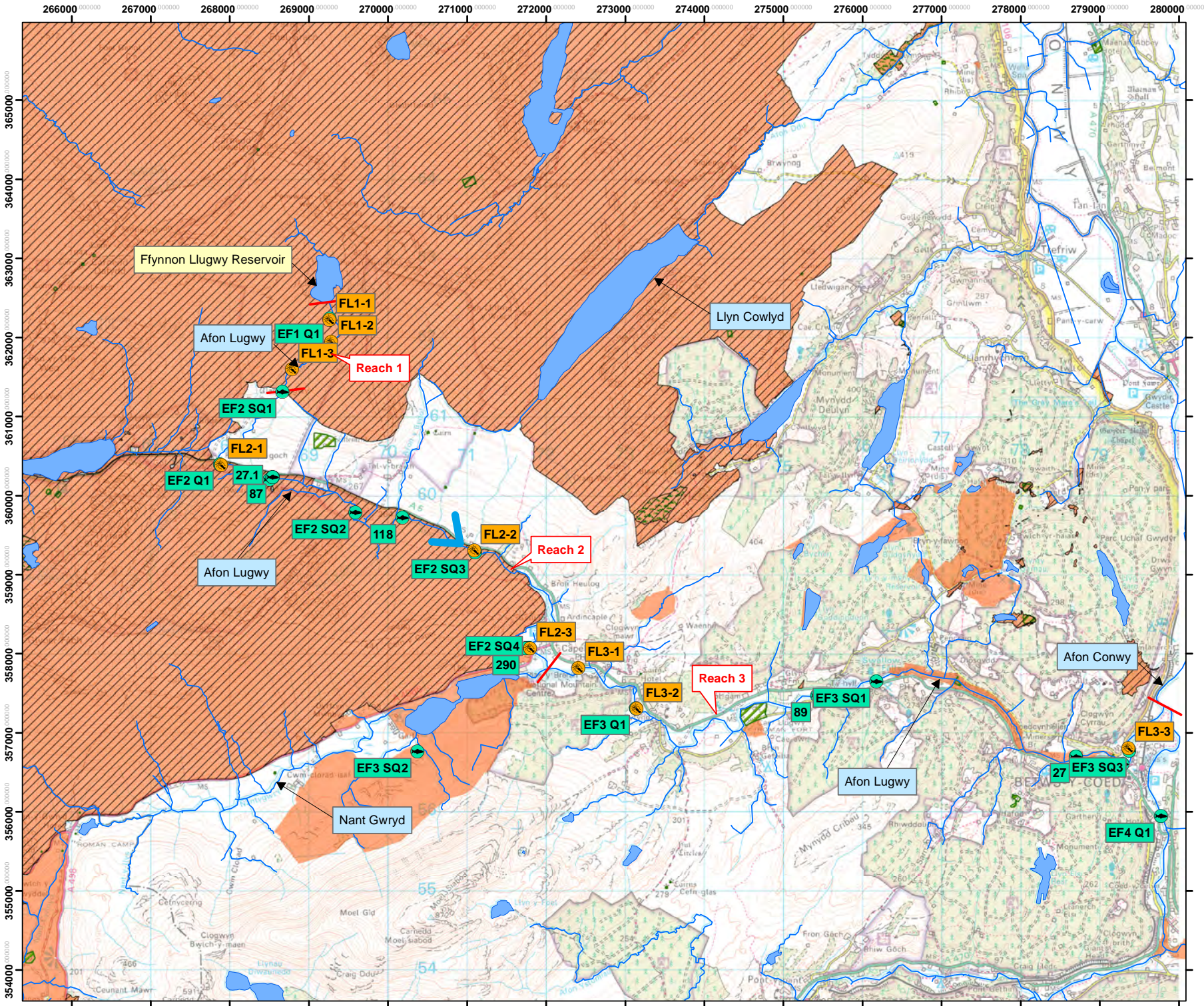
Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
Fish (Atlantic salmon, brown/sea trout, other fish species) Reach 1-3	<ul style="list-style-type: none"> Delays and potential cessation of adult salmon/trout upstream migration due to reduced flows. Delays and potential cessation of salmon and sea trout smolt migration due to reduced flows. Reduced water quality. Loss of spawning and juvenile habitat as a result of reduced river levels. Increased mortality (density dependant) as a result of increased predation and competition 	<p>The fish community in the impacted reach is reasonably well understood as a result of monitoring carried out by NRW & Welsh Water¹⁸.</p> <p>Surveys to be repeated every three years. To complement any existing NRW monitoring, monitoring sites are located at:</p> <ul style="list-style-type: none"> Reach 1 - DCWW Site: EF1 Q1 Reach 2 - DCWW Site: EF2-SQ4 Reach 3 - DCWW Site: EF3 SQ3 Control Site: D/s Reach 3 - DCWW Site: Conwy EF4 Q1 	<p>Electric-fishing surveys to monitor fish populations at one site in each of the impacted reaches, including a d/s control site on the Conwy.</p> <p>In severe drought conditions, no fish population surveys are advised during drought as this may cause further stress.</p> <p>Walkover of impacted reaches:</p> <ul style="list-style-type: none"> Identification of key habitats which are at risk of low flow impacts. <p>Appropriate trigger values would be set for level and flow for spawning habitats based on local circumstances, timing, seasonality and expert opinion.</p>	<p>No fish population surveys are advised during drought as this may cause further stress.</p> <p>Additional walkovers, if situation is expected to deteriorate in stream sections known to contain high fish densities, nursery and cover habitats. Record extent of exposed marginal habitats, bed substrates and estimates of overlying silt cover.</p> <p>Frequency of walkovers to be determined based on the on-set of environmental drought walkover and expert judgement of the resolution required to monitor the impacts of the drought.</p>	<p>Targeted installation of woody debris features to provide fish with the habitat required to support feeding and development (growth).</p> <p>If the results of the walkovers deem spawning gravels to be at risk to siltation, the following mitigation action/s may be undertaken: Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)</p> <p>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)</p> <p>If the results of the walkovers deem important habitats to be at risk to exposure/reduction (in extent), the following</p>	<p>Two years of annual post-drought fish population surveys (including lamprey specific surveys) at baseline monitoring sites (corresponding with a control and impact site/s) to determine any changes in population dynamics both temporally and spatially.</p> <p>The results of the fish population surveys should help inform mitigation, targeting habitat restoration where deemed to be appropriate to support and enhance affected populations.</p> <p>Walkover of key fish habitat locations recording the number of juvenile lamprey habitat potentially affected. Record extent of exposed marginal habitats, and composition of the bed substrate and estimates of overlying silt cover.</p> <p>If the results of the walkovers deem important habitats to be at risk to exposure/</p>	Welsh Water

¹⁸ Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Ffynnon Llugwy Reservoir, July 2018

Feature reach and	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger monitoring and inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
					<p>mitigation action/s may be undertaken:</p> <p>Deployment of aeration equipment in key reaches that have standing or slow flowing water with low oxygen levels.</p> <p>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> <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 stranded/at risk, relocating fish to</p>	<p>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 to the free movement of fish during key migration periods, i.e. during adult salmonid and juvenile lamprey migration (late summer/autumn). • 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 reach and	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
					<p>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>		
Afon Llugwy SSSI	<ul style="list-style-type: none"> Implementation of the drought permit has 	Bryophyte monitoring and mitigation to be undertaken					

Feature reach and	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger monitoring and inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
Reach 3	potential to have a limited effect on wetted widths, splash zone and humidity within the river reach, thereby potentially impacting the bryophyte assemblage of the SSSL	at the sites identified for the relevant sections above.					



- Legend**
- Hydrological Reach
 - Water Courses
 - Reservoir
 - Fish Survey
 - Macroinvertebrate Survey
 - Special Area of Conservation
 - National Nature Reserve
 - Scheduled Ancient Monuments
 - Site of Special Scientific Interest
 - Direction of Flow



Scale: 1:45,000
 Note: All locations are approximate
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Project Title: **Welsh Water Drought Plan Environmental Assessment**
 Figure Title: **Environmental Monitoring: 8001-4 Reduction of Ffynnon Llugwy Compensation water**

Figure Number: **Figure 10.1** Date: **February 2019**

11 CONCLUSIONS

This EAR provides an assessment of the potential environmental impacts relating to the implementation of the Ffynnon Llugwy drought permit. If granted and implemented, the drought permit would authorise a temporary reduction in the compensation release from Ffynnon Llugwy reservoir to the Afon Llugwy from 4.5Ml/d to 2.5Ml/d. This would help conserve storage in the reservoir to maintain public water supplies.

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 permit (Stage 2).

The hydrological impact assessment is identified as **major** impacts on Reaches 1 and 2 of the Afon Llugwy, and **moderate** impacts on Reach 3, due to the reduced reservoir compensation flow release.

Consequently, there are **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 the Eryri SAC / SSSI, Afon Llugwy SSSI, WFD status and Community Assessment / Environment (Wales) Act Section 7 species, landscape and recreation as environmental features for which an environmental assessment was required. The assessment has concluded that there are **major** impacts on Eryri SSSI, aquatic ecology, specifically: **major** impacts on fish and bryophytes, **moderate** to minor impacts on macrophytes and macroinvertebrates, as well as **minor** impacts for phytobenthos.

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

The environmental assessment has identified significant impacts of implementation of a drought permit at Ffynnon Llugwy. Consequently, in line with regulatory guidance for drought permit assessments, mitigation measures have been proposed and further discussion with NRW is required in order to develop suitable mitigation measures.

In summary, it has been concluded that the environmental effects on river flows, water quality and ecology of implementing a drought permit at Ffynnon Llugwy, 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)

		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)

		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)

		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		
		<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)

% Decrease in minimum reservoir level	% Increase in duration of reservoir drawdown			
	<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 Ffynnon Llugwy reservoir and the Afon Llugwy river catchment during the period of implementation of the drought permit and subsequent reservoir level recovery.

For the purposes of this assessment, the “without drought permit” baseline includes the continuation of abstraction and statutory rate of compensation release (4.5Ml/d) under the existing abstraction licence from Ffynnon Llugwy Reservoir. This represents normal operating arrangements during a typical summer/autumn period. The assessed drought permit assumes a temporary reduction in the compensation rate of 2Ml/d (from 4.5 Ml/d to 2.5Ml/d), to conserve storage in Ffynnon Llugwy Reservoir.

B.1.1 Welsh Water’s Existing Operations

Welsh Water’s licence (number 23/66/8/10) to abstract water under the Water Resources Act 1991 at Ffynnon Llugwy Reservoir (see **Figure B1.1**) includes the following conditions:

- 2,827 million litres (Ml) authorised to be abstracted per annum
- At an abstraction rate not exceeding 7.7282Ml/d¹

Compensation flow releases provisions from the reservoir are included in the associated impounding licence (number 23/66/8/14), and also detailed in the North Wales Hydro Power Act 1973:

- Provision of a uniform statutory compensation water discharge of 4.5Ml/d at all times to the downstream Afon Llugwy.

The abstraction for potable supply is made directly from the reservoir and piped by gravity to Mynydd Llandegai Water Treatment Works (WTW) and Capel Curig WTW for treatment.

Approximately 1.4km downstream of Ffynnon Llugwy Reservoir, part of the Afon Llugwy flow is diverted by a stream capture system into the Llyn Cowlyd West Leat which transfers water to Llyn Cowlyd Reservoir for hydro-power generation. The stream capture system is licensed separately (held by RWE Innogy plc, licence number 23/66/10/0003). The licence authorises maximum abstraction of 132,392 Ml/yr at a rate not exceeding 1,300 Ml/d for the purposes of hydro-electric generation and 41.82 Ml/yr for domestic, industrial and agricultural purposes. Natural Resources Wales (NRW) have advised that the leat has no compensation flow or Hands Off Flow requirement associated with it.

¹ 1 Ml/d is 1 million litres per day.

B.1.2 Welsh Water's Proposed Drought Permit Operations

The drought permit involves a proposed reduction in the compensation release from Ffynnon Llugwy to the Afon Llugwy from 4.5Ml/d to 2.5Ml/d. This will conserve the longevity of reservoir storage for use in direct supply during a drought and improve the probability of reservoir winter refill. The drought permit will influence the downstream Afon Llugwy as far as the Llyn Cowlyd stream capture leat, and potentially further downstream depending on the abstraction arrangements at the leat.

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

The compensation release from Ffynnon Llugwy Reservoir sustains flow in the upper Afon Llugwy year round by 4.5Ml/d. From photographs provided by NRW, the design of the downstream leat intake structure appears to be such that low catchment flows continue past the flow diversion weir. Only when flow is above a certain level does the leat start to capture water directly at the crossing point (however the flow at which this occurs is not known). Consequently, at low flows when reservoir outflow is limited to compensation only, the impacts of the drought permit will likely extend downstream of the leat until catchment flow accretion has significantly increased flows in the Afon Llugwy. The study area is shown on **Figure B1.1**.

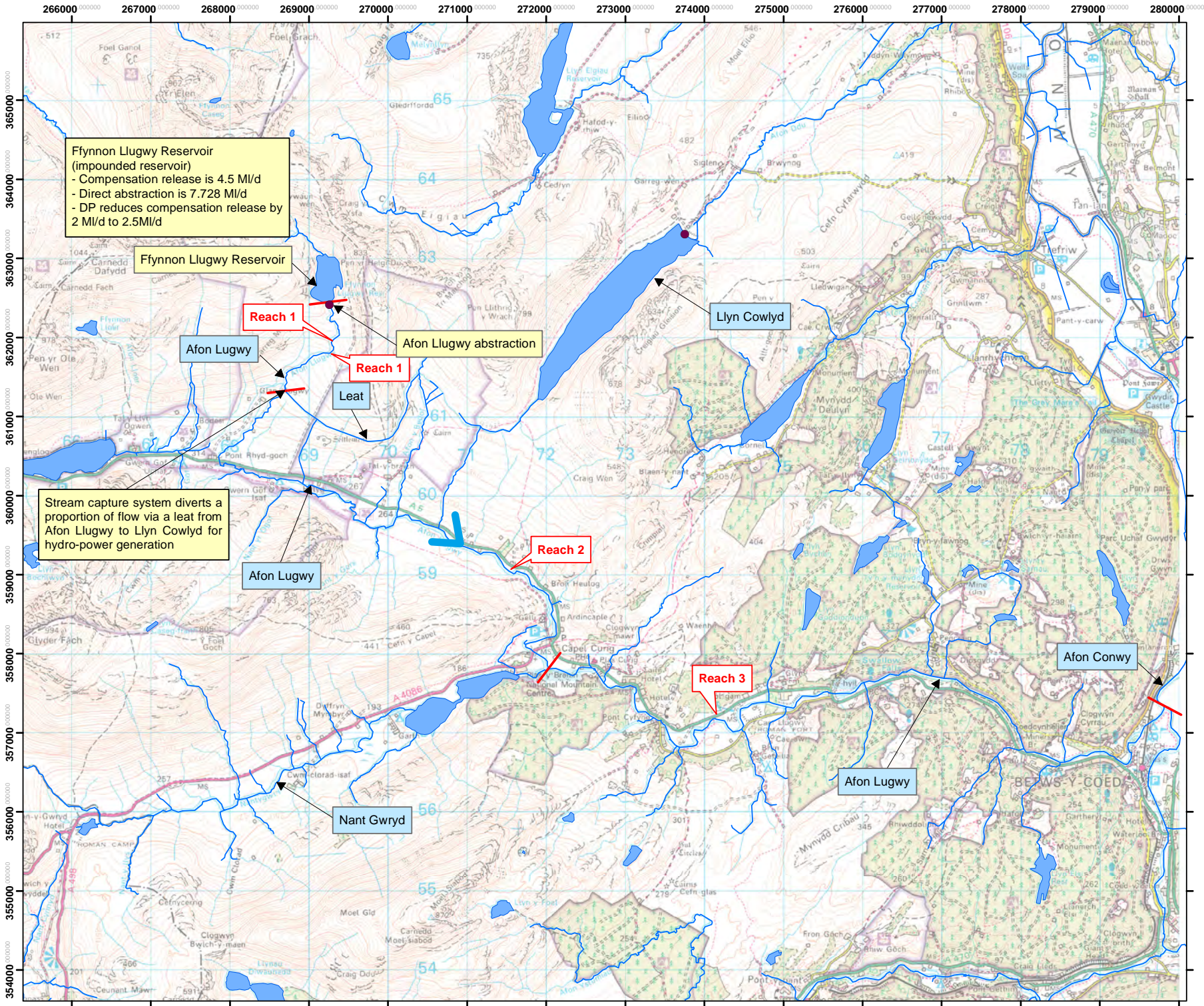
The physical environment includes consideration of hydrology and hydrodynamics; geomorphology; and water quality. The assessment has three principle objectives:

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 DPG² and set out in Figure 2 of the DPG.
2. It is used to support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Section 5 of this report.
3. Where sensitive features are the physical environment itself, it provides supporting technical information for their screening and assessment.

This appendix is set out in the following sections:

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

² 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.



Ffynnon Llugwy Reservoir
 (impounded reservoir)
 - Compensation release is 4.5 MI/d
 - Direct abstraction is 7.728 MI/d
 - DP reduces compensation release by 2 MI/d to 2.5MI/d

Stream capture system diverts a proportion of flow via a leat from Afon Llugwy to Llyn Cowlyd for hydro-power generation



Legend

- Hydrological Reach
- Watercourse
- Reservoir
- Abstractions
- Direction of Flow

Scale: 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: 8001-4 Reduction of Ffynnon Llugwy Compensation water**

Figure Number: Figure B1.1	Date: February 2019
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B2 HYDROLOGICAL AND HYDROGEOLOGICAL IMPACT

B.2.1 Reference Conditions

B.2.1.1 Catchment Overview

This small mountainous river catchment (74.9km² total drainage area from upstream of Ffynnon Llugwy Reservoir to the Afon Conwy confluence) is a tributary of the Afon Conwy, in the county of Gwynedd. The catchment rises on the north eastern slopes of the Snowdon massif in the Snowdonia National Park and joins the Afon Conwy at Betws-y-Coed. Some 2km upstream of Betws-y-coed, the Afon Llugwy forms the waterfalls known as Swallow Falls, a renowned tourist attraction, and the area is popular with walkers and other recreational users.

Ffynnon Llugwy Reservoir was constructed in 1930. The 8m high earth embankment with concrete core holds back a maximum usable storage of 2,078Ml with a surface area of 16ha (at top water level) at an altitude of 550m. The 2.26km² catchment draining into the reservoir has high rainfall on a steep mountain landscape.

B.2.1.2 Baseline Data Availability

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

- Daily Ffynnon Llugwy water level data: 1989 to present
- Daily Ffynnon Llugwy compensation flow data: 1988 to present
- Daily Ffynnon Llugwy abstraction flows: 1988 to present.

There is no continuous measurement of the Afon Llugwy catchment flow downstream of the Ffynnon Llugwy Reservoir. Several flow values are available from spot flow gauging undertaken during 1996 and 2002; these are mainly located at the reservoir outflow although one measurement was taken at the Llyn Cowlyd take-off leat. More recently, in 2016 and 2018, further spot flow gauging was undertaken at a number of key locations within the Afon Llugwy catchment.

Continuous monitoring of river level is undertaken by NRW at Cwmlanerch on the Afon Conwy, about 1km downstream of the confluence with the Afon Llugwy. The Afon Conwy has a large catchment area at this point (344km²), of which the Afon Llugwy sub-catchment contributes only around a fifth; however, this gauging station represents the most relevant available, long-term continuous river flow record to the study area.

Available flow data include:

- NRW Cwmlanerch river flow gauge on the Afon Conwy downstream of the Afon Llugwy confluence: daily river flow from 1964 to 2018

The reference conditions of Ffynnon Llugwy reservoir and the Afon Llugwy / Afon Conwy

catchments are summarised below, based on the available hydrological data as set out above.

B.2.1.3 Hydrology

Ffynnon Llugwy Reservoir

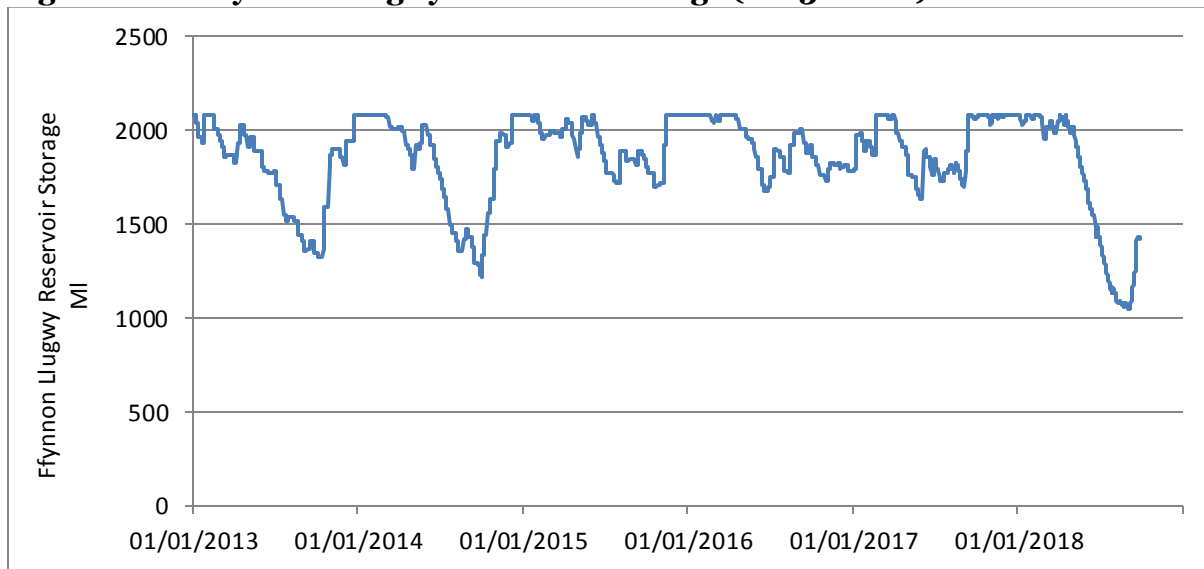
Typically, reservoir levels range from about 14m to about 22m (1989 - 2018) above datum in Ffynnon Llugwy. The top water level is at 20m above datum and when the reservoir is at full capacity, any overflows pass over the dam spillway into Afon Llugwy. A summary of reservoir levels from 1989 to 2018 is given in **Table B2.1**. This shows that in very dry conditions the reservoir level can fall to 6.7m below the overflow level (minimum September level at 13.2m above datum).

Table B2.1 Summary of Recorded Mean, Maximum and Minimum Daily Reservoir Level in Ffynnon Llugwy Reservoir (1989 - 2018) (m above datum)

Percentage of time lake level equalled or exceeded	Mean daily reservoir level, metres, per month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum reservoir level	20.3	22.2	21.2	21.2	21.0	20.5	20.5	20.2	20.2	21.1	21.1	21.1	22.2
10% (high level)	20.1	20.1	20.1	20.1	19.9	19.9	19.8	19.9	20.0	20.1	20.2	20.2	20.1
50%	20.0	19.9	19.8	19.6	19.2	18.7	18.2	18.2	18.3	19.4	20.0	20.0	19.5
80%	19.8	19.4	19.3	18.9	18.7	17.7	17.4	16.7	16.8	18.0	19.0	19.5	18.2
90%	19.4	19.0	18.8	18.6	18.2	17.4	16.7	16.2	16.0	16.8	18.7	19.1	17.3
95%	19.0	18.8	18.6	18.1	17.6	17.1	16.5	15.8	15.5	16.1	18.3	18.8	16.7
99% (low level)	18.3	18.5	18.2	17.1	16.7	16.5	14.4	13.4	13.6	15.2	16.8	18.2	15.4
Minimum reservoir level	18.2	17.0	18.0	16.7	16.5	16.0	13.9	13.3	13.2	14.4	16.7	18.0	13.2

Figure B2.1 illustrates the typical drawdown patterns in Ffynnon Llugwy Reservoir during the six year period 2013 - 2018. The reservoir is regularly drawn down during the summer/autumn period, although significant drawdown does not occur in every year and storage has remained above 50% of full capacity throughout the period from 1989 for which data are available. The lowest recorded drawdown was to a storage volume of 1046 Ml (50.3%) in September 2018. The option would not increase the level of drawdown on the lake.

Figure B2.1 Ffynnon Llugwy Reservoir Storage (2013 - 2018)



Abstraction rates from the reservoir, to supply Capel Curig WTW and Mynydd Llandegai WTW, have typically been in the range 3.5 – 7Ml/d over the past fourteen years. A step increase in daily throughput at Mynydd Llandegai WTW occurred at the end of 2011; the reason for this is not known but it may be due to rezoning of supplies at that time. A decrease in daily throughput occurred in the summer of 2018, and the combined abstraction from Ffynnon Llugwy Reservoir to supply both treatment works is currently (autumn 2018) around 4Ml/d.

Afon Llugwy at Ffynnon Llugwy

The Afon Llugwy is 23km long, with a catchment area of 74.9km² at its confluence with the Afon Conwy. At the Ffynnon Llugwy reservoir overflow (spillway) weir, the catchment area is 2.3km². The compensation flow release from the reservoir is measured, however overflows which occur when the reservoir is at full capacity are not measured.

The statutory compensation flow requirement is for a daily release of 4.5Ml/d. Recorded flows are generally in the range 3 – 5Ml/d, however a meter at a secondary discharge point was only introduced at the end of 2010 and therefore any discharge from this point prior to 2010 would not have been measured.

Other than the compensation flow record, there is limited measured flow data available for the Afon Llugwy. A small number of spot flow gauging results are available for locations just downstream of the reservoir, from spring 1996 and summer 2002. Further spot flow gauging was undertaken at several locations within the Afon Llugwy catchment during 2016 and 2018; these include locations in all three river reaches on which this hydrological assessment is based (see section **B2.2.1**).

The spot flow gauging results are summarised in **Table B2.2** below, together with the recorded compensation flows on the dates of each gauging exercise.

Table B2.2 Summary of Spot Flow Gauging Results in the Afon Llugwy

Date	Location/ Reach	Grid Reference	Spot Flow, m ³ /s	Spot Flow, Ml/d	Recorded Compensation flow, Ml/d	Flow At Pont Gethin (Lledr) Ml/d	Percentile at Pont Gethin (summer)	Reservoir status
17/05/1996	Reservoir outflow (upper R1)	SH69286220	0.0436	3.77	3.684	35.424	Q93	Below top water level (no spill)
03/07/2002	Reservoir outflow (upper R1)	SH69266224	0.0435	3.76	3.694	267.84	Q41	Below TWL (no spill)
03/07/2002	Reservoir outflow (upper R1)	SH69276226	0.011	0.95	3.694	267.84	Q41	Below TWL (no spill)
03/07/2002	Weir at Llyn Cowlyd West Leat	SH68716141	0.1142	9.87	3.694	267.84	Q41	Below TWL (no spill)
03/07/2002	Small tributary of Afon Llugwy near Llyn Cowlyd West Leat	SH68576135	0.029	2.5	3.694	267.84	Q41	Below TWL (no spill)
10/08/2016	Reservoir outflow (upper R1)	SH69266224	0.033	2.851	5.509	75.168	Q79	Below TWL (no spill)
03/10/2016	Reservoir outflow (upper R1)	SH69266224	0.035	3.024	5.651	178.848	Q53	Below TWL (no spill)
10/08/2016	Short distance upstream of Llyn Cowlyd leat (lower R1)	SH68746157	0.083	7.171	5.509	75.168	Q79	Below TWL (no spill)
03/10/2016	Short distance upstream of Llyn Cowlyd leat (lower R1)	SH68746157	0.163	14.083	5.6507	178.848	Q53	Below TWL (no spill)
10/08/2016	Pont Rhyd-goch (main road crossing) (upper R2)	SH67876046	0.054	4.666	5.509	75.168	Q79	Below TWL (no spill)
03/10/2016	Pont Rhyd-goch (main road crossing) (upper R2)	SH67876046	0.04	3.456	5.651	178.848	Q53	Below TWL (no spill)
10/08/2016	Dol-Llech (u/s of Capel Curig) (mid R2)	SH71105930	0.15	12.96	5.509	75.168	Q79	Below TWL (no spill)
03/10/2016	Dol-Llech (u/s of Capel Curig) (mid R2)	SH71105930	0.259	22.378	5.651	178.848	Q53	Below TWL (no spill)
10/08/2016	Upstream of Conwy confluence at Betws-y-coed (lower R3)	SH79365683	0.733	63.331	5.509	75.168	Q79	Below TWL (no spill)
03/10/2016	Upstream of Conwy confluence at Betws-y-coed (lower R3)	SH79365683	2.153	186.019	5.651	178.848	Q53	Below TWL (no spill)
10/08/2016	Llyn Cowlyd take-off leat	SH68676134	0.022	1.901	5.509	75.168	Q79	Below TWL (no spill)
03/10/2016	Llyn Cowlyd take-off leat	SH68676134	0.102	8.813	5.651	178.848	Q53	Below TWL (no spill)

Date	Location/ Reach	Grid Reference	Spot Flow, m ³ /s	Spot Flow, Ml/d	Recorded Compensation flow, Ml/d	Flow At Pont Gethin (Lledr) Ml/d	Percentile at Pont Gethin (summer)	Reservoir status
30/05/2018	Reservoir outflow (upper R1)	SH69266224	0.028	2.4192	5.106	48.0384	Q89	Below TWL (no spill)
30/05/2018	Short distance upstream of Llyn Cowlyd leat (lower R1)	SH68746157	0.058	5.011	5.106	48.0384	Q89	Below TWL (no spill)
30/05/2018	Pont Rhyd-goch (main road crossing) (upper R2)	SH67876046	0.028	2.419	5.106	48.0384	Q89	Below TWL (no spill)
30/05/2018	Dol-Llech (u/s of Capel Curig) (mid R2)	SH71105930	0.182	15.725	5.106	48.0384	Q89	Below TWL (no spill)
30/05/2018	Upstream of Conwy confluence at Betws-y-coed (lower R3)	SH79365683	0.96	82.944	5.106	48.0384	Q89	Below TWL (no spill)
30/05/2018	Downstream of Capel Curig Upper R3	SH73145730	0.575	49.68	5.106	48.0384	Q89	Below TWL (no spill)

Storage in Ffynnon Llugwy Reservoir was below top water level on all dates on which spot flow gauging was carried out, so that no overflows (spill) would have been occurring. The results must be treated with caution as they indicate flows only on specific dates, and do not necessarily capture the lowest flow levels occurring in the catchment. The flow in the nearby Afon Lledr (at Pont Gethin) on the dates of the spot flow gauging exercises ranged from 35.4Ml/d to 178.8Ml/d, representing flow percentiles of approximately Q₅₃ to Q₉₃ for the summer period of July to September, and so the majority of the spot flow gauging results are unlikely to be representative of low or extreme low flow conditions within the Afon Llugwy catchment (with the exception of the measurement on 17/5/1996, which however only relates to the location immediately downstream of the reservoir outflow).

The results indicate flow accretion of between 2.6Ml/d to 11Ml/d in the upper Afon Llugwy between the reservoir outflow and the Llyn Cowlyd take-off leat, corresponding to Afon Lledr flow percentiles of Q₈₉ to Q₄₁. These values are broadly similar to the drop in flow of 2.6Ml/d to 10.6Ml/d between lower reach 1 and upper reach 2, measured in 2016 and 2018, of which approximately 80% is accounted for by the leat flow measured on the two occasions in 2016. This suggests that the Llyn Cowlyd leat abstraction may be configured/operated to allow the compensation flow from Ffynnon Llugwy Reservoir to continue past the take-off structure, however this cannot be confirmed without further information about the operation of the leat.

Afon Conwy at Cwmlanerch

NRW continuously monitors river flow on the Afon Conwy at the Cwmlanerch gauging station (NGR: SH80135808), which is some 22km downstream of Ffynnon Llugwy Reservoir, and approximately 1km downstream of the Afon Llugwy confluence, at an altitude of 11.6m AOD.

The available flow record extends from 1964 to 2018 and is summarised in **Table B2.3** below.

Table B2.3 Summary of Recorded Mean, Maximum and Minimum Daily Flow in the Afon Conwy at Cwmlanerch gauging station (1964 - 2018)³

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	32400	33264	27510	15016	10247	12355	10904	12960	15708	26870	23820	37403	37403
10% (high flow)	5808	4825	3983	2644	2140	1698	1698	2402	3554	4830	5599	6875	4007
50%	1685	1112	932	678	470	352	331	479	642	1100	1612	1669	799
80%	662	481	458	274	201	160	141	179	227	405	677	608	291
90%	427	356	335	182	133	119	90	114	143	272	458	435	179
95% (low flow)	316	271	271	143	107	93	68	81	108	199	340	329	122
99% (extreme low flow)	217	199	201	95	68	69	44	50	64	63	203	258	65
Minimum flow	152	82	73	66	38	53	27	36	49	38	156	132	27

The low flow statistics for the summer period (1st April to 30th September inclusive) are: Summer Q₉₅ = 92.5Ml/d; Summer Q₉₉ = 56.3Ml/d.

Using relative sub-catchment area and rainfall ratios at various locations within the Afon Llugwy catchment, it is theoretically possible to use these to estimate flow percentile values at these other locations. **Table B2.4** summarises sub-catchment areas and SAAR (standard annual average rainfall) values between the reservoir outflow and the confluence with Afon Conwy. Estimated year round flow percentiles (Q₉₅ and Q₅₀) and summer flow percentiles (Q₉₅ and Q₉₉) have been calculated from the flow statistics at Cwmlanerch using the annual average flow (AAF) ratio. However, it should be noted that flow in the upper Afon Llugwy is a very small proportion of the gauged Afon Conwy flow by catchment area, therefore any flow estimates should be treated as indicative only for the purposes of establishing the approximate extent of the hydrologically impacted reach of the Afon Llugwy due to implementation of the drought permit.

Note also that the estimated flow statistics have not been calculated for the locations in Reach 1 and the upper part of Reach 2, as the low flow values at these locations are strongly influenced by the compensation release from Ffynnon Llugwy Reservoir and the operation of the Llyn Cowlyd abstraction leat downstream of the reservoir outflow.

³ Includes data from the following drought years: 1976, 1984, 1995, 2018

Table B2.4 Contributing Afon Llugwy sub-catchment areas, rainfall values and annual average flow ratios at Cwmlanerch flow gauge

Area / Location	Grid Reference	Catchment Area (km ²)	SAAR (mm)	AAF Ratio at Cwmlanerch flow gauge	Estimated year round flow statistics (Ml/d)		Estimated summer low flow statistics (Ml/d)	
					Q ₉₅	Q ₅₀	Q ₉₅	Q ₉₉
Afon Llugwy at Ffynnon Llugwy Reservoir outflow	SH693624	2.3	3062	1.0%	-	-	-	-
Afon Llugwy at Llyn Cowlyd take-off weir/leat	SH687614	3.0	3033	1.3%	-	-	-	-
Afon Llugwy at A5 road crossing	SH678604	4.3	3017	1.8%	-	-	-	-
Afon Llugwy at Capel Curig (u/s of Nant Gwryd confluence)	SH720579	21.3	2690	8.1%	9.9	64.6	7.5	4.5
Afon Llugwy at Capel Curig (d/s of Nant Gwryd confluence)	SH720578	46.1	2825	18.4%	22.4	147.0	17.0	10.4
Afon Llugwy at Betws-y-coed (u/s of Conwy confluence)	SH798573	74.9	2494	26.4%	32.2	211.1	24.4	14.9
Afon Conwy at Cwmlanerch (Gauged)	SH801580	344.5	2055	100%	122.0	799.4	92.5	56.3

As the nearest gauging station within the Llugwy/Conwy catchment is some distance downstream of the river reaches of interest, and gauges a significantly larger catchment area, a gauged record from a nearby catchment has been considered as an alternative donor gauge from which to estimate Afon Llugwy flow statistics at Capel Curig and Betws-y-Coed. The gauging station at Pont Gethin on the Afon Lledr is located approximately 7 km from Capel Curig and 4 km from Betws-y-Coed; the catchment area at this location is 72.8km² which is very similar to that of the Afon Llugwy at Betws-y-coed. The standard average rainfall (SAAR) for Pont Gethin is 2450mm, which again is similar to that of the Afon Llugwy at Betws-y-coed (2494mm).

The available flow record extends from 1995 to 2018 and is summarised in **Table B2.5** below. These flow statistics have been used as a sensitivity check to verify the hydrological impacts for Reaches 2 and 3 (see section **B2.2.2**).

Table B2.5 Summary of Recorded Mean, Maximum and Minimum Daily Flow in the Afon Lledr at Pont Gethin gauging station (1995 - 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	11578	8087	5046	2730	4484	3879	4432	4104	4795	6483	6152	12010	12010
10% (high flow)	1584	1400	923	605	674	534	570	726	1073	1258	1410	1782	1089
50%	402	281	194	157	118	90	110	149	142	294	365	416	197
80%	131	112	91	59	50	33	35	54	60	101	157	132	73
90%	88	82	67	40	32	22	21	31	39	68	110	93	44
95% (low flow)	70	63	53	31	26	17	14	21	27	53	90	78	29
99% (extreme low flow)	45	41	40	20	18	9	7	11	15	37	60	62	14
Minimum flow	36	34	34	15	14	6	6	4	9	22	38	56	4

The low flow statistics for the summer period (1st April to 30th September inclusive) are: Summer Q₉₅ = 20.7Ml/d; Summer Q₉₉ = 10.3Ml/d. The relative sub-catchment areas, SAAR values and estimated flow percentile values at key Afon Llugwy locations are shown in **Table B2.6**. These are slightly lower but broadly similar to the Afon Llugwy flow percentiles estimated from the Afon Conwy record, providing assurance that the two catchments have similar flow characteristics.

Table B2.6 Contributing Afon Llugwy sub-catchment areas, rainfall values and annual average flow ratios at Pont Gethin flow gauge

Area / Location	Grid Reference	Catchment Area (km ²)	SAAR (mm)	AAF Ratio at Pont Gethin flow gauge	Estimated year round flow statistics (Ml/d)		Estimated summer low flow statistics (Ml/d)	
					Q ₉₅	Q ₅₀	Q ₉₅	Q ₉₉
Afon Llugwy at Capel Curig (u/s of Nant Gwryd confluence)	SH720579	21.3	2690	32.1%	9.4	63.2	3.3	6.6
Afon Llugwy at Capel Curig (d/s of Nant Gwryd confluence)	SH720578	46.1	2825	73.0%	21.5	143.8	7.5	15.1
Afon Llugwy at Betws-y-coed (u/s of Conwy confluence)	SH798573	74.9	2494	104.8%	30.9	206.5	10.8	21.7
Afon Lledr at Pont Gethin (Gauged)	SH801580	72.8	2450	100%	29.5	197.0	20.7	10.3

B.2.2 Hydrological Impact

For the purposes of this assessment, the “without drought permit” baseline is based on normal abstraction arrangements and compensation from Ffynnon Llugwy Reservoir continuing at the statutory rate of 4.5Ml/d. The assessed drought permit assumes the continuation of Welsh Water’s abstraction from the reservoir, with a temporary reduction of 2Ml/d in the daily compensation release flows (from 4.5 Ml/d to 2.5Ml/d).

B.2.2.1 Hydrological Zone of Influence

A review of the flows and physical habitat characteristics of the river network downstream of Ffynnon Llugwy Reservoir has identified the likely hydrological zone of influence of the drought permit, which has been used to define the study area. The study area includes the Afon Llugwy, comprising three distinct hydrological reaches, as shown on **Figure B1.1**:

- Reach 1 is the Afon Llugwy, from the Ffynnon Llugwy reservoir outflow downstream to the weir and take-off leat to Llyn Cowlyd.
- Reach 2 is the Afon Llugwy, from the Llyn Cowlyd take-off leat to Capel Curig upstream of the Nant Gwryd confluence.
- Reach 3 is the Afon Llugwy from Capel Curig to the confluence with the Afon Conwy at Betws-y-coed.

The potential hydrological impacts of the drought permit have been assessed for Ffynnon Llugwy Reservoir and these three separately identified river reaches, as summarised in **Table B2.7** and **Table B2.8** (at the end of this section).

The details of the assessment for each reach are presented below.

B.2.2.2 Hydrological Impact Assessment

Ffynnon Llugwy Reservoir

The impact on Ffynnon Llugwy Reservoir would be a marginal increase in water levels / reservoir storage relative to the position without the drought permit, due to the reduced compensation flow release which would help to conserve water in storage. The duration of shoreline exposure due to reservoir drawdown would therefore be slightly shorter compared to the baseline drought scenario as the reservoir would reach top water level slightly earlier during the winter refill period. This would be considered as a **minor beneficial** impact and has not been assessed further.

River Reach Assessment

In the absence of a continuous gauged flow record in the downstream Afon Llugwy catchment, approximate low flow percentile values have been determined by comparing relative catchment areas and Standard Annual Average Rainfall (SAAR) values at Capel Curig and

Betws-y-Coed with those of the NRW gauging station at Cwmlanerch on the Afon Conwy (see **Table B2.4**). These estimates should be regarded as *indicative* only, and are used solely for the purposes of determining the extent of the drought permit hydrological impacts on the Afon Llugwy.

As a further check, alternative flow values have been determined at Capel Curig and Betws-y-Coed, scaled by relative catchment areas and SAAR values from the relevant flow statistics of the 24-year gauged record at Pont Gethin on the Afon Lledr (see **Table B2.6**).

Reach 1 – Afon Llugwy (Ffynnon Llugwy Reservoir Outflow to Llyn Cowlyd take-off weir/leat)

In Reach 1, the Afon Llugwy is a steep boulder-bedrock mountain stream falling 180m over the 1.7km stretch. The 3-4m channel is fully wetted at high flows (at times of reservoir overflow (spill) and flow accretion downstream of the reservoir), but occupying a smaller proportion of the channel at low flows. Flow is cascade or step-pool in type.

It is very unlikely that Ffynnon Llugwy Reservoir will be at full capacity when a drought permit is implemented, therefore no overflows (spill) will be occurring and the only outflow from the reservoir will be the compensation flow release. The reduction in compensation flow rate from 4.5Ml/d to 2.5Ml/d represents a 44% reduction in summer low and extreme low flows in the upper Afon Llugwy immediately below the reservoir.

The hydrological impact of this drought permit on Reach 1 is, therefore, assessed as **major** at any time of year.

Reach 2 – Afon Llugwy (Llyn Cowlyd take-off weir/leat to Capel Curig, upstream of the Nant Gwryd confluence)

At the upper end of Reach 2, it is assumed that there would be very limited further flow accretion during the short length of Reach 1 in drought conditions, and therefore the percentage flow reduction of 44% due to the reduction in compensation release from Ffynnon Llugwy Reservoir would be still applicable at the upper end of Reach 2. The hydrological impact of this drought permit on upper Reach 2 is, therefore, assessed as **major** at any time of year.

Further downstream towards the lower end of Reach 2 there may be some further flow accretion in the Afon Llugwy as it flows down to the A5 road bridge and onwards to Capel Curig. It is assumed that during the implementation of this drought permit, liaison with the operator of the Llyn Cowlyd West Leat would be undertaken to ensure that abstraction through the leat is either discontinued or minimised, to avoid any additional impact to flows in Reach 2. The reduction in flow is however still estimated to be a significant percentage of the indicative summer low flow values (27% of the summer Q_{95} and 44% of the summer Q_{99}), and the hydrological impact of this drought permit on lower hydrological Reach 2 is, therefore, assessed as major during the summer months of July to September inclusive.

If based on the Pont Gethin gauged record as an alternative source from which to estimate flow percentile values for this reach, the reduction in flow would be 30% of the summer Q_{95} and 61% of the summer Q_{99} , so that the hydrological impact would still be assessed as major in the summer months as above.

During the winter period, the indicative low and median year round flow statistics at the lower end of Reach 2 are 9.9Ml/d (Q_{95}) and 64.6Ml/d (Q_{50}). The reduction in flow of 2Ml/d represents a percentage reduction of 20.3% and 3.1% respectively in these flow values. The hydrological impact of the drought permit on lower hydrological Reach 2 is would be less due to flow accretion, assessed as minor during the winter months of October to December inclusive.

If the Pont Gethin flow record is used as an alternative from which to estimate the key flow statistics for the Afon Llugwy, then the percentage flow reductions due to the drought permit are 21.2% of the year round low flow (Q_{95}) and 3.2% of the year round median flow (Q_{50}). This would still lead to an assessment of a minor hydrological impact on lower Reach 2 during the winter months as above.

Reach 3 – Afon Llugwy (Capel Curig to the Afon Conwy confluence to at Betws-y-Coed)

The impact of the reduced compensation flow release on Reach 3 is less than that on Reaches 1 and 2 due to further catchment flow accretion, in particular from the Nant Gwryd stream which flows down from the Snowdon massif through the Llynau Mymbyr lake system, just above Capel Curig at the top of reach 3. The 2Ml/d reduction in compensation flow releases is a smaller percentage of the indicative summer low flow estimates for upper Reach 3 (12% of the summer Q_{95} and 19% of the summer Q_{99}), and therefore the hydrological impact of this drought permit on upper Reach 3 is assessed as **moderate** during the summer months of July to September inclusive. For the lower part of this reach, immediately upstream of the Afon Conwy confluence at Betws-y-coed, the flow reduction represents reductions of 8% of the summer Q_{95} and 13% of the summer Q_{99}), and therefore the hydrological impact of this drought permit on lower Reach 3 is assessed as minor during the summer months as above.

If based on the Pont Gethin gauged record as an alternative source from which to estimate flow percentile values for this reach, the reduction in flow would be 13% of the summer Q_{95} and 27% of the summer Q_{99} (upper Reach 3), and 9% of the summer Q_{95} and 19% of the summer Q_{99} (lower Reach 3), so that the hydrological impact would be assessed as major (upper Reach 3) and minor (lower Reach 3). The assessment for upper Reach 3 is borderline between moderate and major (from July to September) due to the slight differences in estimated flow statistics from the two alternative donor gauge locations.

During the winter months, the 2Ml/d reduction in flow represents a 8.9% reduction in the year round low flow statistic (Q_{95}) and a 1.4% reduction in the year round median flow (Q_{50}) at the upper end of Reach 3. Further down the reach, just upstream of the Afon Conwy confluence at Betws-y-coed, the flow reduction represents reductions of 6.2% of the year round Q_{95} and 0.9%

of the year round Q₅₀. The hydrological impact of the drought permit is therefore assessed as **negligible** for the whole length of Reach 3 during the winter months of October to December inclusive.

Using the Pont Gethin flow record as an alternative donor gauge for the estimated flow percentiles would indicate that the drought permit leads to reductions of 9.3% and 1.4% in the year round low and median flow statistics (Q₉₅ and Q₅₀ respectively) at the upper end of Reach 3. At the lower end of Reach 3, the equivalent percentage flow reductions would be 6.5% and 1%. The hydrological impact of the drought permit would therefore still be assessed as negligible for all of Reach 3 during the winter months as above.

The 2Ml/d reduction in the reservoir compensation flow release is not likely to have any discernible impact on the Afon Conwy, as even in its lowest reach the Afon Llugwy flow only represents around a fifth to a quarter of the gauged Afon Conwy flow downstream of the confluence, and the magnitude of low and extreme low flows at the Cwmlanerch gauging station are such that a flow reduction of 2Ml/d would only be around a 2% or 4% reduction in the summer low and extreme low flow statistics respectively. The Afon Conwy has therefore been excluded from further assessment.

B.2.2.3 Hydrological Impact Summary

Three reaches have been considered for which the assessed hydrological impacts range from **moderate** to **major** in the summer months of July to September inclusive, and from **negligible** to **major** in the winter months of October to December inclusive. The impacted reaches are shown in **Table B2.7** and **Table B2.8** and establish the full in-channel zone of influence of the drought permit for environmental sensitivity screening (see **Figure B1.1**).

The impact on Ffynnon Llugwy Reservoir itself has been assessed as **minor beneficial**.

Table B2.7 Hydrological and Monitoring Reaches identified in the Study Area – Summer Impact (July to September)

Hydrological Reach	Reach boundary		Reach length	% flow reduction		Hydrological Impact (summer)
	Upstream	Downstream		Summer Q ₉₅ (Indicative)	Summer Q ₉₉ (Indicative)	
Ffynnon Llugwy Reservoir	n/a	n/a	n/a	n/a	n/a	Minor beneficial
1 Afon Llugwy	Ffynnon Llugwy Reservoir Outflow	Llyn Cowlyd west leat	1.7 km	44%	44%	Major
2 Afon Llugwy	Llyn Cowlyd west leat	Capel Curig u/s of Nant Gwryd confluence	8 km	44%	44%	Major
3 Afon Llugwy	Capel Curig u/s of Nant Gwryd confluence	Afon Conwy confluence	11 km	12%	19%	Moderate

Table B2.8 Hydrological and Monitoring Reaches identified in the Study Area – Winter Impact (October to December)

Hydrological Reach	Reach boundary		Reach length	% flow reduction		Hydrological Impact (winter)
	Upstream	Downstream		Summer Q ₉₅ (Indicative)	Summer Q ₉₉ (Indicative)	
Ffynnon Llugwy Reservoir	n/a	n/a	n/a	n/a	n/a	Minor beneficial
1 Afon Llugwy	Ffynnon Llugwy Reservoir Outflow	Llyn Cowlyd west leat	1.7km	44%	44%	Major
2 Afon Llugwy	Llyn Cowlyd west leat	Capel Curig u/s of Nant Gwryd confluence	8km	44%	44%	Major
3 Afon Llugwy	Capel Curig u/s of Nant Gwryd confluence	Afon Conwy confluence	11km	8.9%	1.4%	Negligible

B3 PHYSICAL ENVIRONMENT ASSESSMENT

B.3.1 Geomorphology and Sediment Transport

The Afon Llugwy is a tributary of the Afon Conwy, flowing from Ffynnon Llugwy Reservoir. The Afon Llugwy passes under the A5 road bridge and then over Swallow Falls, a multiple waterfall system, before passing through Betws-y-Coed. Approximately 1.4km downstream of Ffynnon Llugwy Reservoir, the Afon Llugwy is diverted by a stream capture system into the Llyn Cowlyd west leat which transfers water to Llyn Cowlyd Reservoir for hydro-power generation.

A geomorphology walkover survey has previously been completed in 2017 by APEM, on behalf of Welsh Water. Three locations, one in each reach, have been surveyed following RHS+ methodology which selects a 500m representative length in each reach.

Reach 1 is characterised by banks wholly composed on earth and moderately sloping. Boulders and cobbles dominate the bed substrate, with finer pebbles and gravels being introduced in the downstream 250m of the survey section. Undercutting is also present and becomes more prominent downstream. The main flow types are rippled, chaotic and chute flow. Other features include some pooled sections, ponded areas

Reach 2 is similar in character to Reach 1, however, the bank face is generally steeper in nature and the bed substrate has greater variation throughout the section. Undercut banks are still common in addition to erosion in some parts. The flow type is dominated by rippled flow and broken standing waves, and there is a greater percentage of smooth flow present. Tree cover significantly increases in reach 2 with percentage cover as high as 75% in some 50m sections. Channel features present include riffles, pools, and mid and side bars. Algal cover is also high with a range of between 15 and 85% across the sections.

The surveyed section in Reach 3 displays a more varied bank substrate, with other materials such as cobbles, pebbles, bedrock, gabions and rip-rap present in addition to earth. Undercutting is once again present, and the right bank is reinforced in the downstream section. The channel substrate is largely cobbles and boulders and flow type is primarily rippled in the uppermost 250m and smooth-dominated further downstream. Tree cover increases with one section noted as having 100% coverage.

Additionally, there are two RHS sites (site 4534) located 6.5km and (site 5811) 9.8km downstream of the study area on the River Llugwy. Furthermore, there is a geomorphological assessment of the Ffynnon Llugwy Reservoir by NRW⁴. The geomorphological assessment highlights the presence of culverts and flow splitting features within the reach. Bed substrate is of boulder grade, and there is local downcutting into soft superficial drift geology. Due to impounding structures, there is a lack of morphological continuity between parts of the watercourse impacting sediment transport and conveyance down the reach. Nonetheless, the

⁴ Ffynnon Llugwy Reservoir (SH6925662448), Geomorphological Assessment 02/11/12

report states that currently the river is largely unhindered and can entrain sufficient sediment from other sources. As the river reaches the channel floor, energy levels decrease, the channel becomes more uniform and meanders across the floodplain.

Significant changes to sediment transport or geomorphology are considered unlikely for the following reasons:

- The majority of sediment transport and morphological change is likely to occur at high flows and when the reservoir is overflowing (spilling). The magnitude and frequency of these flows will not be affected by the proposed compensation flow reductions, additionally the river has the capability of entraining sufficient sediment from other sources⁵;
- Prolonged periods of low flow could in theory result in additional deposition of fine sediment over coarse channel substrate, e.g. areas of gravel beds. However, this is considered unlikely, since there are few sources of fine sediment in the study reach that would be mobilised under low flows (e.g. sewage treatment works discharges), and low flow conditions would already occur in the baseline;
- Reductions in wetted perimeter could in theory lead to drying and destabilisation of the channel margins, resulting in excess erosion once high flows resume. However, a significant effect is considered to be highly unlikely, given the relatively short duration of flow reductions, and that any significant flow reductions would occur only at low flows at which the channel dimensions and velocity would be well within the bankfull width already.

Therefore, it is concluded that the impact of the drought permit on sediment dynamics and bank erosion is **negligible**. However, the major hydrological impacts associated with a reduction in compensation flow discharge will likely result in a reduction in wetted width and flow velocity below those normally observed in the upper Afon Llugwy at times of low flow. Due to the lack of baseline data, geomorphological impacts are therefore assessed as **moderate (uncertain)** in Reaches 1 and 2 and **minor (uncertain)** in Reach 3.

B.3.2 Water Quality

Water quality monitoring has not been undertaken in the upper reaches of the Afon Llugwy within the extent of hydrological influence of this drought permit. In addition, no monitoring has been carried out in the culvert which links the Afon Llugwy with Llyn Cowlyd. The closest NRW routine monitoring site (NRW Site: 25006, SH7916056400) is located approximately 18km downstream on the Afon Llugwy near Betws-y-Coed. This monitoring site is unlikely to represent the same water quality conditions as immediately downstream of Ffynnon Llugwy Reservoir, particularly as a major tributary, the Nantygwryd, enters 9km downstream of Ffynnon Llugwy Reservoir.

Because no historic water quality monitoring has been carried out on the Afon Llugwy it is,

⁵ Ffynnon Llugwy Reservoir (SH6925662448), Geomorphological Assessment 02/11/12

therefore, not possible to assess the possible impacts of this drought permit. As an alternative approach the existing WFD classifications for the containing WFD river waterbodies have been assessed. The RMBP2 WFD status for the appropriate waterbodies are outlined in **Table B3.1**.

Table B3.1 Summary of RMBP2 WFD classification

Waterbody ID	Name	Overall Status	Ecological Status	Ammonia Status	DO Status	Phosphate Status
GB110066054870	Llugwy - Nantgwryd to Ffynnon Llugwy	Moderate	Moderate	High	High	High
GB110066054850	Llugwy - Conwy to Nantgwryd	Moderate	Moderate	High	High	High

As previous WFD assessment of these waterbodies indicates High status for ammonia, DO and SRP, it is expected there will be **moderate (uncertain)** risk in Reaches 1 & 2 and **minor (uncertain)** risk in Reach 3 during the implementation of the drought permit. This assessment should be supplemented with monitoring data if it becomes available.

B.3.3 Environmental Pressures

B.3.3.1 Flow Pressures

No significant abstractions have been identified, other than the abstraction for hydro-electric power generation taken via the Llyn Cowlyd leat. It is understood that the leat has no compensation flow or Hands Off Flow requirement associated with it, but it is not clear how the intake structure is configured and what proportion of the upstream flow continues to the lower reaches of the Afon Llugwy. In any event, if compensation flow from Ffynnon Llugwy is reduced then it may be necessary to reduce the leat flow to Llyn Cowlyd, so the impacts on this abstraction would need to be assessed.

B.3.3.2 Water Quality Pressures

No water quality pressures have been identified.

B4 PHYSICAL ENVIRONMENT IMPACT SUMMARY

Potential impacts on the physical environment associated with the Ffynnon Llugwy Reservoir reduced compensation flow release drought permit are summarised in **Table B4.1**.

Table B4.1 Summary of Potential Changes to the Physical Environment of the Impacted Reaches from Implementation of Ffynnon Llugwy Reservoir Reduced Compensation Release Drought permit

Ffynnon Llugwy	
Reservoir levels <i>Minor beneficial impacts</i>	<ul style="list-style-type: none"> The impact on Ffynnon Llugwy Reservoir would be a marginal increase in levels/storage, relative to the position without the drought permit, due to the reduced outflow which would help to conserve water in storage.
Afon Llugwy (Reach 1 & 2)	
Flows in the Afon Llugwy <i>Major impacts during the period July to December inclusive</i>	<ul style="list-style-type: none"> Reductions of up to 44% in river flows with corresponding reductions in wetted depths/wetted widths (potential marginal habitats), during the summer and autumn period
Water quality in the Afon Llugwy <i>Moderate (uncertain) risk during the period July to December inclusive</i>	<ul style="list-style-type: none"> WFD waterbodies indicates High status for Ammonia, DO and phosphorus and therefore at greater risk of deterioration under major hydrological impacts. However the lack of water quality monitoring data means there is a level of uncertainty.
Surface water abstractions and risk to abstractors <i>Moderate (uncertain) risk during the period July to December inclusive</i>	<ul style="list-style-type: none"> Potential impact on HEP abstraction through the Llyn Cowlyd West Leat, which may need to be reduced or discontinued during the implementation of the drought permit.
Consented discharges <i>Negligible risk</i>	<ul style="list-style-type: none"> No consented discharges
Geomorphology <i>Moderate (uncertain) risk during the period July to December inclusive</i>	<ul style="list-style-type: none"> Major hydrological impacts will likely result in a significant reduction in wetted width and flow velocity below those normally observed in the upper Afon Llugwy.
Afon Llugwy (Reach 3)	
Flows in the Afon Llugwy <i>Moderate/major impacts during the period July to September inclusive; negligible impacts during the period October to December inclusive</i>	<ul style="list-style-type: none"> Reductions of up to 19% in river flows (27% based on Afon Lledr as donor gauge), with corresponding reductions in wetted depths/wetted widths (potential marginal habitats), during the summer and autumn period
Water quality in the Afon Llugwy <i>Moderate (uncertain) risk during the period July to September inclusive</i>	<ul style="list-style-type: none"> WFD waterbodies indicates High status for Ammonia, DO and phosphorus and therefore at greater risk of deterioration under minor hydrological impacts. However the lack of water quality monitoring data means there is a level of uncertainty.
Surface water abstractions and risk to abstractors <i>Negligible risk</i>	<ul style="list-style-type: none"> No surface water abstractions
Consented discharges <i>Negligible risk</i>	<ul style="list-style-type: none"> No consented discharges
Geomorphology <i>Moderate (uncertain) risk during the period July to September inclusive</i>	<ul style="list-style-type: none"> Moderate hydrological impacts may lead to a reduction in wetted width and flow velocity below those normally observed in the upper Afon Llugwy.

B5 CUMULATIVE IMPACTS

The assessment only considers the effects of a single drought permit application and not the cumulative or in-combination effects if another drought permit within the same catchment were applied for and implemented concurrently. However it is also necessary to consider the cumulative effects with other drought options which may be implemented at the same time within the catchment and/or the water resource zone.

The cumulative effects of this drought permit with other drought options in the Afon Llugwy catchment and the North Eryri Ynys Mon WRZ are summarised in **Table B5.1** below.

Table B5.1 Cumulative Impacts of the Ffynnon Llugwy Reservoir Drought permit with other Drought Options

Organisation	Potential In-combination Impacts	Further Consideration Required (Yes/No)
Welsh Water - other drought options in the North Eryri Ynys Mon WRZ	<u>8001-2 (Removal of Llyn Cwellyn 10ML/d abstraction rate)</u> – The impacts of this option do not occur within the same catchment and therefore no in-combination effects are anticipated.	No
	<u>8001-3 (Reduction of Alaw Compensation water)</u> – The impacts of this option do not occur within the same catchment and therefore no in-combination effects are anticipated.	No
	<u>8001-5 (Reduction of Cefni Compensation water)</u> – The impacts of this option do not occur within the same catchment and therefore no in-combination effects are anticipated.	No

APPENDIX C

ENVIRONMENTAL FEATURES

ASSESSMENT METHODOLOGY

A.1 ENVIRONMENTAL FEATURES ASSESSMENT METHODOLOGIES

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

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

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

Assessment sheets are included for the following features:

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

FLOW PRESSURES

Potential Effects

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

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

Definition of Risk

Continuously flowing watercourses

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

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

Ephemeral watercourses

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

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

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

Data Requirements

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

Assessment Methodology and Uncertainty

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

Groundwater abstractions

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

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

Surface water abstractions – continuously flowing watercourses

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

Surface water abstractions – ephemeral watercourses

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

All abstractions

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

WATER QUALITY PRESSURES

Potential Effects

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

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

Definition of Risk

Continuously flowing watercourses

In order to define the potential risk to water quality from discharges into the river in a readily understandable manner, a series of criteria have been defined. The assessment will use the following criteria, based on the potential severity of the risk to water quality during an ongoing drought.

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

Ephemeral watercourses

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

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

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

Data Requirements

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

Assessment Methodology and Uncertainty

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

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

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

Continuously flowing watercourses

- 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).
- 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).
- 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.

- 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 4 mg/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 4 mg/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

<p>Potential Effects</p> <p>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.</p>
<p>Definition of Impacts</p> <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.
<p>Data Requirements</p> <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

<p>Potential Effects</p> <p>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 <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.</p>
<p>Definition of Impacts</p> <p>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.</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 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 +/- 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.
<p>Data Requirements</p> <p>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.</p> <p>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:</p> <ul style="list-style-type: none"> • 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 Management (CIEEM) Ecological Impact Assessment (EclA) 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 2 cm and 30 cm (>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 2 cm and 30 cm (>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 2 cm and 30 cm (>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
			Deterioration in water quality
Adult	<ul style="list-style-type: none"> Sheltered sections created by woody debris, tree roots, leaf litter, macrophyte cover or larger stones. 		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
European eel, <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
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. 		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased significance of barriers to impede migration as a result of decreased flows
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Barbel <i>Barbus barbus</i>			
Spawning	<ul style="list-style-type: none"> Run/glide flow Less than 50cm deep Velocities greater than 0.5m/s Substrate composed of clean and uncompacted gravel 	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
			Deterioration in water quality
Nursery	<ul style="list-style-type: none"> Marginal shallow bays set back from or within margins of main channel Depths between 1cm and 30cm No discernible to minimal flow Substrate composed of > 30% gravel and sand with low silt content Lack of or very little riparian shading 		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	<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 larger 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 Ffynnon Llugwy drought permit. Baseline data and the impact assessments are presented for the environmental features that form part of the scope of the assessment (established by the screening exercise described in Section 3.2.2 of the EAR and results of which are summarised in Section 5.2). The features assessment presented in full below is summarised in Section 5.3 of the EAR.

Points of interest referred to throughout the text 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 permit 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 IEMA¹ and the CIEEM study guidelines². 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**.

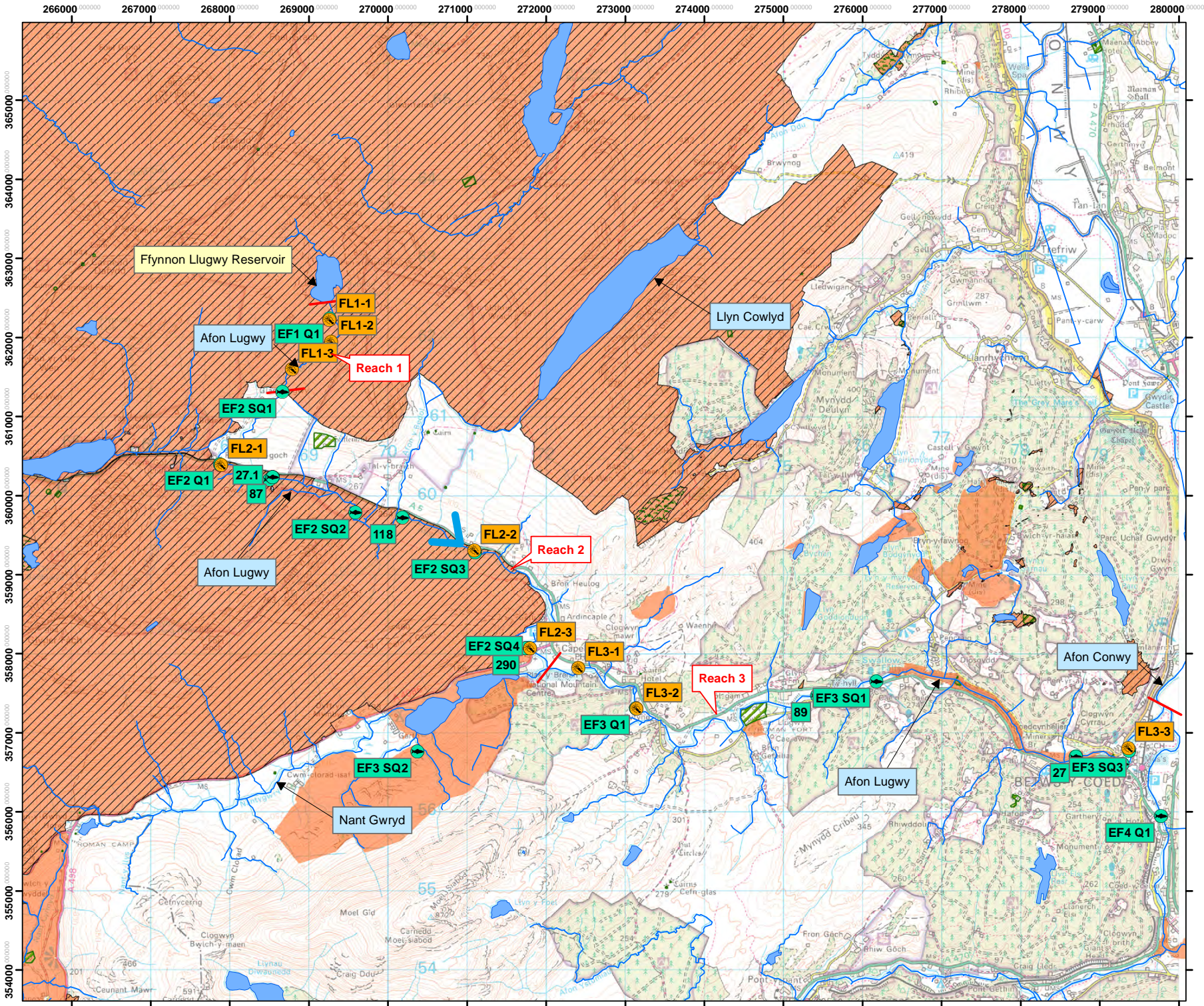
Desk-based assessments have been completed for each of the sensitive receptors, where applicable, in order to determine the magnitude of impact in the relevant lake/river reaches for the Ffynnon Llugwy drought permit. Each feature assessment describes the analyses carried out and a statement of the assessed 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 Landscape and Recreation

¹ IEMA (2004) Guidelines for Environmental Impact Assessment.

² CIEEM (2018) Guidelines for Ecological Impact Assessment in the United Kingdom, January 2016



Legend

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

Scale: 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: 8001-4 Reduction of Ffynnon Llugwy Compensation water**

Figure Number: **Figure D1.1** Date: **February 2019**

D2 DESIGNATED SITES

D.2.1 Eryri SAC / Eryri SSSI

D.2.1.1 Baseline

Ffynnon Llugwy Reservoir is located within Snowdonia National Park, parts of which are designated a SAC (Eryri). There are 19 qualifying features, comprising seventeen Annex I habitats and two Annex II species. The majority of these are terrestrial montane habitats; two pertain to freshwater:

- Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*
- Floating water-plantain *Luronium natans*.

The Afon Llugwy flows through three SAC management units, Units 37, 56 and 57. The Key Habitat for Unit 37 is Summit heath; Key habitats and species for Unit 56 are Blanket Bog, Summit Heath and Rare plants and assemblage; and Key Habitats for Unit 57 are Blanket Bog and Alpine and Boreal Heath. No habitats or species listed as present in the management plan for these units pertain to habitats provided or supported by the Afon Llugwy.

Ffynnon Llugwy forms Management Unit 103. The Conservation Objectives for the SAC³ describe the status of the habitat feature “Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and / or of the *Isoëto-Nanojuncetea*” within this Management Unit as “unknown”, indicating that the reservoir could potentially support this habitat but that no data exists with which to assess this.

This 20,346ha site is also a designated SSSI (Eryri) for its features of geological, geomorphological and biological interest. The bedrock geology supports a wide range of upland and montane habitats with a large number of rare and scarce species, a wide variety of upland habitats and important higher and lower plants, birds and invertebrates⁴.

A number of SSSI features listed within the designation potentially pertain to habitats afforded by Ffynnon Llugwy or the Afon Llugwy. These include:

- Lichen assemblage
- Bryophyte assemblage
- Aquatic and marginal plant assemblage
- Upland invertebrate assemblage
- Atlantic salmon *Salmo salar*
- *Nitella gracillis* (stonewort)
- *Lecanora achariana* (lichen)

Both Ffynnon Llugwy and the Afon Llugwy have potential to support a range of lichens,

³ Countryside Council for Wales (2008) Core Management Plan including Conservation Objectives for Eryri SAC

⁴ Countryside Council for Wales (2002) Eryri Site Of Special Scientific Interest Citation

bryophytes and invertebrate species, potentially including rare species, which would contribute to the overall assemblages for which the SSSI is notified. Ffynnon Llugwy has the potential to support an aquatic and marginal plant assemblage of interest, however, as a reservoir, this is likely to be of secondary interest to other lakes within the SSSI. Although it has potential to support the stonewort species *Nitella gracillis* and the lichen *Lecanora achariana* (Tarn achariana) they are thought unlikely to be present due to the regulated nature of the waterbody, but survey would be required to confirm this. *Lecanora achariana* occurs, rarely, in the splash zone of rivers⁵, and could, therefore, potentially also be present within the Afon Llugwy. Salmon are present within the lower reaches of the Afon Llugwy but do not occur within the boundary of the SAC / SSSI due to obstacles to migration (waterfalls) downstream.

D.2.1.2 Assessment

The hydrological effects of the drought permit on Ffynnon Llugwy are assessed a beneficial impact (see **Appendix B**) and therefore no adverse impacts on SAC or SSSI features supported by Ffynnon Llugwy are expected.

No habitats or species listed as present in the SAC Management Plan for the units in which the Afon Llugwy occurs pertain to habitats provided or supported by the Afon Llugwy. Therefore, impacts of the drought permit on the Eryri SAC are assessed as **negligible**.

The Eryri SSSI designation includes a number of assemblages (lichen, bryophyte, invertebrate), of which parts may be supported by the habitats afforded by the Afon Llugwy. Major adverse hydrological impacts within the SSSI boundary have been assessed as likely to have moderate adverse impacts on macrophyte communities (including lichens and bryophytes) and macroinvertebrate communities. Impacts on the bryophyte community associated with the Ffynnon Llugwy drought permit in Reach 1 assessed as major adverse, during the period July to September and minor during the period October to December (see Section D.3.1.2). The impact of the drought permit on the Eryri SSSI is assessed as **major** adverse, short-term and reversible.

D.2.2 Afon Llugwy SSSI

D.2.2.1 Baseline

The Afon Llugwy SSSI is designated primarily for two features of interest⁶:

- A good example important in demonstrating characteristic features of upland, bedrock-confined stream channels (geomorphology). This includes several major knickpoints (changes in gradient) set within a glacially and glaciofluvially over-deepened valley. Well-developed mountain torrents reaches between the steeper sections add to the range of geomorphological interests.

⁵ Lichens of Wales <http://wales-lichens.org.uk/species-accounts/lecanora-achariana>

⁶ Countryside Council for Wales (2012) Afon Llugwy Site of Special Scientific Interest: Your Special Site and its Future

- An Oceanic bryophyte assemblage of national importance (mosses and liverworts). This includes records of 11 nationally scarce species and more than 40 Atlantic and western species.

The bryophyte assemblages are particularly diverse in the deep gorges at Swallow Falls and Miners Bridge. These ravines are exceptionally well-suited to the growth of oceanic mosses and liverworts due to the high humidity levels provided by the spray from the waterfalls along with the dense woodland canopy and steep ravine sides. The cliffs above the north side of Swallow Falls also support several notable oceanic mosses and liverworts.

The habitats afforded by the SSSI also support a range of other wildlife, including five species of bat, *Salmo salar* (Atlantic salmon), *Salmo trutta* (brown / sea trout), *Lutra lutra* (European otter), *Arvicola amphibius* (water vole) and *Alcedo atthis* (common kingfisher).

D.2.2.2 Assessment

The Afon Llugwy SSSI occurs within Reach 3, and as such hydrological impacts of the drought permit on the river are assessed as moderate for summer (reduction of 12% and 19% during summer low and extreme low flows respectively) and negligible for winter (8.9% and 1.4% of summer low and extreme low flows respectively). This has potential to have an effect on wetted widths, splash zone and humidity within the river reach during summer low flow periods, thereby potentially impacting the bryophyte assemblage of the SSSI. Given the distance of the SSSI from the reservoir and flow accretion down the catchment before this point, operation of the drought permit would not prolong any period of low flows beyond what would be experienced naturally, as at times of higher flow in rest of the catchment the contribution of the flow from Ffynnon Llugwy, and therefore the difference due to operation of the drought permit, would become much less significant.

Impacts of the drought permit on the bryophyte community are discussed in Section D3.1. The impacts on the bryophyte communities of the Afon Llugwy SSSI are assessed as **minor** adverse, short-term and reversible during July to September.

Summary

The potential impacts of the Ffynnon Llugwy drought permit 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 **Appendix B** and 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 2 and represent the worst case impacts of implementing a drought permit, 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 and 2 – Afon Llugwy		
EryriSAC	<ul style="list-style-type: none"> No water dependant habitats or species located in the units in which the Afon Llugwy occurs. Impacts of the drought permit on the are assessed as negligible 	Negligible
EryriSSSI	<ul style="list-style-type: none"> Implementation of the drought permit has potential to have a limited effect on wetted widths, splash zone and humidity within the river reach, thereby potentially impacting the bryophyte assemblage of the SSSI. 	Major
Reach 3 – Afon Llugwy		
Afon Llugwy SSSI	<ul style="list-style-type: none"> Implementation of the drought permit has potential to have a limited effect on wetted widths, splash zone and humidity within the river reach, thereby potentially impacting the bryophyte assemblage of the SSSI. 	Minor

D3 WFD STATUS AND COMMUNITY ASSESSMENT / NOTABLE SPECIES

D.3.1 Bryophytes

D.3.1.1 Baseline

Baseline bryophyte data was collected for the Afon Llugwy within each of the hydrological reaches in 2016⁷. Bryophytes species were recorded within permanent 20 cm x 20 cm quadrats (30 no. in total; 10 no. in each reach). The quadrats were located mainly on steep rock faces within the zone between low and high water flows. Bryophyte vegetation in general was also recorded within randomly located non-permanent 20 cm x 20 cm quadrats (90 no. in total; 10 no. in each zone (3 no.) in each of the three reaches. The randomly located quadrats were located on rocks and banks within each of the three zones along each reach. The three zones were:

1. lower 'stream channel' zone (low rocks in the streams; almost always submerged);
2. middle 'stream bank' zone (surfaces of varying steepness on rock outcrops and boulders within and adjacent to the streams, between low and high water levels); and
3. upper 'riparian corridor' zone (steep rock walls and banks adjacent to the streams, above the high water level).

Overall, the species most commonly recorded in the permanent quadrats are the nationally common riparian mosses *Sciuro-hypnum plumosum* (in 17 out of 30 quadrats) and *Racomitrium aciculare* (16), and the western oceanic moss *Isothecium holtii* (13). These are relatively large, robust mosses, but many smaller bryophyte species were also recorded in these quadrats, including the oceanic liverworts *Aphanolejeunea microscopica* (nationally uncommon) and *Lejeunea patens*. Oceanic species were recorded most commonly in the quadrats in the lower reach (Reach 3), where the river is larger and flows through sheltered woodland.

For the non-permanent surveys, the data is presented for each of the sample zones within each hydrological reaches:

Reach 1

- Zone 1 (uppermost zone- 'riparian corridor' zone; steep rock walls and banks adjacent to the streams, above the high water level). Steep banks with vegetation consisting mainly of a mixture of grasses (especially *Nardus stricta*, *Festuca ovina* and *Molinia caerulea*), the herb *Galium saxatile* and the large mosses *Hylocomium splendens*, *Polytrichum commune* and *Pleurozium schreberi*. Many other species also present (total of 31 species in all 10 quadrats combined), especially bryophytes including *Pseudoscleropodium purum*, *Rhytidiadelphus squarrosus*, *Sphagnum denticulatum*,

⁷ Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Ffynnon Llugwy Reservoir, July 2018

S. palustre and the liverworts *Pellia epiphylla*, *Diplophyllum albicans* and *Barbilophozia floerkei*.

- Zone 2 (middle zone- 'stream bank' zone (surfaces of varying steepness on rock outcrops and boulders within and adjacent to the streams, between low and high water levels). Steep rock surfaces which are largely bare but with scattered tufts and patches of bryophytes, mainly the moss *Racomitrium aciculare*. Other species were infrequent and included *Sciuro-hypnum plumosum*, *Isothecium holtii*, *Hyocomium armoricum* and *Andreaea rothii*.
- Zone 3 (lowest zone- 'stream channel' zone; low rocks in the streams; almost always submerged). These low rock surfaces in the stream were largely bare but possessed a sparse growth of the moss *Racomitrium aciculare* and the liverworts *Marsupella emarginata* and *Scapania undulata*.

Reach 2

- Zone 1 (uppermost zone). These were steep to gently sloping banks with more or less continuous vegetation consisting mainly of grasses (especially *Agrostis capillaris*), herbs (especially *Hypochaeris radicata*, *Plantago lanceolata*, *Trifolium repens*, *Prunella vulgaris* and *Achillea millefolium*) and bryophytes including the mosses *Thuidium tamariscinum*, *Atrichum undulatum*, *Hylocomium splendens*, *Hypnum jutlandicum*, *Calliergonella cuspidata* and *Bryum pseudotriquetrum*. A total of 53 species was recorded in all 10 quadrats combined. The species composition resembles that of a mossy acidic to neutral grassland.
- Zone 2 (middle zone). These steep rock surfaces were partly bare and colonized by tufts and patches of bryophytes, especially the robust mosses *Racomitrium aciculare*, *Sciuro-hypnum plumosum* and *Isothecium holtii*, but also other species including *Bryum capillare* and the small liverworts *Lejeunea lamacerina* and *Marsupella emarginata*.
- Zone 3 (lowest zone). These low rock surfaces (some steep; others flatter) ranging from just above to just below water level had a sparse and patchy growth of bryophytes consisting mainly of the mosses *Racomitrium aciculare*, *Isothecium holtii* and *Fontinalis squamosa*, and the liverwort *Scapania undulata*. The first two species were mainly just above water level and the last two just below water level.

Reach 3

- Zone 1 (uppermost zone). On these steep banks 1-3 m above the river margin there was a mixture of vascular plants, especially *Hedera helix*, *Luzula sylvatica*, *Oxalis acetosella*, *Sanicula europaea* and *Viola riviniana*, and the mosses *Hyocomium armoricum*, *Thuidium tamariscinum*, *Mnium hornum*, *Hookeria lucens*, *Rhizomnium punctatum* and *Rhytidiadelphus loreus*, and the liverwort *Saccogyna*

viticulosa. The vegetation is reasonably species-rich, with a total of 35 species recorded among the 10 quadrats.

- Zone 2 (middle zone). These steep rock surfaces possessed a variable cover of bryophytes, consisting mainly of sheets of the Pleurocarpous mosses *Thamnobryum alopecurum*, *Ctenidium molluscum* and *Heterocladium heteropterum* and tufts of *Racomitrium aciculare*. Other bryophytes occurred more sparsely, including the mosses *Isothecium holtii*, *Hyocomium armoricum*, *Sciuro-hypnum plumosum*, *Amphidium mougeotii* and the liverworts *Marsupella emarginata*, *Plagiochila porelloides* and *Lejeunea lamacerina*,
- Zone 3 (lowest zone). Bryophyte cover and diversity was limited on the lower rock surfaces around water level, with the commonest species recorded consisting of the moss *Hyocomium armoricum*. *Scapania undulata* was also common around or just below water level, along with smaller amounts of other species occur, including *Racomitrium aciculare*.

D.3.1.2 Assessment

The lower reach of the Afon Llugwy has for many years been known to possess a rich bryophyte community, including some uncommon western oceanic species. This was further supported by the 2016 data. The 30 permanent quadrats on rocks include the type of habitat in which hydrological change could occur as a result of changes in water levels, as well as the type of habitat in which uncommon hygrophilous oceanic species most commonly occur: steep rock surfaces from 0 cm to approximately 100 cm above water level, evidently subjected to periodic splash, spray and submergence.

Oceanic bryophytes are found where a number of environmental factors combine to provide humid conditions that rarely drop below optimal levels for the most sensitive species. Oceanic bryophytes are generally less tolerant to desiccation than more common species. Splash and humidity would be very limited at times of low and very low flow, and a further reduction in these flows is likely to impact these species. Given the potential for the drought permit to be implemented for up to six months, marginal communities may die as a result of desiccation. There is also risk of deteriorating water quality during the implementation of the drought permit. Any deterioration in water quality, notably nutrient levels may benefit already abundant filamentous algal growth in Reach 1 and 2, smothering submerged bryophyte communities. Overall, impacts may reduce abundance, with recovery taking more than one growing season. Impacts on the bryophyte community associated with the Ffynnon Llugwy drought permit in Reach 1 and 2 are assessed as **major adverse**, medium term, temporary and reversible for July to September and minor for October to December. Impacts on the bryophyte community associated with the Ffynnon Llugwy drought permit in Reach 3 are expected to be reduced due to lessened hydrological impacts over a shorter time period, and are therefore assessed as **minor adverse**, short term, temporary and reversible for July to September only.

D.3.1.3 Summary

The potential impacts of the Ffynnon Llugwy drought permit on the bryophyte community are summarised in **Table D3.1**. 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 likely sensitivities of the macrophyte community. The impacts presented in **Table D3.1** represent the worst-case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D3.1 Summary of Impacts on the Macrophyte Community

Feature	Impact	Significance of Impact
Reach 1 – (Afon Llugwy - Outflow of Ffynnon Llugwy to Llyn Cowlyd take off leat)		
Reach 2 (Afon Llugwy - Llyn Cowlyd take off leat to Capel Curig)		
Bryophytes	<ul style="list-style-type: none"> • Changes to community composition due to changes in splash and humidity. • Reduction in growth as a result of major impacts on water levels and flows. • Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity. 	<p>Major (July to September) Minor (October to December)</p>
Reach 3 – (Afon Llugwy - Capel Curig to the confluence with the Afon Conwy)		
Bryophytes	<ul style="list-style-type: none"> • Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity. • Reduction in growth as a result of moderate (July to Sept) impacts on water levels and flows. • Changes to community composition due to changes in splash and humidity. 	<p>Minor (July to September only)</p>

D.3.2 Macrophytes

D.3.2.1 Baseline

Baseline macrophyte data was collected at a single site in Reaches 1 to 3 in August 2017⁸. Survey locations are detailed in **Table D3.2**.

Table D3.2 Macrophyte survey locations

Reach	NGR
1	SH 68713 61473
2	SH 71074 59321
3	SH 79550 57060

Macrophyte results were provided using the standard LEAFACS2 methodology⁹ 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

⁸ Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Ffynnon Llugwy Reservoir, July 2018
⁹ WFD-UKTAG (2014) UKTAG river assessment method – macrophytes and phyto-benthos (River LEAFACS2).

river. The LEAFPACS2 method assesses the condition of river macrophyte communities using data on presence and abundance of species and groups of species recorded during a standard survey comprising a 100m river section. These indices are briefly described below:

- (i) River Macrophyte Nutrient Index (RMNI): an index of eutrophication (high scores indicate enriched conditions);
- (ii) Number of macrophyte taxa which are truly aquatic, i.e. hydrophytes (NTAXA);
- (iii) Number of functional groups of macrophyte taxa which are hydrophytes (NFG): an assessment of the structural diversity of the plant community; and
- (iv) Percentage cover of all green filamentous algal taxa over the whole of the surveyed river sections (ALG).

RMNI score is a measure of the macrophyte community’s association with nutrient levels on a scale of 1 – 10. High scores are associated with species that dominate under nutrient enriched eutrophic conditions.

Table D3.3 provides a summary of RMNI scores recorded at sites within the study reaches and **Table D3.3** provides an average RMNI score for the catchment.

Table D3.3 Macrophyte results, 2017

Reach	Site Location (NGR, downstream extent)	Matrix				Environmental Variables	
		RMNI	NTAXA	NFG	ALG	Total % Cover of Macrophytes	Total % cover of filamentous algae
1	SH 68713 61473	3.73	8.0	4.0	4.8	70	55
2	SH 71074 59321	3.96	9.0	4.0	5.1	60	40
3	SH 79550 57060	4.16	8.0	5.0	0.0	25	0

RMNI scores increased from 3.73 in Reach 1, to 4.16 in Reach 3. The low RMNI scores obtained within the Afon Llugwy are indicative of a community with a preference for oligotrophic to mesotrophic conditions, and would therefore be considered sensitive to pollution. Number of taxa and number of functional groups remained similar within all reaches. Whilst not consistent with the relatively low RMNI scores, filamentous algal cover was high in Reach 1 and 2, potentially highlighting nutrient enrichment in these reaches combined with the lack of bankside and riparian vegetation resulting in low shading of the channel bed. The survey site in Reach 3 did not contain any filamentous algae, indicating either a nutrient enrichment may be reduced in the lower reaches of the hydrological zone of impact.

Table D3.4 LEAFPACS parameter averaged scores, 2017

	RMNI	RMHI	NTAXA	NFG	ALG
Ffynnon Llugwy	3.95	4.66	8.33	4.33	3.30

D.3.2.2 Assessment

The assessment of impacts on the macrophyte community should be considered in the context of the watercourse under baseline conditions.

Baseline data suggests that the macrophyte communities of the Afon Llugwy are associated with nutrient poor, upland high gradient streams and rivers with coarse substrates, and are adapted to moderate to high flow velocities.

Reduction in flows could reduce the overall extent of habitat favoured by species favouring fast flow, and favour those species more adapted to slow flow and marginal / riparian conditions. There is a risk of deteriorating water quality during the implementation of the drought permit based on previous WFD assessments of waterbodies.

Hydrological impacts as a result of drought permit implementation in Reach 1 and 2 are anticipated to be major adverse; a reduction in flow of up to 44% during summer low and extreme low flows (both Q₉₅ & Q₉₉) throughout summer and winter periods (July to December), with an associated reduction in velocity, wetted width/ depth and bed exposure during this period, which would be outside of the envelope experienced under normal hydrological conditions.

Due to the potential extent of change to wetted area, velocities, splash and humidity, operation of the drought permit has the potential to affect the condition and extent of macrophyte communities. Low flows may also favour the proliferation of filamentous algae species due to changes in velocity and water temperature, with high densities of filamentous algae already observed in Reaches 1 and 2. Any deterioration in water quality, notably nutrient levels may benefit already abundant filamentous algal growth, smothering submerged macrophyte communities. Overall, impacts may reduce abundance and diversity in the community. Therefore the impacts of the drought permit on the macrophyte communities in Reach 1 and 2 are assessed as **moderate** adverse during the growing season (July-September) and **minor** adverse during the period October-December.

Hydrological impacts associated with the implementation of a drought permit in Reach 3 are assessed as moderate adverse in July to September and negligible between in October to December. Changes to wetted width and depth, velocity, splash zone and humidity, could affect the composition and condition of the macrophyte, including filamentous algae levels. Impacts are anticipated to be reduced compared to Reach 1 and 2 and limited to the summer months of July to September (minor hydrological impact), which coincides with the growing season. The impacts of the drought permit on the macrophyte communities of Reach 3 are

expected to be **minor adverse**, short term, temporary and reversible between July and September only.

D.3.2.3 Summary

The potential impacts of the Ffynnon Llugwy drought permit 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 likely sensitivities of the macrophyte community. The impacts presented in **Table D3.5** represent the worst-case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D3.5 Summary of Impacts on the Macrophyte Community

Feature	Impact	Significance of Impact
Reach 1 – (Afon Llugwy - Outflow of Ffynnon Llugwy to Llyn Cowlyd take off leat)		
Macrophytes	<ul style="list-style-type: none"> Reduction in growth as a result of major impacts on water levels and flows. Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity 	<p>Moderate (July to September)</p> <p>Minor (October-December)</p>
Reach 2 (Afon Llugwy - Llyn Cowlyd take off leat to Capel Curig)		
Macrophytes	<ul style="list-style-type: none"> Reduction in growth as a result of major impacts on water levels and flows. Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity 	<p>Moderate (July to September)</p> <p>Minor (October-December)</p>
Reach 3 – (Afon Llugwy - Capel Curig to the confluence with the Afon Conwy)		
Macrophytes	<ul style="list-style-type: none"> Reduction in growth as a result of major impacts on water levels and flows. Changes to community composition due to changes to flow rates and habitat loss due to reduction in wetted width. Increase in filamentous algae levels due to increased nutrients/water temperature/decreased velocity 	<p>Minor (July to September only)</p>

There is a risk of short-term deterioration in status of the macrophyte component of the ‘Llugwy - Nant gwryd to Ffynnon Llugwy’ (GB110066054870) and ‘Llugwy - Conwy to Nant gwryd’ (GB110066054850) waterbodies due to the drought permit. Impacts of drought permit implementation on the macrophyte communities of the impacted reaches have been summarised as minor to moderate adverse, short-term, temporary and reversible. Consequently, the macrophyte component of the ‘Llugwy - Nant gwryd to Ffynnon Llugwy’ (GB110066054870) waterbody is considered to be at **moderate** risk of short-term deterioration, and that of the ‘Llugwy - Conwy to Nant gwryd’ (GB110066054850) at **minor** risk of short-term deterioration.

D.3.3 Macroinvertebrates

D.3.3.1 Baseline

Baseline macroinvertebrate data has been collected for Reaches 1 to 3 between 2016 (autumn season only) and 2017 (spring and autumn season)¹⁰, with survey locations provided in **Table D3.5**.

Table D3.5 Macroinvertebrate survey locations

Reach	Site Code	NGR
1	FL1-1	SH 69261 62226
	FL1-2	SH 69283 61946
	FL1-3	SH 68785 61600
2	FL2-1	SH 67893 60389
	FL2-2	SH 71092 59305
	FL2-3	SH 71796 58068
3	FL3-1	SH 72408 57819
	FL3-2	SH 73143 57304
	FL3-3	SH 79363 56807

Sampling was undertaken following the standard NRW protocol involving a three-minute kick / sweep sample encompassing all the available instream habitats in proportion to their occurrence. These datasets were used to calculate a series of standard biotic indices: Biological Monitoring Working Party (BMWP) scores; Average Score Per Taxon (ASPT); Lotic Invertebrate Flow Evaluation (LIFE); and number of taxa (NTAXA).

LIFE scores are used to assess how sensitive a macroinvertebrate community is to change in flow. Family LIFE scores are provided for all available data. **Table D3.6** outlines LIFE score interpretation.

BMWP is primarily used to monitor the impact of organic water quality but also responds to other pressures such as habitat reduction, siltation and toxic pollutants. High BMWP scores are associated with good water and habitat quality. Comparisons between sites with BMWP scores must be used with caution as change to river type can have considerable influence over BMWP score.

ASPT is derived from BMWP and provides the average BMWP sensitivity score of all the taxa found in the sample's macroinvertebrate assemblage. This index provides a more reliable means of comparing macroinvertebrate community quality between sites whilst also reducing the influence of sampling artefacts such as variable sampling effort. As such ASPT is used as the primary means of assessing macroinvertebrate response to water quality in this assessment. As a guide ASPT scores above 5 represent macroinvertebrate communities living in good water quality. Scores below 5 indicate water quality stress on the macroinvertebrate

¹⁰ Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Ffynnon Llugwy Reservoir, August 2018

community. ASPT scores provide a more reliable means of comparing macroinvertebrate community quality between sites, whilst also reducing the influence of sampling artefacts such as variable sampling effort. As such ASPT is used as the primary means of assessing macroinvertebrate response to water quality in this assessment.

Table D3.6 Interpretation of Macroinvertebrate Community LIFE Scores

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

The LIFE scores obtained from baseline monitoring are displayed in **Figure D3.1**. Whilst seasonal variation exists between sites and reaches, the scores range from 7.8 to 8.5 across the monitoring period, and describes a macroinvertebrate community which is highly sensitive to reduced flows and therefore is consistent with a community associated with fast flowing water.

ASPT and BMWP scores are displayed in **Figure D3.2** and **Figure D3.3**. ASPT scores ranged from 5.77 to 7.04 across the monitoring period. This reflects a macroinvertebrate community which is representative of good to high water quality. BMWP scores ranged from 99 to 188; matching the outcomes of the ASPT scores.

This community is exemplified by the presence of a number of highly pollution sensitive species including stonefly *Chloroperla torrentium*, caddisfly *Odontocerum albicorne*, and blue-winged olive mayfly *Serratella ignita*.

Figure D3.1 Observed Family LIFE scores within the Afon Llugwy

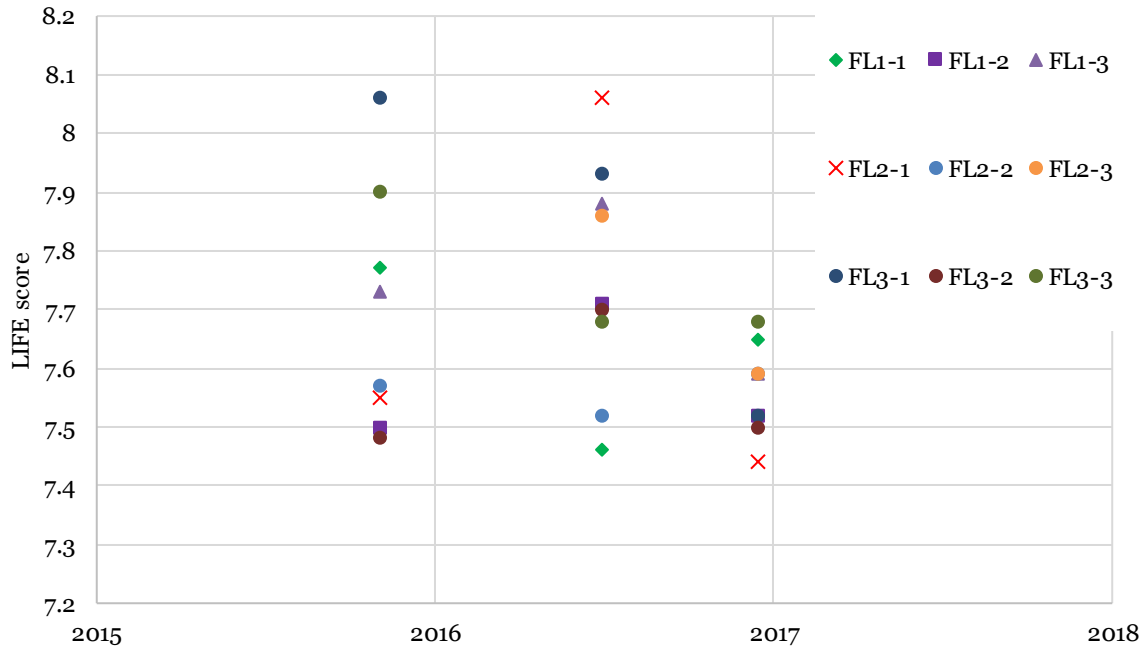


Figure D3.2 Observed ASPT scores within the Afon Llugwy

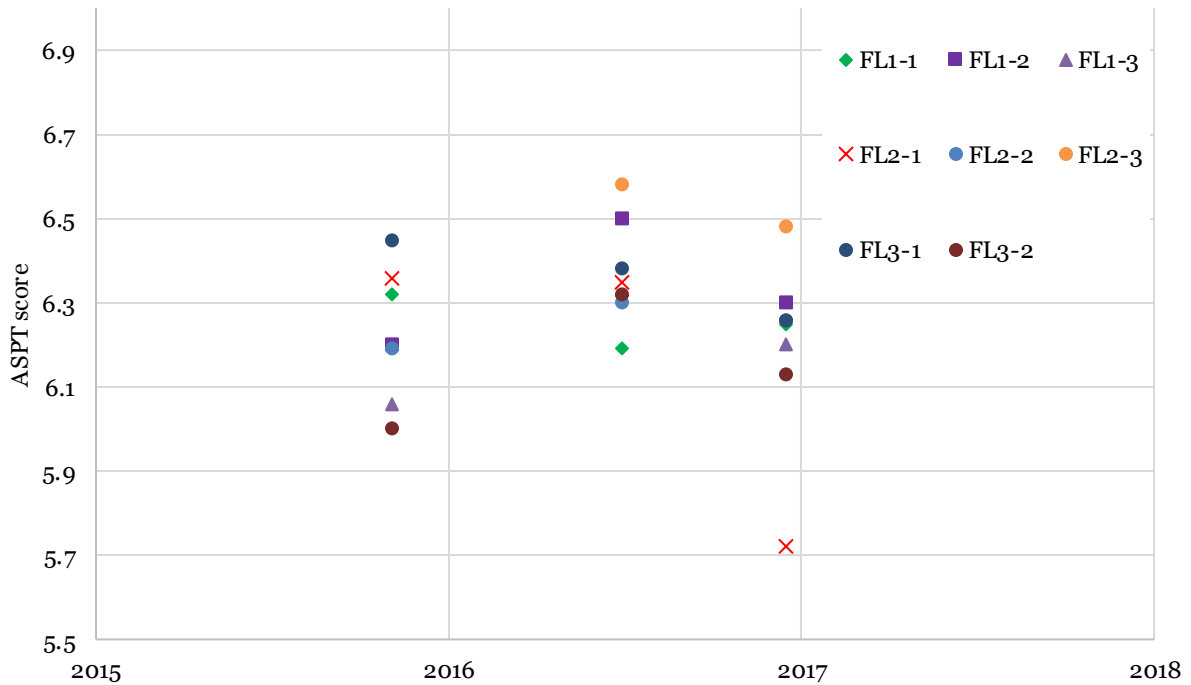
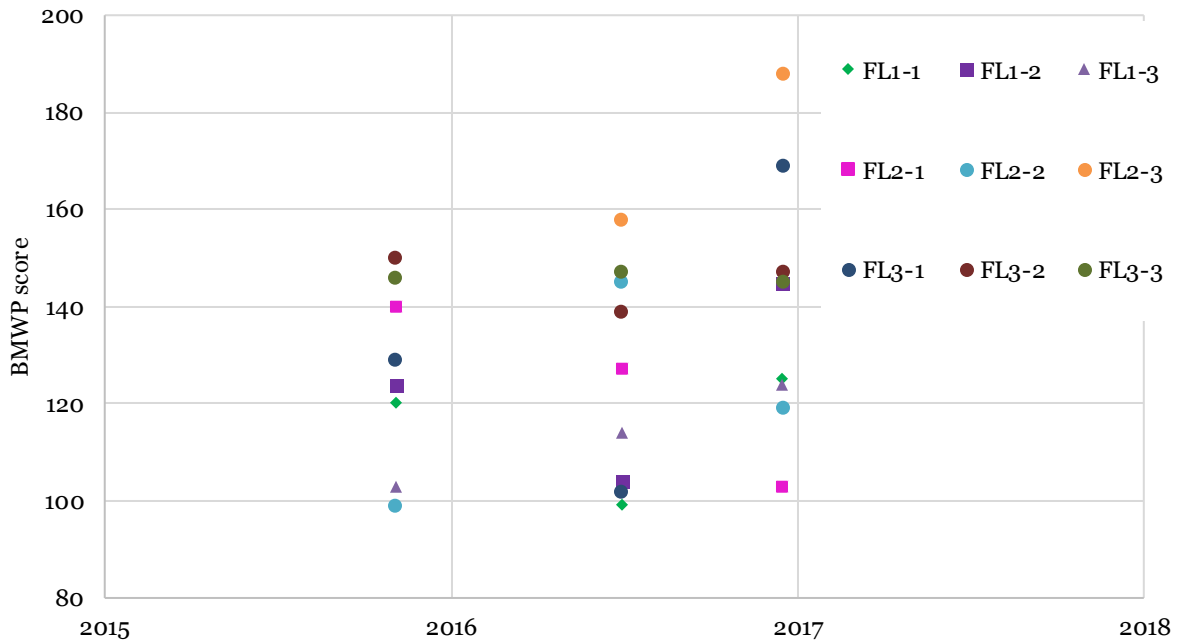


Figure D3.3 Observed BMWP scores within the Afon Llugwy



Environmentally Sensitive Species

No records of native white-clawed crayfish *Austropotamopobius pallipes* (EU Habitats & Species Directive Annex 2 Species) were received from NRW for the Afon Llugwy, however, due to the paucity of data returned overall, a survey would be required to confirm the presence or absence of this species.

Whilst no records of freshwater pearl mussel (*Margaritifera margaritifera*) were included in data received from NRW for the impacted reaches, the previous EMP for the site¹¹ notes records for them from the Afon Llugwy. This species is protected under Schedule 5 of the Wildlife and Countryside Act (1981) and listed under Annexes II and V of the EU Habitats and Species Directive and Annex III of the Bern Convention.

Surveys to identify suitable survey locations and freshwater pearl mussel (FWMP) surveys were completed in September 2017¹². The survey locations are presented in **Table D3.6**. Approximately 50 metre lengths at the identified survey sites were methodically searched for individual FWPM.

Surveys completed in all reaches in 2017 did not identify any presence of freshwater pearl mussels, however it was concluded that the Afon Llugwy does have appropriate habitat with the potential to support them.

¹¹ Cascade (2007). DCWW. Provision of an Environmental Monitoring Plan. Environmental Monitoring Plan for Ffynnon Llugwy Reservoir (N6). Final. 30th May 2007. Produced by Cascade for Welsh Water.

¹² Apem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Ffynnon Llugwy Reservoir, July 2018

Table D3.4 Freshwater pearl mussel survey locations, 2017

Reach	Locations
1	SH 69277 62262, SH 68975 61699, SH 68228 60821
2	SH 68513 60234, SH 70868 59373, SH 71853 58031
3	SH 72642 57780, SH 74444 57300, SH 75626 57496

Surveys completed in all reaches in 2017 did not identify any presence of freshwater pearl mussels, however it was concluded that the Afon Llugwy does have appropriate habitat with the potential to support them.

D.3.3.2 Assessment

The assessment of impacts on the macroinvertebrate community should be considered in the context of the watercourse under baseline conditions. Baseline data available for the three reaches indicates that the, assemblages of macroinvertebrates at the sampling locations were typical of relatively fast-flowing, unpolluted, gravel-bottomed streams. The 2016 and 2017 survey results indicated that the community was dominated by sensitive taxa, including mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera). Adult riffle-beetles (Elmidae) were also recorded in 2016. The BMWP, ASPT and LIFE scores are indicative of a macroinvertebrate community which is indicative of very good water quality and fast flowing water, and are consequently sensitive to reductions in both water quality and flow.

As the drought permit is anticipated to result in a reduction in wetted width in Reaches 1 to 3, marginal habitat loss (utilised by some macroinvertebrate taxa) is likely to occur. Reductions in velocity may increase stress amongst flow sensitive taxa, resulting in their loss from the reach. As the LIFE scores for the sites in Reaches 1 to 3 indicate taxa with a preference for fast flows, it is likely that in the short-term this impact will modify the macroinvertebrate community, with a loss of species which prefer fast flows and the potential proliferation of invertebrates which favour slower flows.

Any reduction in water quality which may occur as a result of the hydrological impacts associated with the drought permit are also likely to impact upon the abundance of the sensitive macroinvertebrate community.

The reduced flows could also result in a short-term change to composition of the substrate, with the potential disposition for finer substrates to occur. The drought permit could be implemented for up to six months, which in the short-term could result in the smothering of individuals¹³ and changes to habitat suitability for taxa that require clean gravel based substrates, resulting in a reduction in species diversity.

Assessment of the likely impact of the drought permit on the macroinvertebrate fauna of the

¹³ Ryan, P. A. (1991) Environmental effects of sediment on New Zealand streams: A review. *New Zealand Journal of Marine and Freshwater Research* 25 pp 207 - 221.

Afon Llugwy has been made considering the hydrological and water quality impacts described in **Appendix B** and summarised in Section 3.1.2. Overall, considering the temporary and reversible hydrological impacts of the drought permit and the effective recolonisation strategies of macroinvertebrate species, impacts on the macroinvertebrate community in Reach 1 and 2 are assessed as **moderate** adverse, short term, temporary and reversible for July to December, and **minor adverse**, short term, temporary and reversible for Reach 3 for July to September only.

Environmentally Sensitive Species

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

Freshwater pearl mussels have previously been recorded in the Afon Llugwy. However, the 2017 surveys suggest that, while Afon Llugwy does have the potential to support the species, no individuals were recorded during the 2017 survey and it is likely that the species is extinct in this area. At best, there may be the occasional individual mussel overlooked during the survey. As no freshwater pearl mussel individuals were recorded within the hydrological zone of influence, the impact of the drought permit on freshwater pearl mussel is considered **negligible**.

No records of white-clawed crayfish have been returned for the Afon Llugwy, therefore white-clawed crayfish are not considered a potential receptor for the drought permit. However, due to the general paucity of data returned for this site, further surveys are required to support this conclusion.

Summary

The potential impacts of the Ffynnon Llugwy drought permit on the macroinvertebrate community are summarised in **Table D3.4**. The impacts, and their magnitude, have been based on the hydrological impacts (see Section 4.2 of the main report), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Section 4.3 of the main report) and the likely sensitivities of the macroinvertebrate community. However, baseline data on macroinvertebrate communities would be required to make an informed assessment of impacts. The impacts presented in **Table D3.4** represent the worst case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D3.4 Summary of Impacts on Macroinvertebrate Communities

Reach 1 – (Afon Llugwy - Outflow of Ffynnon Llugwy to Llyn Cowlyd take off leat)		
Macroinvertebrate community	<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 • Reduction in species diversity and abundance as a result of reduced recruitment. 	Moderate (July to December)
Freshwater pearl mussel	<ul style="list-style-type: none"> • Reduction in habitat area and suitability • Potential for mortality due to reduced flows and wetted width. 	Negligible
Reach 2 (Afon Llugwy - Llyn Cowlyd take off leat to Capel Curig)		
Macroinvertebrate community	<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 • Reduction in species diversity and abundance as a result of reduced recruitment. 	Moderate (July to December)
Freshwater pearl mussel	<ul style="list-style-type: none"> • Reduction in habitat area and suitability • Potential for mortality due to reduced flows and wetted width. 	Negligible
Reach 3 – (Afon Llugwy - Capel Curig to the confluence with the Afon Conwy)		
Macroinvertebrate community	<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 	Minor (July to September only)
Freshwater pearl mussel	<ul style="list-style-type: none"> • Reduction in habitat area and suitability 	Negligible

There is a risk of short-term deterioration in the status of the macroinvertebrate component of the ‘Llugwy - Nant gwryd to Ffynnon Llugwy’ (GB110066054870) and ‘Llugwy - Conwy to Nant gwryd’ (GB110066054850) waterbodies due to the drought permit. Impacts of drought permit implementation on the macroinvertebrate communities of the impacted reaches have been summarised as minor to moderate adverse, short-term, temporary and reversible. Consequently, the macroinvertebrate component of the ‘Llugwy - Nant gwryd to Ffynnon Llugwy’ (GB110066054870) waterbody is considered to be at **moderate** risk of short-term deterioration, and that of the ‘Llugwy - Conwy to Nant gwryd’ (GB110066054850) at **minor** risk of short-term deterioration.

D.3.4 Fish

D.3.4.1 Baseline

Existing Data

Information on fish populations specific to the hydrological zone of influence on the Afon Llugwy between Ffynnon Llugwy and the Afon Conwy at Betws y Coed consists of eleven fully quantitative electric fishing surveys; one in Reach 1, five in Reach 2, four in Reach 3 and one downstream on the Conwy. Previous data used to inform the baseline assessment includes three recent semi-quantitative electric fishing surveys in Reach 2 undertaken in 2010 and 2011 and historical datasets from two sites located in Reach 3 upstream of Betws y Coed.

In response to recommendations for a more detailed fisheries monitoring programme to be

undertaken to inform the assessment, eleven surveys were undertaken by APEM on behalf of Welsh Water in 2016¹⁴. Data from five sites¹⁵ were provided by NRW as part of a data request for this assessment. Three semi-quantitative juvenile salmonid monitoring locations (Sites 87, 118 and 290) were sampled by NRW in 2010, 2011 and 2017 are located with good coverage of Reach 2. Data from 2017 and 2018 has been provided by NRW for fry specific surveys (Site 303¹⁶) of the lower Llugwy in Reach 3. The remaining data for Reach 3 is provided by two other sites (Sites 27 and 89), however, there is no data more recent than 2004 for these sites. A longer-term dataset was provided for Site 27 but this documents historical monitoring (more than ten years old). No data is available for Reach 1.

‘Principal’ Atlantic salmon rivers (numbering 64 in England and Wales) are assessed annually with the most recent report published in 2017¹⁷. The River Conwy, of which the Afon Llugwy is a tributary, is classified as a principal salmon river. The status of individual river stocks in England and Wales is evaluated annually against their stock conservation limits (CLs) and management targets (MTs). In England and Wales, CLs have been developed that indicate the minimum spawning stock levels below which stocks should not be allowed to fall. The CL for each river is set at a stock size (defined in terms of eggs deposited) below which further reductions in spawner numbers are likely to result in significant reductions in the number of juvenile fish produced in the next generation. In reviewing management options and regulations, NRW also use an over-arching management objective that a river’s stock should be meeting or exceeding its CL in at least four years out of five (i.e. >80% of the time) on average. A management target (MT) is set for each river, representing a spawning stock level for managers to aim at in order to meet this objective.

The Conwy is classified as currently ‘Probably at risk’ (5 - 50% probability of meeting the management objective) with a predicted classification of ‘Probably at risk’ in 2022. Following a steep decline since 2010, the estimated egg deposition has continued to increase since 2014, with the 2017 estimate attaining its highest level since 2010. Whilst egg deposition has increased in recent years, salmon stocks in the Conwy will continue to decline (uncertain)¹⁸. Maintaining migratory corridors and spawning and nursery areas for salmon is recognised as particularly important in this instance.

The ‘Llugwy - Nantgwryd to Ffynnon Llugwy’ (GB110066054870) and ‘Llugwy - Conwy to Nantgwryd’ (GB110066054850) waterbodies are both designated as heavily modified and were assessed as being at moderate status for fish in 2009, and good status in 2015. The 2018 cycle 2 interim classification status for fish in GB110066054870 was assessed as good¹⁹. No interim

¹⁴ A pem (2018) Dwr Cymru Welsh Water Drought Plan Monitoring 2016 to 2018: Ffynnon Llugwy Reservoir, July 2018

¹⁵ Reach 2: Site 87 located at SH 6854 6023, sampled 2004, 2010, 2011 & 2017 (semi-quantitative); Site 118 located at SH 70182 5 9720, sampled 2010 (semi-quantitative); Site 290 located at SH 71741 58065 sampled 2010, 2011, and 2017 (semi-quantitative). Reach 3: Site 89 located at SH 75427 57469, sampled 2004 (semi-quantitative); Site 27 located at SH 7870 5670 sampled 1985, 1986, 1988-1991 (timed and semi-quantitative).

¹⁶ Reach 3: Site 303 located at SH 79291 56606 (five minute timed fry surveys)

¹⁷ Cefas. 2017. Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2017. Preliminary assessment prepared for ICES, April 2018

¹⁸ Natural Resources Wales – Know Your River – Conwy. Salmon & Sea Trout Catchment Summary: 2017

¹⁹ Based on Natural Resources Wales 2018 Cycle 2 Interim Classification Data - https://drive.google.com/file/d/14w17jL05sNuToVELqMCK_yc6DdHU7STb/view

2018 status was available for GB110066054850.

Data Limitations

In order to obtain a suitable baseline, a suite of electric fishing surveys were undertaken on behalf of Welsh Water in 2016, resulting in an increase to the spatial and temporal data set. Data limitations have therefore been reduced.

Species Composition

A single fish survey was undertaken on the Llugwy in Reach 1 (site name EF1 Q1), recording brown trout *Salmo trutta* only. The population included both young of the year (0+ age class) and larger juvenile size fish, indicating the species has spawned successfully in recent years in this reach of the river. Juvenile lamprey habitat was absent, which indicates lamprey are unlikely to be present in Reach 1.

The most recent data for Reach 2 was collected by NRW in 2017, with the surveys at Site 87 and 290 recording brown trout and minnow *Phoxinus phoxinus* only. Five APEM fish surveys were undertaken in Reach 2 in 2016 (site names EF2 Q1, EF2 SQ1, SQ2, SQ3 & SQ4), also recording brown trout and minnow. As was observed in Reach 1 upstream, brown trout populations show signs of successful natural recruitment in recent years. The upstream limit of minnow in the Llugwy appears to be located shortly upstream of Capel Curig (site name EF2 SQ2). Juvenile lamprey habitat was present at two sites in Reach 2, however no (lamprey) were recorded. NRW survey data for Reach 2 indicates salmon are present in Reach 2 during two out of three sample years but have not been recorded since 2011. Combined with the 2016 data, surveys indicate salmon abundance varies temporally in Reach 2.

The most recent data for Reach 3 was collected by NRW in 2017 and 2018, with the fry specific surveys at Betws y Coed recording juvenile (life stage not specified) salmon and brown trout, along with larger individuals of both species and eel *Anguilla anguilla*. Four APEM fish surveys were undertaken in Reach 3 in 2016 (site names EF3 Q1, EF3 SQ1, SQ2 & SQ3), recording salmon, brown trout, eel, stone loach *Barbatula barbatula* and minnow. Salmon (fry and parr life stages), eel (elver (juvenile) life stage) and stickleback were recorded at the most downstream site only, located at the lowermost point in Reach 3 (site name EF3 SQ3). Historic NRW surveys also recorded salmon in Reach 3, with densities varying between years, indicating varied temporal abundance in Reach 3. Juvenile lamprey habitat was sub-optimal throughout Reach 3, with the exception of the most downstream site where lamprey habitat was absent. No lamprey were recorded in Reach 3.

A single survey was undertaken on the Conwy (site name EF4 Q1) shortly upstream of the confluence with the Llugwy (not in the zone of hydrological impact), recording salmon (parr), eel (elver), minnow and a juvenile lamprey. This suggests lamprey are present in the Conwy, but not in Reaches 1-3 in recent years.

Bullhead *Cottus gobio* are not present in the Conwy catchment²⁰

²⁰ Email communication from T. Dunford, Principal Water Resources Planner, Natural Resources Wales dated 16/06/2016.

Atlantic Salmon

Considerable temporal variation in salmon fry and parr densities is observed in the data recorded in Reach 2 and 3. The available NRW data suggest that juvenile Atlantic salmon densities were generally at or above average at sites in Reach 2 between 2004 and 2011, and absent in 2017. The EMP stated that juvenile Atlantic salmon (fry and parr) densities were generally low at Site 27 located just upstream of Betws y Coed in Reach 3. Density estimates equated to Grades C to F and were mostly D²¹. Juvenile salmon densities are likely to be lower in this area of Reach 3 due to the high-gradient bedrock-dominated channel (sub-optimal habitat for juvenile salmonids). NRW surveys in 2017 and 2018, immediately downstream of Pont y Pair waterfall in the lower reaches of Reach 3, both recorded juvenile salmon, with densities highest in 2018. The greater spatial coverage of the APEM surveys in 2016 also recorded salmon immediately downstream of Pont y Pair waterfall only, indicating limited recruitment upstream of the waterfall since 2011. The density of salmon fry recorded in 2016 equates to Grade D, whilst the NRW Conwy catchment salmonid report²² recorded Grade C in Reach 3 of the Llugwy in 2017. No salmon grades were provided for the 2017 and 2018 NRW fry surveys at Site 303.

Based on the available data, Reach 2 and 3 of the hydrological zone of influence provide an important migratory corridor as well as spawning and juvenile nursery habitat, contributing towards the wider health of the Conwy catchment salmon population.

Brown / Sea Trout

The available data record brown/sea trout throughout Reaches 1 – 3. Densities were highest in Reach 1. Fry and parr densities showed considerable spatial variation, with the greatest densities recorded in the upper and lower reaches of Reach 2. The most recent (2017) NRW survey data for Reach 2 recorded ‘Fair’ (Grade C) densities of juvenile trout in the middle reaches and ‘Good’ (Grade B) densities in the lower reaches, indicating recruitment has been successful in recent years, particularly in the lower reaches of Reach 2. Fry and parr densities were comparable to the historic NRW densities; the historic data (Site 87 in 2004) for the middle reach of Reach 2 recorded a similar density of juvenile trout (an absence of 0+ fish (fry) and ‘Fair’ density of >0+ parr). The most recent survey data from Reach 3 indicates trout recruitment was low in both 2017 and 2018, with very few juvenile fish recorded. The EMP stated that juvenile brown/sea trout (0+ and >0+) densities were generally low at Site 27 located just upstream of Betws y Coed in Reach 3. Density estimates equated to Grades D to E and were mostly E.

As well as being classified as a Principal Salmon River, the Conwy is also a Principal Sea Trout River. The NRW 2017 assessment²³ classifies sea trout as ‘Probably not at Risk’, with the

²¹ For salmonids, a grading system is used based on the original Fisheries Classification System called the National Fisheries Classification (NFC). The electric fishing data are analysed to produce a juvenile salmon and trout density score for each site, using average values from the early 1990s as a baseline. The proportion of sites falling into different salmon abundance Classes (A to F) provides a measure of the health of the juvenile salmon populations for each river. Sites are typically grouped into those that are at or above average (Classes A to C), below average (Class D) and well below average or fishless (Classes E or F).

²² Natural Resources Wales – Know Your River – Conwy. Salmon & Sea Trout Catchment Summary: 2017

²³ Natural Resources Wales – Know Your River – Conwy. Salmon & Sea Trout Catchment Summary: 2017

predicted status in 2022 also classified as 'Probably not at Risk'. Based on current data, NRW assessed sea trout stocks in the Conwy as improving (uncertain) in the future.

It is assumed that Reaches 1 - 3 provide a migratory corridor for sea trout as well as spawning and nursery habitat for both brown and sea trout and adult habitat for non-migratory brown trout.

Lamprey sp.

The 2016 APEM surveys did not record any lamprey within the hydrological zone of influence. A single juvenile was recorded upstream in the main river Conwy, indicating these species may be unable to access the Llugwy. The surveys recorded optimal juvenile lamprey habitat in Reach 2 only, with sub-optimal habitat present throughout much of Reach 3. The Pont y Pair waterfall (located at the downstream end of Reach 3) on the lower Llugwy may also act as an impassable barrier to the migratory lamprey species (*Lampetra fluviatilis* and *Petromyzon marinus*), resulting in an absence of the species upstream in the hydrological zone of influence. Reach 1 and 2 are therefore considered not to contain a significant population of Lamprey sp., whilst only the lowermost reach of Reach 3 may potentially provide limited habitat (e.g. spawning).

European eel

Records of eel are limited to the more recent NRW (2017 & 2018) and APEM (2016) surveys, with the species recorded at the lowermost reach of Reach 3 only. This survey site was located immediately downstream of the Pont y Pair waterfall, which suggests eel are unlikely to be able to easily pass beyond this natural barrier to migration in the Llugwy.

Other Species

Minnow were present throughout much of Reach 2 and 3 (absent from Reach 1). Stone loach were present in low numbers at the most downstream survey site in Reach 3 only, indicating the species are likely to be absent throughout much of the hydrological zone of impact.

Ecological value of fisheries receptors

Atlantic salmon, brook lamprey and river lamprey are Environment Act (Wales) Section 7 and Habitats Directive Annex II species and are considered to be of National importance. Brown/sea trout (Environment Act (Wales) Section 7) and European eel (Environment Act (Wales) Section 7 and IUCN Red List 'Critically Endangered' species) are also considered to be of National importance. Minnow and stone loach are considered to be of Site only importance.

D.3.4.2 Assessment

Hydrological variability in rivers can have a significant influence on the distribution of fish. When extreme low flows, or prolonged periods of low flow, are experienced, for example under continued water abstraction during drought conditions, the resultant changes in the hydrological regime can have significant impacts on resident fish communities. Abstraction of

water from a river or stream reduces the wetted area and volume with the potential for subsequent impacts on fish populations as a result of, for example, intra- and inter-specific interactions (e.g. increased competition for optimal habitat and food)^{24,25}, reduced water quality and reduced reproductive success, growth and condition²⁶.

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

The assessed drought permit assumes a temporary reduction in the compensation rate of 2Ml/d to 2.5Ml/d, to conserve storage in Ffynnon Llugwy Reservoir. As the reservoir is very unlikely to be spilling during drought conditions, the only flow to the Afon Llugwy would consist of the compensation flow. Under a drought permit in these conditions, the river flow in Reaches 1 and 2 is expected to be reduced by up to 44% during summer (July to September) and winter (October to December) low and extreme low flows. River flow in Reach 3 is expected to be reduced by up to 12% and 19% during summer (July to September) low and extreme low flows respectively, and up to 8.9% and 1.4% during winter low and extreme low flows respectively.

Brook and River Lamprey

Migration of River Lamprey

Mature river lamprey migrate upstream into freshwater in the autumn (from October to December²⁷). 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. Lamprey species are only likely to be present in the Afon Llugwy in Reach 3 below Betws y Coed and the hydrological assessment for this reach concludes a moderate adverse effect on flow between July and September and negligible impact between October and December. The impact on river lamprey migration is therefore likely to have the highest impact on the downstream migratory life stage, whilst the negligible flow impact in the later months unlikely to pose a high risk to the upstream migratory life stage. The impact on river lamprey migration is therefore assessed as **minor adverse**, short term, temporary and reversible in Reach 3.

²⁴ 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

²⁵ 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.

²⁶ 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.

²⁷ Maitland PS (2003). Ecology of the River, Brook and Sea Lamprey. *Conserving Natura2000 Rivers Ecology Series No.5*. English Nature, Peterborough

Spawning and Juvenile (ammocoete and transformer) Brook and River Lamprey Habitat

There is the potential for reduced flow to result in a decrease in river levels and wetted width. This has particular significance for juvenile (ammocoetes and transformer) lamprey habitat which tends to consist of silt in shallow, marginal areas. There is therefore the potential for a loss or degradation of this habitat along with gravel spawning habitat. Provided minimum low flows are available, juvenile lamprey may relocate to areas of suitable habitat if river levels decrease, however, competition and stress would likely increase. Whilst juvenile lamprey habitat was assessed as absent (2016 surveys) in the lower reaches of Reach 3, spawning habitats may be present, therefore, based on the precautionary approach, the impact on lamprey spawning habitat is therefore considered to be **minor adverse**, short term, temporary and reversible in Reach 3.

Water Quality

Water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) have been assessed as moderate in Reaches 1 and 2 and minor in Reach 3. Due to an absence of lamprey recorded in Reach 1 and 2, and small numbers recorded shortly downstream of Reach 3 in the Conwy, the impact on brook and river lamprey is considered to **minor adverse**, short term, temporary and reversible in Reach 3.

Atlantic Salmon

Atlantic Salmon Migration

The Afon Llugwy is an important migratory pathway for Atlantic salmon (both upstream-migrating adults and out-migrating smolt). The majority of Atlantic salmon migration into the Afon Llugwy is likely to occur from October to December (although anecdotal evidence suggests small numbers of spring running fish) and therefore a drought permit in the summer to winter period (July to December) is likely to affect this life stage of Atlantic salmon migration. Available data indicates salmon are absent from Reach 1, with the impact on the species therefore assessed as **negligible**. The impact on adult migration is considered to be of high magnitude, short-term, temporary and reversible for Reach 2, and medium magnitude, short-term, temporary and reversible for Reach 3 during July to September only. Negligible flow impacts associated with the drought permit during October to December are unlikely to impact upstream Atlantic salmon migration. The impact on adult Atlantic salmon adult migration is therefore considered to **major adverse**, short term, temporary and reversible in Reach 2, and **moderate adverse**, short term, temporary and reversible in Reach 3 for April to September only.

The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature and therefore there is no potential for a drought permit to interact with part of this migration.

Water Quality

Water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) have been assessed as moderate in Reaches 1 and 2 and minor in Reach 3, and the impact on Atlantic salmon is therefore also considered to be **negligible** in Reach 1, **major adverse** in Reach 2 and **minor adverse** in Reach 3.

Juvenile Atlantic Salmon

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Provided minimum low flows are available, juvenile Atlantic salmon are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. Due to the likely timing of a drought permit, gravels containing alevins and/or early-stage fry (likely to occur in April and May) will not be affected. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible for Reach 2, and medium magnitude, short-term, temporary and reversible for Reach 3 (July to September only). The impact on juvenile Atlantic salmon is therefore considered to be **negligible** in Reach 1, **major adverse**, short term, temporary and reversible in Reach 2 and **moderate adverse**, short term, temporary and reversible in Reach 3.

Brown / Sea Trout

Sea Trout Migration

The Afon Llugwy is thought to be an important migratory pathway for sea trout (both upstream-migrating adults and out-migrating smolt). The majority of upstream adult sea trout migration into the Afon Llugwy is likely to occur from September to November and therefore a drought permit between July and December is likely to significantly affect this stage of the life-cycle. Whilst drought permit impacts are reduced in Reach 3, the lower reaches of the Llugwy provide the 'gateway' to the middle and upper reaches of Reach 1 and 2. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible for Reaches 1 to 3. The impact on adult sea trout migration is therefore considered to be **major adverse**, short term, temporary and reversible in Reaches 1 – 3.

The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature and therefore there is no potential for a drought permit to interact with part of this migration.

Water Quality

Water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) have been assessed as moderate in Reaches 1 and 2 and minor in Reach 3, and the impact on brown/sea trout is therefore also considered to be **moderate adverse** in Reaches 1 and 2 and **minor adverse** in Reach 3.

Juvenile Brown / Sea Trout

There is the potential for reduced flow to result in a decrease in river levels and wetted width. There is therefore the potential for a loss or degradation of juvenile habitat along with gravel spawning habitat. Provided minimum low flows are available, juvenile brown/sea trout are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would increase. Due to the likely timing of a drought permit, gravels containing alevins and/or early-stage fry (likely to occur in April and May) will not be affected. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible for Reaches 1 and 2, and medium magnitude, short-term, temporary and reversible for Reach 3 (July to September only). The impact on juvenile brown/sea trout is therefore considered to be **major adverse**, short term, temporary and reversible in Reaches 1 and 2, and **moderate adverse**, short term, temporary and reversible in Reach 3 (July to September only).

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. In addition, records of elver are limited to the lowermost reaches of Reach 3 only and may be limited beyond this point by the barriers to migration present in Reach 3 (water falls). The impact on upstream eel migration is considered **negligible** for Reaches 1 – 3. The downstream migration of mature (silver) eel tends to occur between September and December in most rivers which coincides with the latter stages of the likely implementation period of the drought permit. Whilst adult life stages of eel were absent from the 2016 survey catch, the presence of juvenile eel in Reach 3 highlights the potential for adults to be present in Reach 3 only. Whilst flow impacts associated with the drought permit between October and December are negligible, any flow reduction during the downstream eel migration period may affect escapement. Therefore, the impact of reduced flow on downstream eel migration in Reach 3 is considered to be of medium/low magnitude, short-term, temporary and reversible. The impacts on the adult migration of eel are therefore considered to be **negligible** in Reaches 1 and 2, and **minor adverse**, short term, temporary and reversible in Reach 3.

Other Fish Species

Spawning and egg incubation of minor species such as minnow and stone loach occurs within the likely July to December period for drought permit implementation. These species are therefore susceptible to impacts associated with low flows. Minnow were present in Reach 2 and 3 only, whilst stone loach were present in Reach 3 only. The impact on minnow is therefore considered to be of high magnitude, short-term, temporary and reversible for Reach 2, and low magnitude, short term, temporary and reversible in Reach 3. The impact on other fish species is therefore considered to be **negligible** for Reach 1, **moderate adverse** in Reach 2 and **minor adverse** in Reach 3 (July to September only).

Summary

The potential impacts of the Ffynnon Llugwy drought permit on the fish community are summarised in **Table D3.1**. 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 fish community. The impacts presented in **Table D3.1** represent the worst case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D3.1 Summary of Impacts on Fish Community in the Hydrological Reaches 1-3

Feature	Impact	Significance of Impact
Reach 1 – (Afon Llugwy - Outflow of Ffynnon Llugwy to Llyn Cowlyd take off leat)		
Brown/sea trout	• Delays and potential cessation of adult upstream sea trout migration due to reduced flows.	Major
	• Delays and potential cessation of smolt migration due to reduced flows.	Major
	• Reduced water quality	Moderate
	• Reduction in spawning and juvenile survival due to habitat loss.	Major
European eel	• Delays and obstruction to upstream juvenile migration	Negligible
	• Increased risk of stress and predation during downstream migration of adult life stage (silver eel)	Negligible
Other fish species	• Minor species are present in Reaches 2 and 3 only. Spawning and egg incubation of the minor species recorded occurs within the likely July to December period for drought permit implementation. These species are therefore susceptible to impacts associated with low flows.	Negligible
Reach 2 (Afon Llugwy - Llyn Cowlyd take off leat to Capel Curig)		
Atlantic salmon	• Delays and potential cessation of adult upstream migration due to reduced flows.	Major
	• Delays and potential cessation of smolt migration due to reduced flows.	Moderate
	• Reduced water quality.	Major
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	Major
Brown/sea trout	• Delays and potential cessation of adult upstream sea trout migration due to reduced flows.	Major
	• Delays and potential cessation of smolt migration due to reduced flows.	Major
	• Reduced water quality	Moderate
	• Reduction in spawning and juvenile survival due to habitat loss.	Major
European eel	• Delays and obstruction to upstream juvenile migration	Negligible
	• Increased risk of stress and predation during downstream migration of adult life stage (silver eel)	Negligible
Other fish species	• Minor species are present in Reaches 2 and 3 only. Spawning and egg incubation of the minor species recorded occurs within the likely July to December period for drought permit implementation. These species are therefore susceptible to impacts associated with low flows.	Moderate
Reach 3 – (Afon Llugwy - Capel Curig to the confluence with the Afon Conwy)		
Brook and river lamprey	• Delays and potential cessation of adult river lamprey migration due to reduced flows.	Minor
	• Reduction in river flow resulting in increased siltation and suffocation of spawning gravels and eggs.	
	• Reduction in spawning and juvenile survival due to habitat loss.	
Atlantic salmon	• Delays and potential cessation of adult upstream migration due to reduced flows.	Moderate
	• Delays and potential cessation of smolt migration due to reduced flows.	Moderate
	• Reduced water quality.	Minor

	<ul style="list-style-type: none"> Loss of spawning and juvenile habitat as a result of reduced river levels. 	Moderate
Brown/sea trout	<ul style="list-style-type: none"> Delays and potential cessation of adult upstream 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. 	Moderate
	<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. 	Moderate
European eel	<ul style="list-style-type: none"> Delays and obstruction to upstream juvenile migration 	Negligible
	<ul style="list-style-type: none"> Increased risk of stress and predation during downstream migration of adult life stage (silver eel) 	Minor
Other fish species	<ul style="list-style-type: none"> Minor species are present in Reaches 2 and 3 only. Spawning and egg incubation of the minor species recorded occurs within the likely July to December period for drought permit implementation. These species are therefore susceptible to impacts associated with low flows. 	Minor

There is a risk of short-term deterioration in status of the fish component of the ‘Llugwy - Nant gwryd to Ffynnon Llugwy’ (GB110066054870) and ‘Llugwy - Conwy to Nant gwryd’ (GB110066054850) waterbodies due to the drought permit. Impacts of drought permit implementation on the fish communities of the impacted reaches have been summarised as minor to moderate adverse, short-term, temporary and reversible in the ‘Llugwy - Conwy to Nant gwryd’ (GB110066054850) waterbody, and negligible to major adverse, short term, temporary and reversible in the ‘Llugwy - Nant gwryd to Ffynnon Llugwy’ (GB110066054870) waterbody. Consequently, the fish component of the ‘Llugwy - Conwy to Nant gwryd’ is considered to be at **major risk** of short term deterioration, and the ‘Llugwy - Conwy to Nant gwryd’ (GB110066054850) at risk of **minor risk** of short term of deterioration.

D.3.5 Phytobenthos

D.3.5.1 Baseline

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

D.3.5.2 Assessment

Impacts on the phytobenthos assemblages of the Afon Llugwy could occur due to the operation of the drought permit, including changes in community composition due to: decreases in velocity; changes to grazing pressure; increases in nutrient level; increases in water temperature; and increases in filamentous algae smothering the substrate.

Due to the short lifecycle of algal species, phytobenthos communities can respond to rapidly to environmental change. Therefore, the major hydrological effects of operation of the drought permit in Reaches 1 and 2 are likely to result in significant changes to the phytobenthos communities present within the timeframe of the drought permit.

WFD EQR metrics for phytobenthos (TDI4 in DARLEQ)²⁸ are designed to detect differences

²⁸ WFD-UKTAG (2014) Phytobenthos: Phytobenthos for Assessing River and Lake Ecological Quality (River DARLEQ2)

in nutrient levels rather than other environmental factors and should not, in theory, be affected unless nutrient levels increase due to the operation of the drought permit. However, it is recognised that other environmental factors can influence TDI4 scores (WFD-UKTAG, 2014) and potential changes to the micro-habitats supporting benthic phytobenthos growth are of such magnitude that there is potential for changes to the phytobenthos community to result in changes to EQR scores, resulting in a potential decrease in WFD ecological status in respect to phytobenthos.

Due to the rapid response of phytobenthos communities to environmental variables, this effect is expected to be short lived, with communities recovering rapidly following return to the normal hydrological regime, and therefore any effect of the drought permit on WFD phytobenthos assessment is likely to be **minor adverse**, short term, temporary and reversible for Reaches 1 and 2 and **negligible** for Reach 3.

However, monitoring of phytobenthos communities within the affected reach would be required to fully assess the effects of the proposed drought permit.

Summary

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

Table D3.4 Summary of Impacts on Phytobenthos Community

Feature	Impact	Significance of Impact
Reach 1 – (Afon Llugwy - Outflow of Ffynnon Llugwy to Llyn Cowlyd take off leat)		
Phytobenthos	<ul style="list-style-type: none"> Decrease in flow affecting phytobenthos community composition through changes to grazing pressure, increases in water temperature, and increases in filamentous algae smothering the substrate Increase in SRP affecting phytobenthos community composition and TDI score Communities are expected to recover rapidly following return to the normal hydrological regime 	Minor
Reach 2 (Afon Llugwy - Llyn Cowlyd take off leat to Capel Curig)		
Phytobenthos	<ul style="list-style-type: none"> Decrease in flow affecting phytobenthos community composition through changes to grazing pressure, increases in water temperature, and increases in filamentous algae smothering the substrate Increase in SRP affecting phytobenthos community composition and TDI score Communities are expected to recover rapidly following return to the normal hydrological regime 	Minor
Reach 3 – (Afon Llugwy - Capel Curig to the confluence with the Afon Conwy)		
Phytobenthos	<ul style="list-style-type: none"> Decrease in flow affecting phytobenthos community composition through changes to grazing pressure, increases in 	Negligible

	<p>water temperature, and increases in filamentous algae smothering the substrate</p> <ul style="list-style-type: none"> • Increase in SRP affecting phytoplankton community composition and TDI score • Communities are expected to recover rapidly following return to the normal hydrological regime 	
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There is a risk of short-term deterioration in status of the phytoplankton component of the ‘Llugwy - Nant gwryd to Ffynnon Llugwy’ (GB110066054870) waterbody due to the drought permit. Impacts of drought permit implementation on the phytoplankton communities of the impacted reaches have been summarised as minor adverse, short-term, temporary and reversible. Consequently, the phytoplankton component of the ‘Llugwy - Nant gwryd to Ffynnon Llugwy’ (GB110066054870) waterbody is considered to be at **minor** risk of short-term deterioration. The risk of short term deterioration in status of the ‘Llugwy - Conwy to Nant gwryd’ (GB110066054850) waterbody is deemed **negligible**.

D4 LANDSCAPE AND RECREATION

D.4.1 Landscape

D.4.1.1 Baseline

Ffynnon Llugwy and the Afon Llugwy are located within Snowdonia National Park. The overall landscape and visual amenity of this area is varied and appealing and as a result, tourism is economically very important. There are no public rights of way with views of the Afon Llugwy within the study area, however, the right to roam (The Countryside and Rights of Way Act 2000) applies to the land in the study area. Land use around the study zone is part of a wider area of acid sensitive geology and soils which is extensively grazed by sheep.

D.4.1.2 Assessment

A review of the hydrological implications of implementing a drought permit has identified major hydrological impacts in Reaches 1 and 2. The impacts include a significant reduction in surface water baseflow, wetted width and wetted depth below those observed in surface watercourses within the area of influence without the drought permit. Therefore landscape and visual amenity impacts may be visible from public rights of way, footpaths, cycle routes and river crossings. However the impact on flows will only be temporary and will be ameliorated once the drought has passed. Flows during drought conditions will naturally be low therefore the implementation of the drought permit is not expected to lead to any material additional landscape and visual amenity impacts and are assessed as **negligible**.

D.4.2 Recreation

D.4.2.1 Baseline

Ffynnon Llugwy and the Afon Llugwy are located within Snowdonia National Park which presents year-round attractions for walking, climbing and several other recreational pursuits.

Ffynnon Llugwy is noted as a game fishery and the Afon Llugwy holds wild trout populations. Intense recreational pressures in the area, particularly on paths and summit areas, have caused severe erosion problems despite management efforts to alleviate this. Canoeing is practised downstream of the study area near Capel Curig.

D.4.2.2 Assessment

Major hydrological impacts have been identified in Reaches 1 and 2 on the Afon Llugwy. Any reduction in wetted width and depth may influence water-dependent activities such as angling and canoeing. However, water levels will already be naturally low in times of drought and will already have curtailed these recreational activities prior to the drought permit implementation. Any impacts will be temporary in nature and will be ameliorated once the drought has passed. Impacts are therefore assessed as **negligible** for Reaches 1 and 2. The drought permit has been assessed as having minor hydrological impacts for Reach 3, and no

impacts on recreational activities are anticipated.

Summary

The potential impacts of the Ffynnon Llugwy drought permit on landscape and recreation are summarised in **Table D4.1**. The impacts presented in **Table D4.1** represent the worst case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D4.1 Summary of Impacts on Landscape and Recreation

Feature	Impact	Significance of Impact
Landscape	<ul style="list-style-type: none"> • Landscape and visual amenity impacts may be visible from public rights of way, footpaths, cycle routes and river crossings. However, the impact on flows will only be temporary and will be ameliorated once the drought has passed. • Flows during drought conditions will naturally be low therefore the implementation of the drought permit is not expected to lead to any material additional landscape and visual amenity impacts 	Negligible
Recreation	<ul style="list-style-type: none"> • Water levels will already be naturally low in times of drought and will already have curtailed recreational activities prior to the drought permit implementation, any further impacts will be temporary in nature and will be ameliorated once the drought has passed. 	Negligible