Dŵr Cymru Welsh Water

Environmental Assessment of Alaw Reservoir Drought Permit (8001-3)

Final

March 2019

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*As part of a share purchase agreement in August 2015, Cascade Consulting (Environment & Planning) Ltd transferred its business to Ricardo plc. All employees transferred to Ricardo Energy & Environment, a trading name of Ricardo-AEA Ltd which is a wholly owned subsidiary of Ricardo plc. The work described in this report spanned the pre-acquisition and post-acquisition period and throughout this time the consultants involved maintained a continuity of service both as employees of Cascade Consulting and then subsequently as employees of Ricardo Energy & Environment.

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

Alaw Reservoir is located in Welsh Water's North Eryri Ynys Môn Water Resource Zone (WRZ) which includes the mainland adjacent to the Menai Straits (North Eryri) and Ynys Môn (Anglesey). Water is supplied from five impounding reservoirs; on the mainland Ffynnon Llugwy, Llyn Cwellyn and Llyn Marchlyn Bach and on Ynys Mon, Llyn Alaw and Llyn Cefni. The resources are operated conjunctively with the ability to feed water from the mainland to parts of the island from the gravity resources of Llyn Cwellyn, Ffynnon Llugwy and Llyn Marchlyn Bach when storage allows. As storage declines, the area of Ynys Môn supported from the mainland is reduced and the area supported by Llyn Alaw and Llyn Cefni increases.

Afon Alaw is a component of the Beddmanarch Cymyran / Llyn Alaw SSSI therefore consideration has been given to the potential impacts of drought permit implementation on the features and species of these designated sites.

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 Resource Wales (NRW) for a drought permit at Alaw, which may be required by Welsh Water in the future.

PROPOSED DROUGHT PERMIT DETAILS

In order to protect public water supplies within Welsh Water's North Eryri Ynys Môn

Water WRZ in the event of a future severe drought, Welsh Water would make an application to Natural Resource Wales for a drought permit to vary the conditions of abstraction from Alaw Reservoir.

If granted, the drought permit involves a proposed reduction in the statutory compensation release from Alaw Reservoir to the Afon Alaw of 1.5Ml/d, from 3.2Ml/d to 1.7Ml/d. This flow reduction 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 is most likely to occur during the summer to winter period, and is considered not to extend outside the period July to December. This has been confirmed by Welsh Water's water resources modelling.

The revised abstraction arrangements would legally 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 the Welsh Ministers / NRW.

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 Alaw. 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

The assessment has concluded that there is a major impact on flows in the Afon Alaw as a result of implementing the drought permit. These hydrological impacts are assessed as leading to moderate impacts on the physical environment of the river, including minor beneficial impact on water quality.

Summary of the Environmental Features Screening

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

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

The assessment has concluded that there are minor to major impacts on fish, moderate impacts on macroinvertebrates, macrophytes, on phytobenthos. Impacts on the Llyn Alaw SSSI and the Beddmanarch Cymyran SSSI are assessed as negligible.

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 Alaw Reservoir.

MITIGATION AND MONITORING

The environmental assessment has identified significant impacts of implementation of a drought permit at Alaw. 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 Alaw during July to December inclusive, over and above those conditions that already exist under "normal", i.e. licensed, baseline conditions, with the onset of a natural drought, would be **major.**

Contents

1 INTRODUCTION

1.1 PURPOSE OF THE ENVIRONMENTAL ASSESSMENT

The objective of this Environmental Assessment Report (EAR) is to provide an independent and robust assessment of the potential environmental effects of the implementation of a drought permit by Dŵr Cymru Welsh Water (Welsh Water) to reduce the statutory compensation release from Alaw Reservoir to the Afon Alaw by 1.5Ml/d. Water stored at Alaw Reservoir is used to provide public water supplies to Welsh Water's North Eryri Ynys Mon (NEYM) Water Resource Zone (WRZ) (see Section 2.1).

This EAR is a 'shelf-copy' report which would be updated in the event that Welsh Water needs to make an application during any future drought to Natural Resources Wales (NRW) for a drought permit at Alaw Reservoir. 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 months of July to December inclusive, the period for which Welsh Water has determined it might require a drought permit for this water source. 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 Alaw drought permit, covers the following waterbodies:

- Afon Alaw – downstream Llyn Alaw (GB110102058981)

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**)
- recommendations for baseline, in-drought and post-drought permit monitoring requirements (**see Section 9 of this report**).

The environmental assessment has been conducted in accordance with Government regulations and using the Welsh Government / Natural Resources Wales Drought Plan

Guideline[1] (DPG); specifically Section 5 and Appendices I and J, and Welsh Government / Defra / NRW / Environment Agency guidance on drought permits and drought orders[2].

Consideration has been given to the potential impacts of drought 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 order application. The circumstances for which an environmental assessment is required are set out in **Box 1** below.

Box 1: Drought Plan Guidance - requirement for environmental assessment

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

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

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

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

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 Alaw Reservoir, consultation with regulators and wider stakeholders has been undertaken to gain feedback on potential adverse effects, gather data and discuss any required monitoring and / or mitigation measures.

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

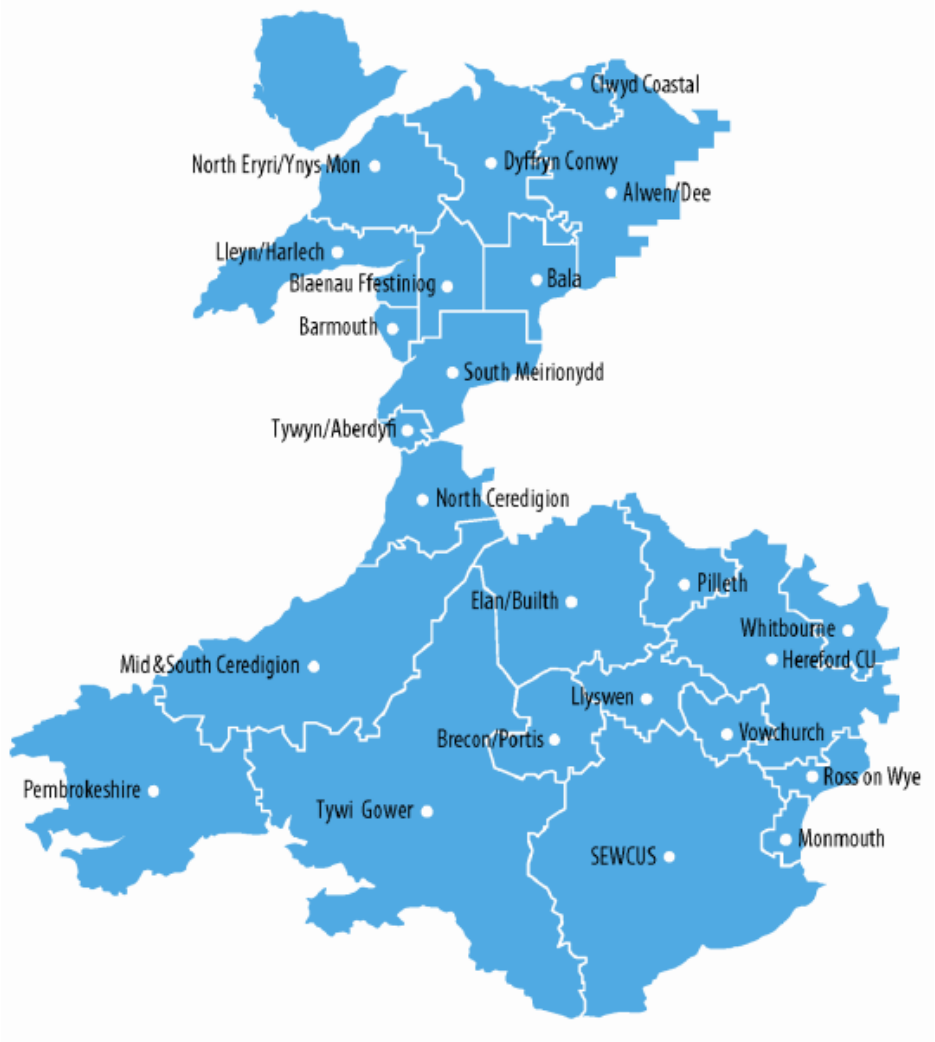
Section 9: Environmental Monitoring Plan (EMP)

Section 10: Conclusions

1.5 WELSH WATER'S SUPPLY SYSTEM

Welsh Water supplies water to more than 3 million people. The Welsh Water supply area covers the majority of Wales and a small part of England. It is split into 24 WRZ's (see Error! Reference source not found.).

Figure 1.1 Welsh Water Water Resource Zones

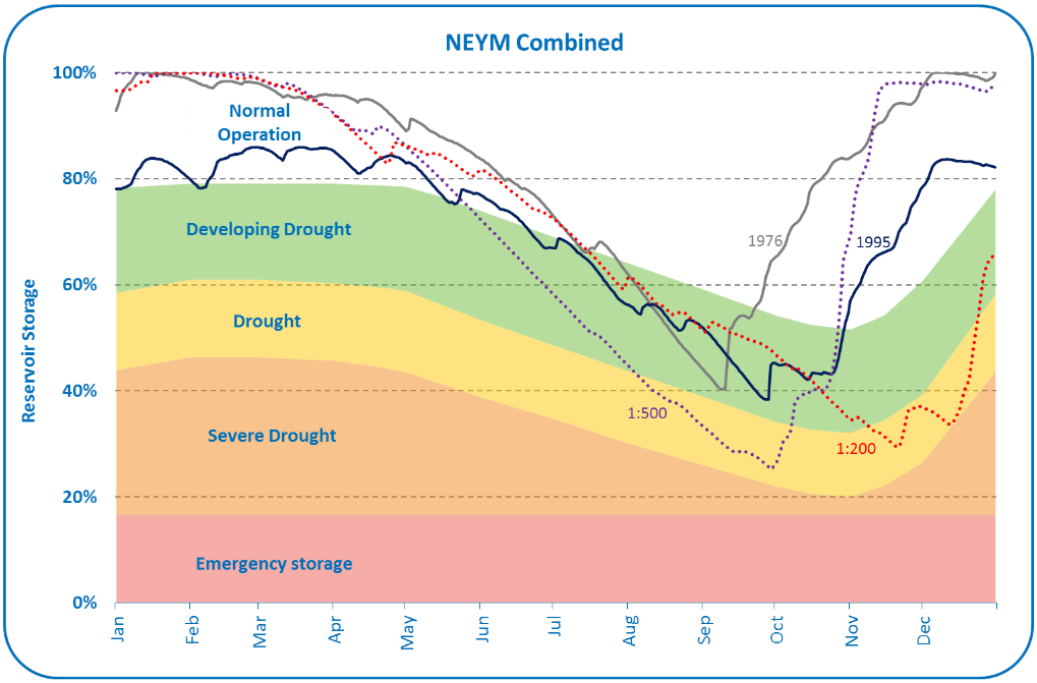


The North Eryri Ynys Môn Water Resource Zone (WRZ) includes the mainland adjacent to the Menai Straits (North Eryri) and Ynys Môn (Anglesey). Water is supplied from five impounding reservoirs; on the mainland Ffynnon Llugwy, Llyn Cwellyn and Llyn Marchlyn Bach and on Ynys Mon, Llyn Alaw and Llyn Cefni. The resources are operated conjunctively with the ability to feed water from the mainland to parts of the island from the gravity resources of Llyn Cwellyn, Ffynnon Llugwy and Llyn Marchlyn Bach when storage allows. As storage declines, the area of Ynys Môn supported from the mainland is reduced and the area supported by Llyn Alaw and Llyn Cefni increases.

The trigger levels for applying for a drought permit at Alaw are based combined reservoir storage falling below a defined level, as shown in **Figure 2.2** (orange shading

labelled 'severe drought'). Welsh Water's assessment in its draft Drought Plan 2020 indicates that drought conditions severe enough to require an application for this drought option are unlikely to occur more frequently than at a return period of around once every 200 years. Fuller details of the work undertaken to assess this risk are provided in Annex 1 to the draft Drought Plan 2020.

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



2 BACKGROUND TO THE DROUGHT PERMIT

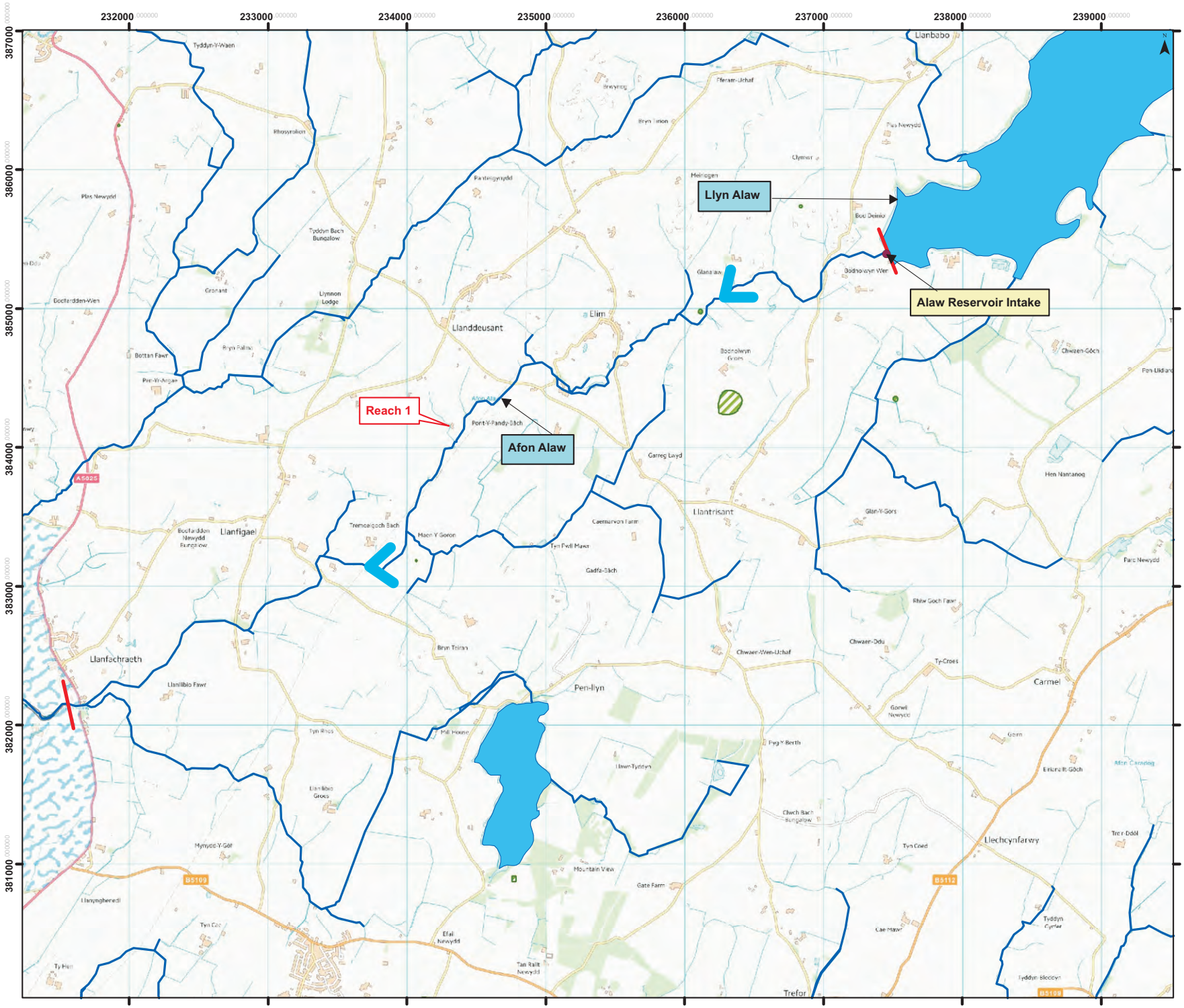
2.1 DESCRIPTION OF EXISTING ARRANGEMENTS AT ALAW RESERVOIR

Welsh Water's licence (number 23/102/6/0006) to abstract water under the Water Resources Act at Alaw Reservoir (see Figure B1.1) includes the following licence conditions:

- 8,637 million litres (Ml) authorised to be abstracted per annum
- At an abstraction rate not exceeding 34Ml/d
- Provision of a uniform statutory compensation water discharge of 3.2Ml/d at all times.

The abstraction for potable supply is made directly from Alaw Reservoir and is typically 14-25Ml/d up to a licensed maximum of 34Ml/d. Water is treated at Alaw Water Treatment Works (WTW) from where it is put into supply.

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



Legend

- Abstraction
- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- Scheduled Ancient Monuments
- Area of Natural Beauty

RICARDO

Dŵr Cymru Welsh Water

1:25,000

Note: All locations are approximate

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Study area: 8001-3 Reduced compensation of Alaw Reservoir

Figure Number: Figure 2.3

Date: February 2019

2.2 WELSH WATER'S DROUGHT PLANNING PROCESS

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

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

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

2.3 STATEMENT OF THE NEED FOR DROUGHT PERMIT

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

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

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

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

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

2.5 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.

2.6 PROPOSED DROUGHT PERMIT DETAILS

In order to protect essential public water supplies within Welsh Water's NEYM 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 Alaw Reservoir.

If granted, the drought permit involves a proposed reduction in the statutory compensation release from Alaw Reservoir to the Afon Alaw of 1.5Ml/d, from 3.2Ml/d to 1.7Ml/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 scheme will influence the downstream Afon Alaw from the outflow at Alaw Reservoir to the tidal limit.

Following the planned installation in 2019 of an eel pass on the low weir downstream of the dam Welsh Water will continue to deliver flow to the eel pass during the implementation of the drought permit. Water will also continue to be sprayed onto the dam face to ensure it stays wetted and mossy throughout the implementation of the drought permit.

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

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

Table 2.1 Alaw Reservoir Existing and Proposed Drought Permit Abstraction

Abstraction Water Source	NGR	Normal Abstraction	Proposed Drought Permit Abstraction	Benefit Ml/d
Alaw Reservoir	SH 39239 86751	Welsh Water's licence (number 23/102/6/0006) to abstract water under the Water Resources Act at Alaw Reservoir (see Figure B1.1) includes the following licence conditions: • 8,637 million litres (Ml) authorised to be abstracted per annum • At an abstraction rate not exceeding 34Ml/d • Provision of a uniform statutory compensation water discharge of 3.2Ml/d at all times. The abstraction for potable supply is made directly from Alaw Reservoir and is typically 14-25Ml/d up to a licensed maximum of 34Ml/d. Water is treated at Alaw Water Treatment Works (WTW) from where it is put into supply.	The drought permit involves a proposed reduction in the statutory compensation release from Alaw Reservoir to the Afon Alaw of 1.5Ml/d, from 3.2Ml/d to 1.7Ml/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 scheme will influence the downstream Afon Alaw from the outflow at Alaw Reservoir to the tidal limit.	1.5 Ml/d

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

2.7 DROUGHT PERMIT PROGRAMME

Drought permits may remain in force for a period of up to six months, and they can be extended for up to a further six months. However, the period of implementation for this drought 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.

2.8 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 from Alaw Reservoir in accordance with the abstraction licence conditions, including the continuation of a daily compensation release of 1.7Ml/d from Alaw Reservoir. The assessed drought permit involves a reduction of 1.5Ml/d in the total flow release (either compensation or regulation) from Alaw Reservoir to the Afon Alaw.

3 APPROACH

3.1 INTRODUCTION

The DPG states that the environmental report must include:

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

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

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

To set the context of the studies, it should be noted that EAR considers the environmental impacts of implementing a drought 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.

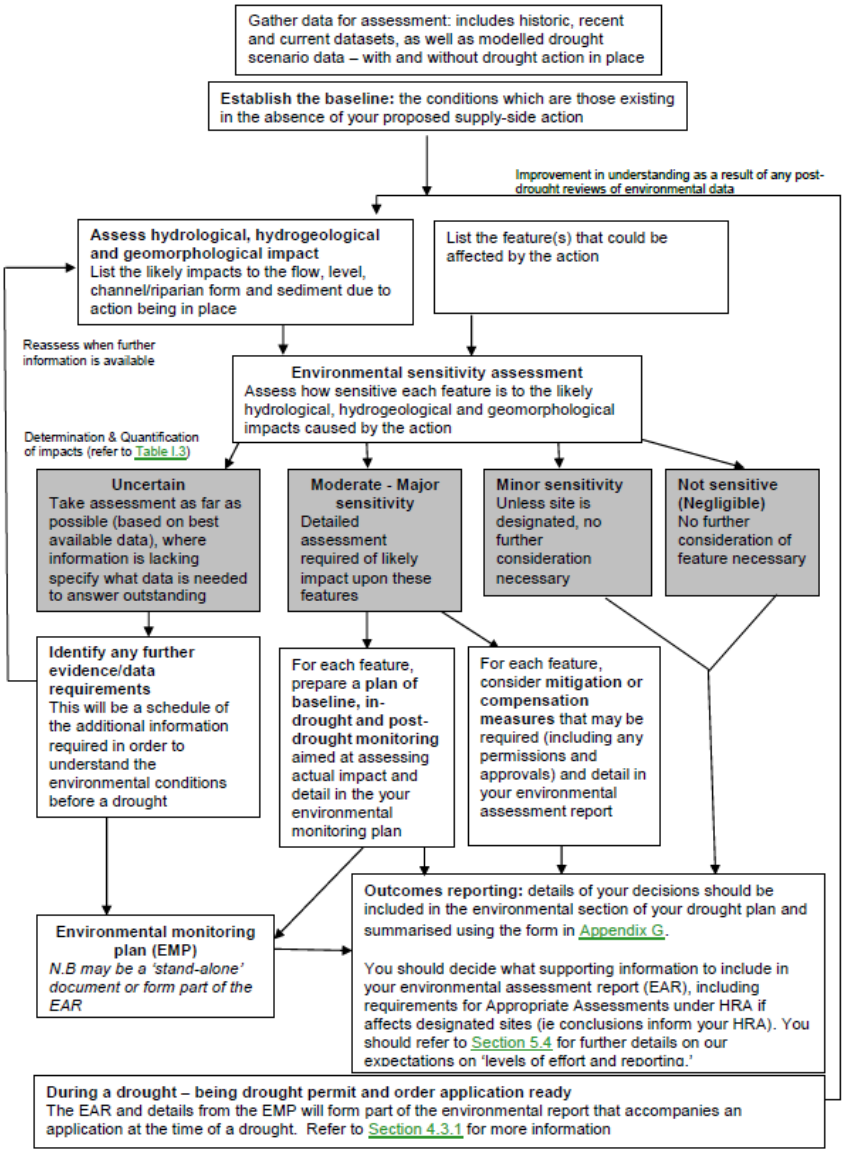
This is discussed further in Section 7.

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 **Figure 3.1** below) identifies the environmental impact activities required.

Figure 3.1 Environmental Impact Activities Identified in the Drought Plan Guideline



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

It is important to acknowledge the basis of the assessment; i.e. impacts of drought 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 permit.
- **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 Alaw 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 Alaw Reservoir 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 on a precautionary basis.

3.3 APPROACH TO ASSESSING IMPACTS, MITIGATION AND MONITORING

3.3.1 General Approach

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

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

[3] 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 IEMA[4,5] and the CIEEM study guidelines[6]. The assessment of impacts on other environmental receptors e.g. recreation and landscape has been carried out largely by qualitative expert judgement.

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

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

The mitigation and monitoring proposals (see Sections 6 and 10) will act as a safeguard that responds and is responsive to both predicted and unpredicted drought impacts.

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

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, 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 ALAW RESERVOIR 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 Alaw Reservoir 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 Alaw, downstream of Alaw Reservoir outflow to the tidal limit at Llanfachraeth

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 Alaw 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 to winter 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

Afon Alaw (Reach 1)	
Flows in the Afon Alaw *Major impacts for up to six months at any time of year*	• Reductions of up to 47% in river flows with corresponding reductions in wetted depths/wetted widths (potential marginal habitats), at any time of year
Water quality in the Afon Alaw *Major risk during the period at any time of year*	• Minor risk to ammonia, moderate for dissolved oxygen and major risk to soluble reactive phosphorous
Consented discharges *Minor risk during the period at any time of year*	• Minor risk from Alaw WTW and two other consented discharges which pose negligible risk
Geomorphology *Moderate impacts during the period of drought permit implementation.*	• The impact on increased siltation is likely to be minor, due to the low concentration of suspended sediment in transport during a drought. Further, the river is adapted to larger bedload and any siltation that does occur will be removed when normal flow resumes, siltation is not expected to increase around the normal natural low flow conditions. Wetted width and depth will be more affected in shallow areas, where a moderate impact on habitat availability is expected.

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 ALAW RESERVOIR 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 Alaw Reservoir 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)
Beddmanarch-Cymyran SSSI	Negligible	The site is designated for biological interest; the large areas of sandbank, mudflat and saltmarsh attracting a number of birds typical to the coastal habitat. With other features of interest including eelgrass and saltmarsh vegetation.	Minor	Yes
Llyn Alaw SSSI	Minor positive	Llyn Alaw SSSI is the largest mesotrophic open water in West Gwynedd. The site is important biologically from an ornithological perspective attracting an array of species including 1% of the British population of shoveler duck *Anas clypeata* and whooper swans *Cygnus cygnus*, nesting and overwintering birds along with a range of mudflat species.	Major	Yes
Environment (Wales) Act Section 7 Species – Fish Atlantic salmon *Salmo salar* River lamprey *Lampetra fluviatilis* Sea lamprey *Petromyzon marinus* Brown and sea trout *Salmo trutta* European eel *Anguilla anguilla*	Major	A number of Habitats Directive and/or Section7 species are noted in the reach. Changes to velocity, depth, wetted width may restrict the access of migratory fish to spawning tributaries or to dry spawning gravels. Reductions in flow are short term and are not anticipated to significantly alter habitat and availability for the resident fish community.	Major	Yes
Habitats Directive Annex 2 - non-priority Fish species Bullhead *Cottus gobio* Brook lamprey *Lampetra planeri*	Major	Two Habitats Directive Annex 2 - non-priority Fish species are noted in the reach. Changes to velocity, depth, wetted width may restrict the access of migratory fish to spawning tributaries or to dry spawning gravels. Reductions in flow are short term and are not anticipated to significantly alter habitat and availability for the resident fish community.	Major	Yes
Environment (Wales) Act Section 7 Species – Mammals Otter *Lutra lutra* Water vole *Arvicola terrestris*	Major	Otter and water vole have been recorded in the area. Otter are water-dependent, foraging in, over or adjacent to water for fish and aquatic invertebrates. However this species are not expected to be significantly impacted by the drought permit implementation, as habitat availability and quality for otter is not anticipated to be significantly altered. Water vole are associated with bankside tree cover, but are considered not to be detrimentally affected.	Negligible	No
Macrophytes	Major	Reduction in flows and level as a result of the drought permit could temporarily reduce the overall extent and / or quality of habitat availability for freshwater macrophytes in the study area.	Moderate	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)
Macroinvertebrates	Major	Reduction in flows and level as a result of the drought permit could temporarily reduce the overall extent of and quality habitat availability for freshwater macroinvertebrates in the study area.	Moderate	Yes
Invasive flora and fauna	Negligible	Cord Grass *Spartina anglica* occurs within the saltmarsh and on parts of the rocky shore.	Uncertain	Yes
Landscape and visual amenity	Major	The search brought five important landscape areas; Transport corridor area and agricultural landscape; The northern coast, visual amenity and rural area site; Llyn Alaw, rural and leisure/landscape area; Central Anglesey, an agricultural and rural zone and a sustrans cycle route, important for landscape and amenity.	Minor	Yes
Recreation	Major	The Afon Alaw provides recreational opportunities, especially for walkers, bikers, fishers and boaters. The area also includes a sustrans cycle route important for leisure and recreation in the area.	Minor	Yes
Archaeology	Major	The search includes three Scheduled Ancient Monument sites; Bedd Branwen Round Cairn, Tregwehelydd Standing Stone and Glan Alaw Standing Stone. These sites are not water dependant.	Negligible	No

5.2.2 WFD Waterbody Status

Table 5.2 identifies the WFD status classification of the WFD waterbodies that may be impacted by implementation of the drought 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	**Alaw - downstream Llyn Alaw (GB110102058981)**	
Hydrological Impact at Location (Major, Moderate, Minor, Negligible)	Moderate	
Heavily Modified Waterbody (Y/N)	No	
RBMP Cycle	RBMP2 (2015)[7]	2018 C2 Interim[8]
Overall Ecological	Moderate	Moderate
Fish	High	High
Macrophytes and Phytobenthos	Not assessed	Not assessed
Phytobenthos (Sub-Element)	Not assessed	Not assessed
Macrophyte (Sub-Element)	Not assessed	Not assessed
Phytobenthos	Not assessed	Not assessed
Macro-invertebrates	Good	Good
Total P/ Phosphate	Good	Good
Ammonia	High	High
Dissolved Oxygen	High	High
pH	High	Moderate
Sensitivity (Uncertain, Moderate/ Major, Minor, Not sensitive)	High	
Further Consideration Required (Y/N)	No	

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 the magnitude of impact in the Alaw Reservoir drought permit hydrological zone of

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

impact. Each feature assessment describes the analyses carried out and a statement of the assessed impact. All impacts are considered to be negative / adverse unless otherwise stated in the feature assessment. The approach is described in Section 3.3.

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

5.3.2 Summary of Features Assessment

Table 5.3 presents the overall summary of the significance of potential impacts of the drought 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
Beddmanarch Cymyran SSSI / Llyn Alaw SSSI		N	N	N	N	N	N	N	N	N	N	N	N
Afon Alaw (Reach 1)													
Macrophytes		N/A	N/A	N/A	N/A	N/A	N/A						
Macroinvertebrates		N/A	N/A	N/A	N/A	N/A	N/A						
Risk to WFD waterbody macroinvertebrate status		N/A	N/A	N/A	N/A	N/A	N/A						
River /sea lamprey	Spawning and juveniles	N/A	N/A	N/A	N/A	N/A	N/A						
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
	Upstream migration (river lamprey)	N/A	N/A	N/A	N/A	N/A	N/A						
	Downstream migration (sea lamprey)	N/A	N/A	N/A	N/A	N/A	N/A						
Atlantic salmon	Spawning, egg survival, and juveniles	N/A	N/A	N/A	N/A	N/A	N/A						
	Adult upstream 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						
Brown / sea trout	Adult migration	N/A	N/A	N/A	N/A	N/A	N/A	N	N				N
	Juveniles (habitat loss)	N/A	N/A	N/A	N/A	N/A	N/A						
	Water quality	N/A	N/A	N/A	N/A	N/A	N/A						
Bullhead		N/A	N/A	N/A	N/A	N/A	N/A						
European eel (silver eel migration)		N/A	N/A	N/A	N/A	N/A	N/A	N	N				
Other fish species- Grayling, minnow, three spined stickleback and stoneloach		N/A	N/A	N/A	N/A	N/A	N/A						
Risk to WFD waterbody fish status		N/A	N/A	N/A	N/A	N/A	N/A						
Phytobenthos		N/A	N/A	N/A	N/A	N/A	N/A						
Invasive Species			N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
Recreation	Angling	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
	Other recreational activities	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
Archaeology		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 – Afon Alaw		
Beddmanarch - Cymyran SSSI	• The Beddmanarch Cymyran SSSI is formed by estuary habitats below the tidal limit as such it is outside of the reach of the hydrological impacts and will not be adversely affected by the implementation of the drought permit.	**Negligible**
Llyn Alaw SSSI	• Changes in hydrological regime could affect the nature conservation interests of the site, primarily overwintering and migratory birds • Operation of the drought permit would result in a change in the hydrological regime from that experienced during drought under normal operating conditions, the change is minor and levels would remain within the general envelope of lake level drawdown experienced during normal operating conditions (e.g. in non-drought years). • Effect on the biota of the reservoir is expected to be negligible.	**Negligible**

5.3.4 WFD and Community Assessment

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

WFD Definitions

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

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

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

Moderate ecological status - the values of the biological quality elements for the

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

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

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

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

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

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

Assessment

A summary of the potential impacts of the drought 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**.

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

Macrophytes

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

Table 5.5 Summary of Impacts of Drought Permit Implementation on Macrophytes

WFD Status/ Community	Impact	Significance of Impact
Afon Alaw – downstream Llyn Alaw (GB110102058981) Current Status: Not assessed	• Macrophyte status not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)		
Macrophyte communities	• 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 increase in nutrients (SRP) and habitat loss due to reduction in wetted width. • Increase in filamentous and epiphytic algae levels due to increased nutrients (SRP) or water temperature and decreased velocity.	**Moderate** (June to September) **Minor** (October to December)

Macroinvertebrates

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

Table 5.6 Summary of Impacts of Drought Permit Implementation on Macroinvertebrates

WFD Status/ Community	Impact	Significance of Impact
Afon Alaw - downstream Llyn Alaw (GB110102058981) Current Status: High	• There is a moderate risk of short-term deterioration in the status of the macroinvertebrate component of the waterbody due to the moderate adverse, short-term, temporary and reversible impacts on the macroinvertebrate community	**Moderate**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)		
Macroinvertebrate communities	• 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. • Reduction is species abundance and/or diversity due to water quality deterioration.	**Moderate**

Fish

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

Table 5.7 Summary of Impacts of Drought Permit Implementation on Fish

WFD Status/ Community		Impact	Significance of Impact
Afon Alaw - downstream Llyn Alaw (GB110102058981) Current status: Good		• There is a major risk of short-term deterioration in status of the fish component of the waterbody due to the minor to major adverse, short-term, temporary and reversible impacts associated with the drought permit	**Major**
Feature		**Impact**	**Significance of Impact**
Reach 1 – Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)			
Environment (Wales) Act Section 7 Species	Brook, river and sea lamprey	• Migration of river and sea lamprey adults and transformers affected or halted by a reduction in flow.	**Moderate**
		• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Major**
		• Reduced water quality	**Negligible**
	Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Major**
		• Reduced water quality	**Moderate**
		• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
	Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Major**
		• Reduced water quality	**Moderate**
		• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
	European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Moderate**
		• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other fish species		• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**

Phytobenthos

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

Table 5.8 Summary of Impacts of Drought Permit Implementation on Phytobenthos

WFD Status/ Community	Impact	Significance of Impact
Afon Alaw - downstream Llyn Alaw (GB110102058981) Current Status: not assessed	• Not assessed	**N/A**
Feature	**Impact**	**Significance of Impact**
Reach 1 – Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)		
Phytobenthos communities	• Changes to community composition due to changes in velocity and water quality	**Moderate**

5.3.5 Invasive Flora and Fauna

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

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

Feature	Impact	Significance of Impact
Reach 1 – Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)		
Invasive Species – *Dugesia tigrina*	Implementation of the drought permit will do nothing favour proliferation of this species.	**Negligible**

5.3.6 Archaeology and Recreation

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

Table 5.10 Summary of Impacts of Drought Permit Implementation on Recreation and Archaeology and Cultural Heritage

Feature	Impact	Significance of Impact
Reach 1 – Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)		
Landscape	• Flows during a drought will be low such that further reduction in flows due to the drought permit would not result in a further loss of aesthetic value	**Negligible**
Recreation	• Impacts on recreation activities (e.g. angling, canoeing, walking) are not anticipated over those from the natural drought conditions	**Negligible**

6 ALAW RESERVOIR DROUGHT PERMIT– MITIGATION

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

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/lake

3) management of sensitive ecological species and communities.

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

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

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[10] for compensation to be agreed with the abstractor.

A suggested suite of mitigation measures for environmental features with potentially significant impacts relating to implementation of the Alaw Reservoir drought permit are given in **Table 9.1**. For these features, a range of precautionary monitoring and triggers leading to enabling of appropriate mitigation measures are also described.

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

7 CUMULATIVE IMPACTS

In accordance with the DPG and the Habitats Regulations, consideration has been given to how the proposed drought 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 NRW Review of Consents reports;
- Assessment of cumulative impacts of the drought permit with other Welsh Water supply-side and drought 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 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 Alaw drought permit with drought order / permit schemes have been identified. However, this should be reviewed at the time of

any future application for a drought permit at Alaw 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 Alaw Reservoir 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 ALAW RESERVOIR 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 ENVIRONMENTAL MONITORING PLAN (EMP)

9.1 INTRODUCTION

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

- Establishing required baseline environmental monitoring and data acquisition to maintain and update the understanding of the environmental baseline conditions and to reduce uncertainties in the assessment.
- Pre-drought 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 is provided in Section 9.2. Monitoring recommendations are set out in Section 9.3.

9.2 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).

9.3 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 9.1** and are illustrated on **Figure 9.1**.

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 9.1 Baseline, Pre, Onset, During and Post Drought Monitoring and Mitigation Recommendations

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	**Monitoring and trigger setting**	**Trigger and monitoring to inform mitigation action**	**Mitigation actions triggered by monitoring**	**Monitoring and post-drought mitigation (where applicable)**	
N/A		Walkover survey during low flow conditions - Mapping of sensitive habitats, communities, species and any monitoring sites that are required in order to improve understanding of the baseline communities.	N/A				Welsh Water
		Spot flow gauging surveys	One site per hydrological reach. Three occasions.	One site per hydrological reach. Three occasions.	N/A	One site per hydrological reach. Three occasions.	Welsh Water
		Biochemical water quality sampling.	One site per hydrological reach. Monthly. Consider continuous monitoring.	One site per hydrological reach. Weekly. Consider continuous monitoring.	N/A	One site per hydrological reach. Monthly, until recovery to pre-drought levels. Consider continuous monitoring.	Welsh Water
Macrophytes **Reach 1**	• Reduction in growth as a result of major impacts on water levels and flows. • Changes to community composition due to changes to flow rates and increase in nutrients (SRP) and habitat loss due to reduction in wetted width. • Increase in filamentous and epiphytic algae levels due to increased	The macrophyte community in the impacted reach is not well understood as limited monitoring has been undertaken. Most recent data (post 2005) is absent, meaning an up to date status of the community is lacking. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites are located at: • NRW Site: At Llanfigael	Survey to be undertaken and macrophytes identified (if drought permit likely to be implemented in the plant growing season. Follow LEAFPACS2 standard methodology [11]. Walkover survey to identify any key sources of nutrient loading. Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.	Walkover of key sections known to be susceptible to lower flows, informed by pre-drought survey. If drought permit implementation occurs in the plant growing season, carry out macrophyte surveys at baseline sites. Follow LEAFPACS2 standard methodology for assessing macrophyte communities. Carry out water quality sampling at the baseline sites including samples for soluble reactive phosphorus.	Mitigating impacts to the macrophyte community as a result of lowered flow and water level is not feasible during drought permit implementation. Mitigating this impact should be triggered by post drought macrophyte community assessments to implement post drought mitigation measures. Consider measures to address identified point sources of nutrient loading. Consider scope for addressing any	In the two years following drought permit implementation and in June to September monitoring period carry out LEAFPACS2 macrophyte surveys at the baseline monitoring sites. To be extended if recovery has not occurred in two years. Significant alteration to macrophyte community composition (as informed by expert judgement, based on baseline data and multivariate statistical analyses) triggers post drought mitigation actions:	Welsh Water

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

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	nutrients (SRP) or water temperature and decreased velocity.				identified sources of nutrient loading from walkover survey, if this would help address water quality risks.	If existing macrophyte community has significantly deteriorated, consider reseeding /replanting where possible to promote recovery. Replanting of macrophyte community composition to be informed by pre-drought community.	
Macroinvertebrates **Reach 1**	• 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. • Reduction is species abundance and/or diversity due to water quality deterioration.	The macroinvertebrate community in the impacted reach is well understood as a result of monitoring carried out by NRW. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites are located at the following NRW sites: • NRW Site: At Llanfigael	Seasonal monitoring of macroinvertebrates at the baseline survey site (summer and autumn). Samples to be collected and identified to species level. Carry out water quality surveys at same time. In severe drought conditions, no in stream monitoring is advised during environmental drought to prevent further harm to the invertebrate community through kick/ sweep sampling.	Seasonal monitoring of macroinvertebrates at the baseline survey sites (summer and autumn). Samples to be collected and identified to species level. Carry out water quality surveys at same time. In severe drought conditions, no in stream monitoring is advised during environmental drought to prevent further harm to the invertebrate community through kick/ sweep sampling.	Mitigating impacts to the macroinvertebrate community as a result of lowered flow and water level is not feasible during drought permit implementation. Mitigating this impact should be triggered by post drought macroinvertebrate community assessments to implement post drought mitigation measures. Consider possible in-stream measures or adjustments to improve habitat conditions, including: • Targeted installation of woody debris features to increase localised flow velocity/scour at the most flow impacted areas of the channel in order to sustain habitat requirements for flow sensitive taxa.	In the two years following drought permit implementation, 3-minute kick sampling and mixed taxon level analysis at the three routine monitoring sites. To be extended if recovery has not occurred in two years. Significant alteration to macroinvertebrate community composition (as informed by expert judgement and based on baseline data) triggers post drought mitigation actions: Targeted habitat alteration/improvements can enhance natural recovery. Habitat restoration techniques can be utilised to improve habitat quality, and flush sediment from benthic substrate. If sedimentation is deemed to be a risk to the community, consider the	Welsh Water

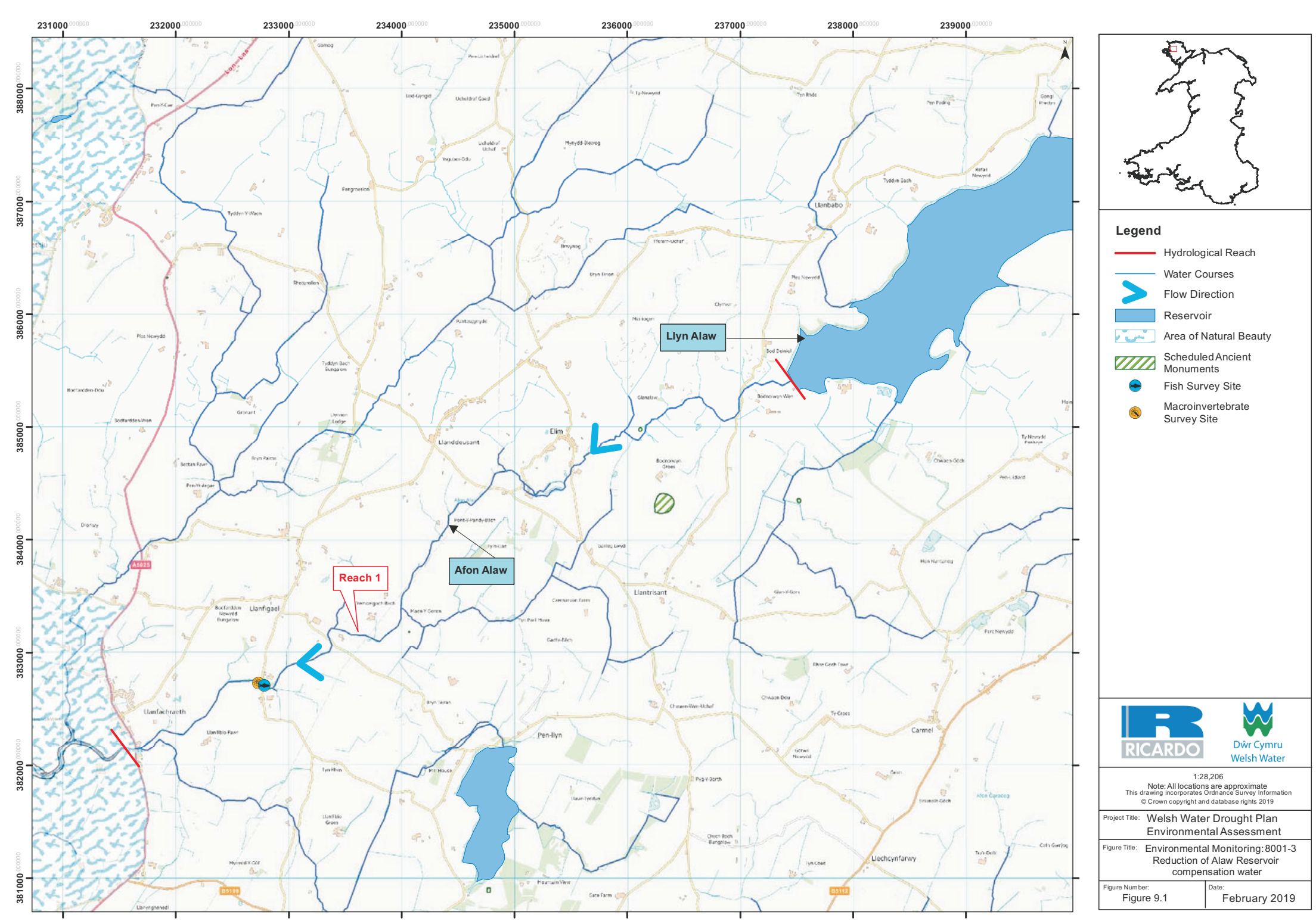
Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring Key locations	On-set of environmental drought Monitoring and trigger setting	During Drought Permit Implementation Period Trigger and monitoring to inform mitigation action	 Mitigation actions triggered by monitoring	Post Drought Permit Monitoring and post-drought mitigation (where applicable)	Responsibility
						removal of fine silt by manual raking of any accessible shallow marginal areas.	
Fish (including brown / sea trout, Atlantic salmon, bullhead, European eel and other fish species) **Reach 1**	• Loss of juvenile fish habitat as a result of reduced flow related impacts • Increased mortality (density dependant) as a result of increased predation and competition • Delays and potential cessation of adult salmonid migration due to reduced flows • Changes in flows and water levels may delay or prevent passage over barriers to migration • Alteration to species distribution and abundance as a result of water	The fish community in the impacted reach not well understood as a result of limited monitoring carried out by NRW. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites are located at: • NRW Site: At Llanfigael (SH3278282712) Electric-fishing surveys to understand baseline fish populations at one sites in the impacted reach Quantitative, lamprey-specific electric fishing surveys targeting known optimal and sub-optimal habitat. One site in each of the impacted reaches. To complement any existing NRW monitoring, in discussion with NRW.	Electric-fishing surveys to monitor fish populations at three sites in the impacted reach. Quantitative, lamprey-specific electric fishing surveys targeting known optimal and sub-optimal habitat. One site in the impacted reach. In severe drought conditions, no fish population surveys are advised during drought as this may cause further stress. Walkover of impacted section of Reach 1 • Identification of key structures which may provide a barrier at lower flows. • Identification of key habitats which are at risk of low flow impacts. Measure dissolved oxygen, conductivity and temperature in the field using calibrated handheld equipment. Appropriate trigger values would be set for level and flow for spawning habitats based on local circumstances, timing, seasonality and expert opinion.	No fish population surveys are advised during drought as this may cause further stress. Additional walkovers, if situation is expected to deteriorate in stream sections known to contain high fish densities, nursery and cover habitats. Record extent of exposed marginal habitats, bed substrates and estimates of overlaying silt cover. Frequency of walkovers to be determined based on the on-set of environmental drought walkover and expert judgement of the resolution required to monitor the impacts of the drought. Targeted fish passage assessment of barriers /obstructions to fish passage and any associated fish passes should be undertaken to ascertain if they pose an increased risk to the free	Targeted installation of woody debris features to provide fish with the habitat required to support feeding and development (growth). If the results of the walkovers deem spawning gravels to be at risk to siltation, the following mitigation action/s may be undertaken: • Gravel washing of key spawning areas to be undertaken prior to salmonid spawning period (winter)[12] • Targeted installation of woody debris features to increase localised flow velocity/scour at impacted spawning gravels (to aid sediment transport and increase water depth for spawning depth) If the results of the	Two years of annual post-drought fish population surveys at baseline monitoring sites (corresponding with a control and impact site/s) to determine any changes in population dynamics both temporally and spatially. Quantitative, lamprey-specific electric fishing surveys targeting known optimal and sub-optimal habitat. One site in the impacted reach. The results of the fish population surveys should help inform mitigation, targeting habitat restoration where deemed to be appropriate to support and enhance affected populations. Walkover of key fish habitat locations recording the number of juvenile lamprey habitat potentially affected. Record extent of exposed marginal habitats, and composition of the bed	Welsh Water

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

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set 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)	
	quality deterioration. • Mortality as a result of water quality deterioration (e.g. oxygen stress)			movement of fish during key migration periods, i.e. during adult salmonid and juvenile lamprey migration (late summer/autumn). Frequency of fish passage assessments to be determined based on the on-set of environmental drought walkover and expert judgement of the resolution required to monitor the impacts of the drought. Measure dissolved oxygen, conductivity and temperature in the field using calibrated handheld equipment. Deployment of automated water quality equipment that continuously monitors for dissolved oxygen.	walkovers deem important habitats to be at risk to exposure/ reduction (in extent), the following mitigation action/s may be undertaken: • Deployment of aeration equipment in key reaches that have standing or slow flowing water with low oxygen levels. • Targeted installation of woody debris features to provide submerged and overhead cover from predation where significant abundances of fish have been identified by walkover surveys. Consider provision of physical deterrents to deter piscivorous birds at significant locations (e.g. scare crows) in consultation with NRW. In extreme cases (where environmental parameters such as dissolved oxygen and temperature allow), consider removal of concentrated abundances of fish	substrate and estimates of overlaying silt cover. If the results of the walkovers deem important habitats to be at risk to exposure/ reduction (in extent), the following mitigation action/s may be undertaken: • Targeted fish passage assessment of barriers /obstructions to fish passage and any associated fish passes should be undertaken to ascertain if they pose an increased risk to the free movement of fish during key migration periods, i.e. during 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	

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)	
					deemed to be stranded/at risk, relocating fish to suitable locations outside of the impacted reach within more suitable catchment, but would need to be discussed with NRW to ensure compliance with the Keeping and Introduction of Fish Regulations 2014. Modify any impacted fish passes (where possible) to ensure passage is maintained during key migration periods (e.g. agree to provide an appropriate proportion of flow into the pass to enable passage). Consider 'Trap & Transport' of concentrated abundances of migrating fish accumulated below impassable barrier/s to spawning grounds upstream of the impacted reach (where environmental parameters such as dissolved oxygen and temperature allow).	improving passage (e.g. fish passage design and installation).	
Phytobenthos **Reach 1**	• Decrease in flow affecting phytobenthos	The phytobenthos and diatom community in the impacted reach is not well understood as limited	Sampling according to DARLEQ2 protocol, at baseline survey sites, in summer and autumn.	Sampling according to DARLEQ2 protocol, at baseline survey sites, in spring and autumn.	No additional measures specified.	Sampling according to DARLEQ2 protocol, at baseline survey sites, in spring and autumn.	Welsh Water

Feature and reach	Potential Impact identified in EAR	Pre-drought baseline monitoring	On-set of environmental drought	During Drought Permit Implementation Period		Post Drought Permit	Responsibility
		Key locations	Monitoring and trigger setting	Trigger and monitoring to inform mitigation action	Mitigation actions triggered by monitoring	Monitoring and post-drought mitigation (where applicable)	
	community composition. • Low risk of deterioration to SRP affecting phytobenthos community composition and TDI score. • Increases in filamentous algae smothering the substrate.	monitoring has been undertaken. Most recent data (post 2005) is absent, meaning an up to date status of the community is lacking. Surveys to ideally be carried out to provide a three-year baseline dataset, then repeated every three years. Monitoring sites are located at: • NRW Site: At Llanfigael Sampling according to DARLEQ2 protocol is recommended at one site in Reach 1. Sampling to be undertaken in at least 1 year, ideally 2-year baseline, ideally encompassing 1 x "normal" flow year and 1 x "dry" flow year, 2 x sampling per year, in spring and autumn.					



Legend

- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- Area of Natural Beauty
- Scheduled Ancient Monuments
- Fish Survey Site
- Macroinvertebrate Survey Site

RICARDO

Dŵr Cymru Welsh Water

1:28,206

Note: All locations are approximate

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Environmental Monitoring: 8001-3 Reduction of Alaw Reservoir compensation water

Figure Number: Figure 9.1

Date: February 2019

10 CONCLUSIONS

This EAR provides an assessment of the potential environmental impacts relating to the implementation of the Alaw Reservoir drought permit. If granted and implemented, the drought permit would enable Welsh Water to reduce the compensation rate by 1.5Ml/d to 1.7Ml/d, conserving storage in the Reservoir and improving the rate of reservoir level recovery after a period of drawdown.

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 assessment has concluded that there is a major impact on flows in the Afon Alaw as a result of implementing the drought permit. These hydrological impacts are assessed as leading to major impacts on the physical environment of the river, including major impact on water quality.

An environmental assessment was therefore required and included for features where screening has identified a major or moderate impact. Screening identified WFD status and Community Assessment / Environment (Wales) Act Section 7 species, landscape and visual amenity and recreation as environmental features for which an environmental assessment was required. The assessment has concluded that there are minor to major impacts on fish, moderate impacts on macroinvertebrates, macrophytes, on phytobenthos. Impacts on the Llyn Alaw SSSI and the Beddmanarch Cymyran SSSI are assessed as negligible.

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

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

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

APPENDIX A
HYDROLOGY AND HYDROGEOLOGY METHODOLOGY

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

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

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

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

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

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

Perennially flowing watercourse hydrological methodology

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

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

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

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

Figure A.1 Hydrological Assessment Matrix (Upland)

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

Figure A.2 Hydrological Assessment Matrix (Lowland)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Intermittently flowing watercourse hydrological methodology

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

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

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

Reservoir hydrological methodology

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

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

Figure A.6 Hydrological Assessment Matrix (Reservoir Impacts)

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

Additional Considerations

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

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

APPENDIX B – 8001-3 HYDROLOGY AND PHYSICAL ENVIRONMENT ASSESSMENT

B1 INTRODUCTION

This appendix assesses the potential impacts on the physical environment of Alaw Reservoir and the Afon Alaw 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 (3.2Ml/d) under the existing abstraction licence from Alaw Reservoir. The assessed drought permit involves a temporary reduction in the compensation rate of 1.5Ml/d to 1.7Ml/d, to conserve storage in Alaw Reservoir and improve the rate of reservoir level recovery after a period of drawdown.

B.1.1 Welsh Water's Existing Operations

Welsh Water's licence (number 23/102/6/0006) to abstract water under the Water Resources Act at Alaw Reservoir (see **Figure B1.1**) includes the following licence conditions:

- 8,637 million litres (Ml) authorised to be abstracted per annum
- At an abstraction rate not exceeding 34Ml/d
- Provision of a uniform statutory compensation water discharge of 3.2Ml/d at all times.

The abstraction for potable supply is made directly from Alaw Reservoir and is typically 14-25Ml/d up to a licensed maximum of 34Ml/d. Water is treated at Alaw Water Treatment Works (WTW) from where it is put into supply.

B.1.2 Welsh Water's Proposed Drought Permit Operations

The drought permit involves a proposed reduction in the statutory compensation release from Alaw Reservoir to the Afon Alaw of 1.5Ml/d, from 3.2Ml/d to 1.7Ml/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.

Following the planned installation in 2019 of an eel pass on the low weir downstream of the dam Welsh Water will continue to deliver flow to the eel pass during the implementation of the drought permit. Water will also continue to be sprayed onto the dam face to ensure it stays wetted and mossy throughout the implementation of the drought permit.

Following the planned installation of an eel pass on the dam wall in 2019 Welsh Water will continue to deliver flow to the eel pass during the implementation of the drought permit.

The drought permit is most likely to occur during the summer to winter period, and is considered not to extend outside the period July to December. This is based on the modelling of the Alaw Reservoir's performance under normal operating conditions and Welsh Water's experience of operating the source. The drought permit scheme will influence the downstream

Afon Alaw from the outflow at Alaw Reservoir to the tidal limit.

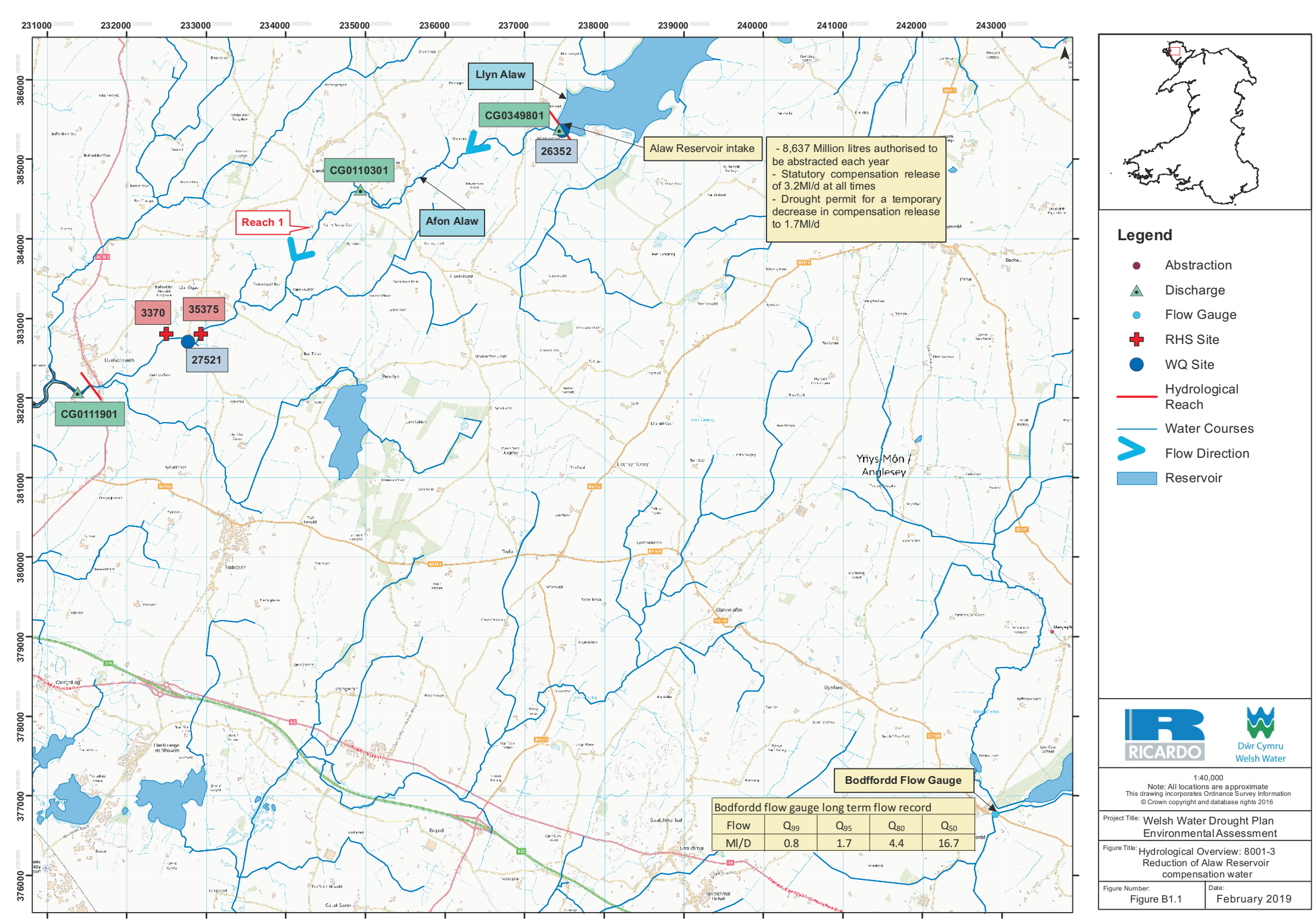
The study area is shown on **Figure B1.1**.

The physical environment includes consideration of hydrology and hydrodynamics; geomorphology; and water quality. The assessment has three 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 DPG[1] and set out in Figure 2 of the DPG.
2. It is used to support the screening and assessment of sensitive features (including ecological features and designated sites) as required by the DPG and set out in Appendix D.
3. Where sensitive features are the physical environment itself, it provides supporting technical information for their screening and assessment.

This appendix is set out in the following sections:

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


Llyn Alaw
CG0349801
26352
Alaw Reservoir intake
- 8,637 Million litres authorised to be abstracted each year
- Statutory compensation release of 3.2Ml/d at all times
- Drought permit for a temporary decrease in compensation release to 1.7Ml/d
CG0110301
Afon Alaw
Reach 1
3370
35375
27521
CG0111901
Ynys Môn / Anglesey
Bodffordd Flow Gauge
Bodfordd flow gauge long term flow record
Flow | Q99 | Q95 | Q80 | Q50
Ml/D | 0.8 | 1.7 | 4.4 | 16.7
Legend
Abstraction
Discharge
Flow Gauge
RHS Site
WQ Site
Hydrological Reach
Water Courses
Flow Direction
Reservoir
RICARDO
Dŵr Cymru Welsh Water
1:40,000
Note: All locations are approximate
This drawing incorporates Ordnance Survey Information
© Crown copyright and database rights 2016
Project Title: Welsh Water Drought Plan Environmental Assessment
Figure Title: Hydrological Overview: 8001-3 Reduction of Alaw Reservoir compensation water
Figure Number: Figure B1.1
Date: February 2019

B2 HYDROLOGICAL IMPACT

B.2.1 Reference Conditions

B.2.1.1 Catchment Overview

Alaw Reservoir is situated to the north of the Isle of Anglesey at an altitude of around 45m. It was built in 1966 and has a maximum usable storage volume of 6,961Ml with a surface area of 3km^2 at top water level.

Alaw Reservoir supports flow in the downstream Afon Alaw. The Afon Alaw stretches 8.6km from the impoundment to the tidal limit at Llanfachraeth. The 33km^2 catchment, draining into the reservoir, has significantly lower rainfall compared to that on mainland Gwynedd, falling on improved pasture with mixed livestock. A further 23km^2 of catchment supplies the downstream Afon Alaw. At low flows, the contribution of the downstream catchment to flow in the Afon Alaw is estimated to be approximately a third of the total flow at the tidal limit.

B.2.1.2 Baseline Data Availability

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

- Daily Alaw water level data, 1997 to 2016 (weekly data is available for 1983 to 1987)
- Daily Alaw compensation flow data, 1991 to 2016
- Daily Alaw abstraction flows, 2000 to 2016.

There is no continuous measurement of the Afon Alaw catchment flow downstream of the Alaw Reservoir. A very limited number of spot flow gauging results are available for locations within the Alaw catchment.

The only continuous monitoring of river level undertaken by NRW on the Isle of Anglesey is at Bodffordd on the Afon Cefni. The Cefni catchment is located some 10km to the south of the Alaw catchment, however this gauging station represents the most relevant continuous river flow record to the study area.

Available flow data include:

- NRW Bodfordd river flow gauge on the Afon Cefni upstream of the Cefni Reservoir impoundment; daily river flow from 1988 to 2014

The reference conditions of Alaw Reservoir and the Afon Alaw catchment are summarised below, based on the available hydrological data as set out above.

B.2.1.3 Hydrology

Alaw Reservoir

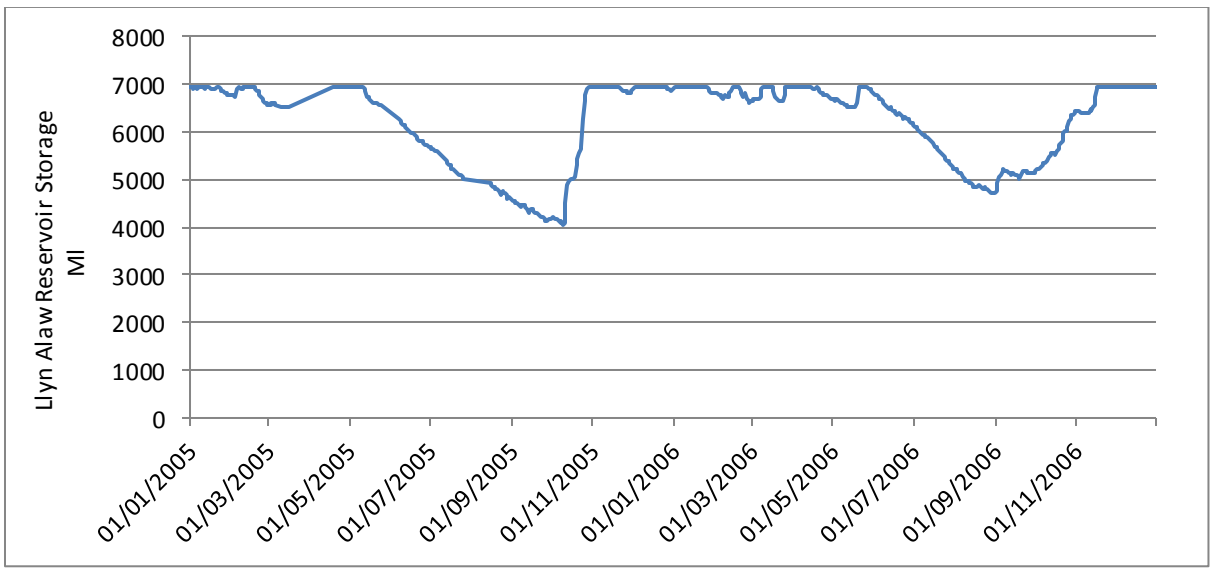
Typically reservoir levels range from about 4m to about 5m above datum in Alaw Reservoir. The lowest level of 3.6m was recorded in September 1984, equivalent to a storage of 3155Ml or around 45%. The top water level is at 5m above datum and when the reservoir is at full capacity, any overflows pass over the spillway into Afon Alaw. A summary of reservoir levels is given in **Table B2.1** below.

Table B2.1 Summary of Recorded Mean Daily Reservoir Level in Alaw Reservoir (1983 – 1987 and 1997 - 2016)

Percentage of time lake level equalled or exceeded	Mean daily reservoir level, metres, per month and maximum/minimum levels												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All year
Maximum reservoir level	5.4	5.3	5.2	5.3	5.2	5.3	5.2	5.2	5.3	5.5	5.4	5.4	5.5
10% (high level)	5.2	5.2	5.2	5.1	5.1	5.0	5.1	5.0	5.0	5.1	5.2	5.2	5.2
50%	5.1	5.0	5.1	5.0	5.0	4.8	4.6	4.5	4.5	4.7	5.0	5.0	5.0
80%	5.0	4.9	4.9	4.9	4.8	4.6	4.5	4.4	4.3	4.3	4.6	5.0	4.6
90%	4.9	4.9	4.9	4.8	4.7	4.5	4.4	4.3	4.2	4.3	4.5	4.8	4.4
95%	4.6	4.7	4.9	4.8	4.7	4.5	4.3	4.1	4.1	4.2	4.4	4.7	4.3
99% (low level)	4.5	4.5	4.7	4.8	4.6	4.4	4.2	4.1	4.0	4.0	4.3	4.5	4.1
Minimum reservoir level	4.4	4.4	4.5	4.0	4.6	4.3	4.1	3.9	3.6	3.9	4.2	4.2	3.6

Figure B2.1 illustrates the typical drawdown patterns in Alaw Reservoir during the relatively dry period of 2005 - 2006.

Figure B2.1 Alaw Reservoir Storage (2005 - 2006)



Afon Alaw

The Afon Alaw is 8.6km long, with a catchment area of 56.7km^2 at its tidal limit at Llanfachraeth. At the Alaw Reservoir spillway weir, the catchment area is 33.5km^2. The compensation release from the reservoir is measured, however overflows which occur when the reservoir is at full capacity are not measured.

The statutory compensation requirement is for a daily release of 3.2Ml/d. Recorded flows are generally in the range 3 - 4Ml/d approximately.

Other than the compensation flow record, there is very little measured flow data available for the Afon Alaw. A small number of spot flow gauging results are available, however these mainly relate to a tributary which joins the Afon Alaw very near to the tidal limit, or to a river reach upstream of the reservoir. None of the spot values relate to low or extreme low flow conditions, as compared to the gauged record at Bodffordd.

Afon Cefni at Bodffordd

Natural Resources Wales continuously monitor river flow on the Afon Cefni upstream of the Cefni Reservoir impoundment at Bodffordd; this is the nearest continuous catchment flow measurement to the Alaw catchment. A summary of the available daily flow data from 1988 onwards is given in **Table B2.2** below.

Table B2.2 Summary of Recorded Mean Daily Flow in Afon Cefni at Bodffordd (1988 – 2014)

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	1002.2	413.9	533.1	366.3	303.3	227.2	166.8	232.4	772.4	1192.3	1088.6	570.2	1192.3
10% (high flow)	131.3	104.3	72.4	49.4	22.9	18.0	13.0	14.8	39.6	97.5	148.7	149.9	85.4
50%	53.0	38.9	22.8	15.6	8.7	4.5	3.4	3.5	5.4	18.7	48.1	56.9	16.7
80%	26.4	20.3	14.2	8.6	5.4	2.9	1.9	1.8	1.7	5.7	23.0	26.5	4.4
90%	19.2	17.0	11.8	6.9	4.2	2.4	1.6	1.3	1.2	3.8	16.8	19.5	2.6
95% (low flow)	13.5	14.9	10.4	5.9	3.6	1.9	1.4	0.7	0.7	2.5	12.0	14.9	1.7
99% (extreme low flow)	8.6	11.8	8.9	5.3	2.3	1.5	0.9	0.2	0.4	1.3	4.7	10.1	0.8
Minimum flow	7.3	8.4	8.3	4.7	1.9	1.4	0.6	0.2	0.3	1.0	3.9	9.1	0.2

The low flow statistics for the summer period (1st April to 30th September inclusive) are: Summer Q_{95} = 1.4Ml/d; Summer Q_{99} = 0.6Ml/d.

B.2.2 Hydrological Impact

B.2.2.1 Hydrological Zone of Influence

A review of the flows and physical habitat characteristics of the river network downstream of Alaw 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 a length of the Afon Alaw from the impoundment at Alaw Reservoir to the tidal limit, comprising one distinct hydrological reach as listed in **Tables B2.5** and **B2.6** and identified on **Figure B1.1**:

- The Afon Alaw reach is, from the Alaw Reservoir outflow to the tidal limit at Llanfachraeth.

The potential hydrological impacts of the drought permit options have been assessed for the Alaw Reservoir and the single river reach, is summarised in **Tables B2.5** and **B2.6** at the end of this section.

The details of the assessment for the reservoir and river reach are presented below.

B.2.2.2 Hydrological Impact Assessment

Hydrological Reach – Alaw Reservoir

The impact on Alaw 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. The duration of shoreline exposure would be slightly shorter, compared to the baseline drought scenario, as the reservoir would reach top water level slightly earlier during the winter refill period. This would be considered as a minor positive impact and has not been assessed further.

River Reach Assessment

In the absence of any gauged flow data in the downstream Afon Alaw catchment, we have determined approximate flow values by comparing relative catchment areas and SAAR (standard annual average rainfall) values at Llanfachraeth with those of the NRW gauging station at Bodffordd on the Afon Cefni. These estimates should be regarded as ***indicative*** only, and are used solely for the purposes of determining the approximate magnitude of the drought permit hydrological impacts on the lower Afon Alaw.

Table B2.4 Summary of Catchment Areas and Key Summer Flow Statistics: Afon Alaw / Afon Cefni

Location	Grid Reference	Catchment area km²	SAAR mm	Ratio of catchment area x rainfall to Bodffordd	Summer (April to September inclusive) Naturalised Low Flow Statistics		
					Q_{99}	Q_{95}	Source
Afon Cefni at Bodffordd	SH429768	21.7	1056	100%	0.6	1.4	Data record
Afon Alaw at Alaw Reservoir outflow	SH372854	33.5	1023	150%	0.9	2.1	Area-flow apportionment
Afon Alaw at tidal limit at Llanfachraeth	SH315822	56.7	1001	248%	1.5 (3.8*)	3.5 (4.6*)	Area-flow apportionment

*Adjusted to allow for Alaw compensation effects

A similar calculation can be used to estimate year round low and median flow statistics at Llanfachraeth as 4.2Ml/d (Q_{95}) and 41.4Ml/d (Q_{50}).

Hydrological Reach 1 – -Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)

The Afon Alaw is a typical Anglesey river; a sluggish low-gradient river flowing over boulder clay and moraine, dropping 40m over the 8.6km hydrological reach. The channel is shallow and typically wide with a gravel-pebble substrate overlain with silt. The flow pattern is smooth. The river banks are mostly natural, steep and composed of earth. There are no significant tributaries to the Afon Alaw between the Alaw Reservoir outflow and the tidal limit and no continuous flow gauging. The compensation release from the Alaw Reservoir is a substantial proportion of the flow in this hydrological reach during low flow periods.

It is very unlikely that the Alaw Reservoir will be at full capacity when a drought permit is implemented, therefore no spill will be occurring and the only outflow from the reservoir will be the compensation release. The reduction in compensation flow rate from 3.2Ml/d to 1.7Ml/d therefore represents a 47% reduction in summer low and extreme low flows in the upper Afon Alaw immediately below the reservoir. Similarly, during winter refill periods, as no spill will be occurring whilst the reservoir is refilling, the reduction in compensation flow rate still represents a 47% reduction in flow.

At the lower end of the reach, summer low and extreme low flow statistics have been estimated by area-flow apportionment with the Bodffordd gauge as 3.8Ml/d (Q_{99}) and 4.6Ml/d (Q_{95}). The reduction in compensation of 1.5Ml/d therefore represents a 32.6-39.5% reduction in flow at the lower end of reach 1. The corresponding estimates for the year round low (Q_{95}) and median (Q_{50}) flow statistics are 4.2Ml/d and 41.4Ml/d, so that the reduced compensation would still represent a 35.7% and 3.6%, respectively, flow reduction at Llanfachraeth, even during periods of winter rainfall when there is significant flow accretion along the river reach. This would be assessed as a moderate impact.

The hydrological impact of this drought option on Reach 1 is, therefore, considered to be **major** at all times of year, although during winter it reduces to a moderate impact at the lower end of the river reach.

B.2.2.3 Hydrological Impact Summary

The hydrological impact is **major**, for the assessed river reach although during winter periods the impact is potentially reduced to moderate at the lower end of the reach. The impacted reach is shown in **Tables B2.5** and **B2.6** and establishes the full in-channel zone of influence of the drought permit for environmental sensitivity screening (see **Figure B1.1**).

The impact on the Alaw Reservoir itself has been assessed as **minor positive**.

Table B2.5 Hydrological and Monitoring Reaches identified in the Study Area – Summer Impacts (July – September)

Hydrological Reach	Reach boundary		Reach length	% flow reduction		Hydrological Impact
	Upstream	Downstream		Summer Q_{95}	Summer Q_{99}	
Alaw Reservoir	n/a	n/a	n/a	n/a	n/a	**Minor Positive**
Afon Alaw	Alaw Reservoir Outflow	Tidal limit at Llanfachraeth	8.6km	47%	47%	**Major**

Table B2.6 Hydrological and Monitoring Reaches identified in the Study Area – Winter Impacts (October – December)

Hydrological Reach	Reach boundary		Reach length	% flow reduction		Hydrological Impact
	Upstream	Downstream		Year round Q_{95}	Year round Q_{50}	
Alaw Reservoir	n/a	n/a	n/a	n/a	n/a	**Minor Positive**
Afon Alaw	Alaw Reservoir Outflow	Tidal limit at Llanfachraeth	8.6km	47%	47%	**Major**

B3 PHYSICAL ENVIRONMENT ASSESSMENT

B.3.1 Geomorphology and Sediment Transport

Geomorphology data for the study area are limited. Data are available for three NRW River Habitat Survey (RHS) sites in the hydrological of the Afon Alaw (see **Figure B1.1**). The RHS sites can be found at the following distances downstream from the start of the reach; RHS site 370 - 2.26km; RHS site 35375 - 6.58km and; RHS site 3370 -7.08km. The RHS survey data is supplemented with extant aerial imagery.

Overall the hydrological reach comprises a sinuous river, underlain by Llanuirn and Arenig upstream and Andesitic Lava and Tuff geology downstream. Channel width and depth are documented as 9m and 1m, respectively upstream at RHS site 370. Downstream channel width and depth are recorded as 9 m and 0.2 m, respectively (RHS site 3370).

Flow is variable along the reach, and laminar (run-glade sequences) flow was observed at RHS survey site 370. Riffles dominate downstream at RHS sites 35375 and 3370. Bedload substrate is predominantly gravel-pebble, with some silt and cobble. In-channel depositional features were observed at RHS site 35375, and the point bar was vegetated. No bank substrate data was provided by the RHS data.

Modification increases downstream, and the lower reach of the Alaw channel (RHS sites 35375 and 3370, and an HMS score of 300 (obviously modified) was recorded at the latter RHS site) has been straightened in some sections and is significantly modified. In addition, there has been a minor impact from poaching in RHS site 3370. Anthropogenic features such as bridges are found within the reach. Land-use is improved and semi improved grassland with some wet woodland, banktop vegetation is uniform.

Bed substrate would generally be expected to become finer closer to the tidal limit, however in this location, an increase of in-channel finer substrate was not observed using extant aerial imagery. Using the data from upstream, larger bedload is expected to dominate the stream, including the tidal area; this is confirmed by the dominance of riffles.

Due to the drought permit, increased siltation is not expected to increase from the natural variation during low flow conditions, further suspended sediment transported during drought conditions will not be significant in this bedload dominated system. The drought permit will affect wetted widths and depths, especially in shallow locations, however much of the lower part of the reach is managed with steep banks. Impacts on wetted width and depth in the shallow locations is expected to be moderate.

B.3.2 Water Quality

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

To support the assessment of potentially sensitive environmental features (Appendix D), an understanding has been developed of the water quality of the rivers within the zone of influence of the drought order, including trends over time and with respect to river flow. For WFD classification, the Environment Agency has set out[2] following UKTAG evidence[3] what pressures, including water quality pressures, each biological quality element is capable of responding to. For the purposes of assessment here, the supporting water quality parameters are set out: for fish and macroinvertebrates (where identified as sensitive features) as dissolved oxygen saturation and total ammonia concentration; and for macrophytes and algae (phytobenthos / diatoms) (where identified as sensitive features) as soluble reactive phosphorus (SRP). Specifically, for macrophytes, if the hydrological impacts of drought permit implementation have been identified within the main macrophyte growing season (April to September), an assessment of SRP has been undertaken.

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

Ten years of NRW routine monitoring data were reviewed to provide an overview of water quality in the hydrological zone of impact. On the Afon Alaw, within the extent of influence of the drought order, there are two NRW water quality sampling sites, one on Llyn Alaw, Llyn Alaw at Dam, Anglesey (Site 26352) and one on the River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey (Site 27521) (**Table B3.1** and **Figure B1.1**). Data are available for these sites (2007 to 2015) and include measurements of a suite of parameters.

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

Table B3.1 Details of NRW Water Quality Sampling Points

Reach	Site Name	NRW Site Code	Grid reference	Location
Lynn Alaw	Llyn Alaw at Dam, Anglesey	26352	SH3748285365	Llyn Alaw Dam
River Alaw	River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey	27521	SH3277082710	1.7km U/S of tidal limit

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

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

Reach – Llyn Alaw

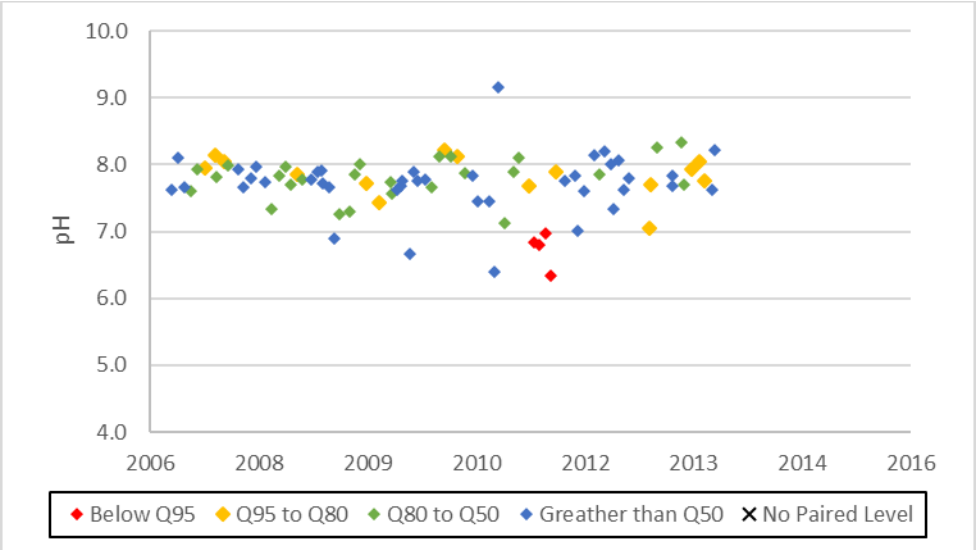
Water quality data are available for one NRW monitoring point in Llyn Alaw (minor positive hydrological impact); Llyn Alaw at Dam, Anglesey (site 26352). Alkalinity data is not available at this location.

The monitoring site 26352 represents the outflow from Llyn Alaw. The average pH in Llyn Alaw over the ten year review period was 7.71 and the maximum water temperature was 23.3°C.

pH

pH measurements in Llyn Alaw at Dam, Anglesey were reviewed and data presented in **Figure B3.1**.

Figure B3.1: pH at Llyn Alaw at Dam, Anglesey, Incorporating Appropriate WFD Status Bands

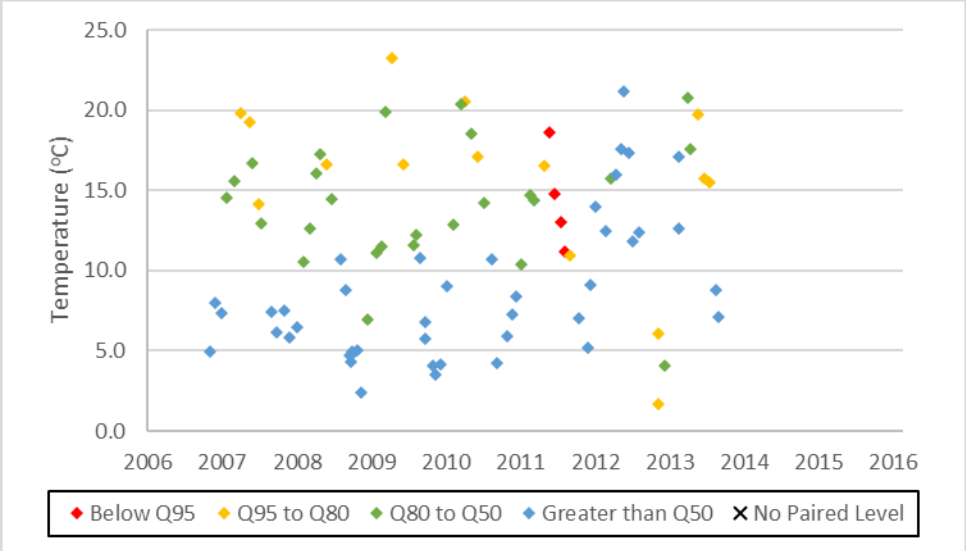


pH measurements on the Llyn Alaw at Dam, Anglesey (see **Figure B3.1**) were predominantly stable throughout the time series. No clear relationship is apparent between reservoir depth and pH suggesting effect on pH is limited.

Temperature

Temperature measurements in Llyn Alaw at Dam, Anglesey were reviewed and data presented in **Figure B3.2**.

Figure B3.2: Temperature in Llyn Alaw Near Overflow

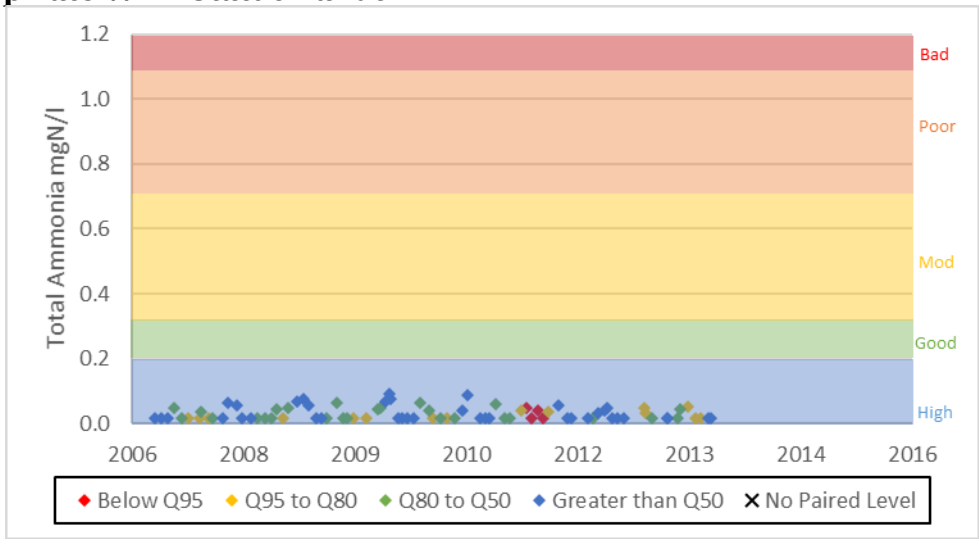


Temperature measurements in Llyn Alaw at Dam, Anglesey (see **Figure B3.1**) were widely stable throughout the time series. A clear relationship is apparent between reservoir depth and temperature indicating reduced reservoir depth results in increased temperatures. Some seasonality is apparent with highest temperatures in summer and lowest in winter.

Total Ammonia Concentration

Total ammonia concentrations on the Llyn Alaw at Dam, Anglesey were reviewed and data presented in **Figure B3.1** against the relevant WFD standards for an upland low alkalinity river[4].

Figure B3.1: Total Ammonia at Llyn Alaw at Dam, Anglesey, Incorporating Appropriate WFD Status Bands



Total ammonia concentrations on the Llyn Alaw at Dam, Anglesey (see **Figure B3.1**) were all consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l).

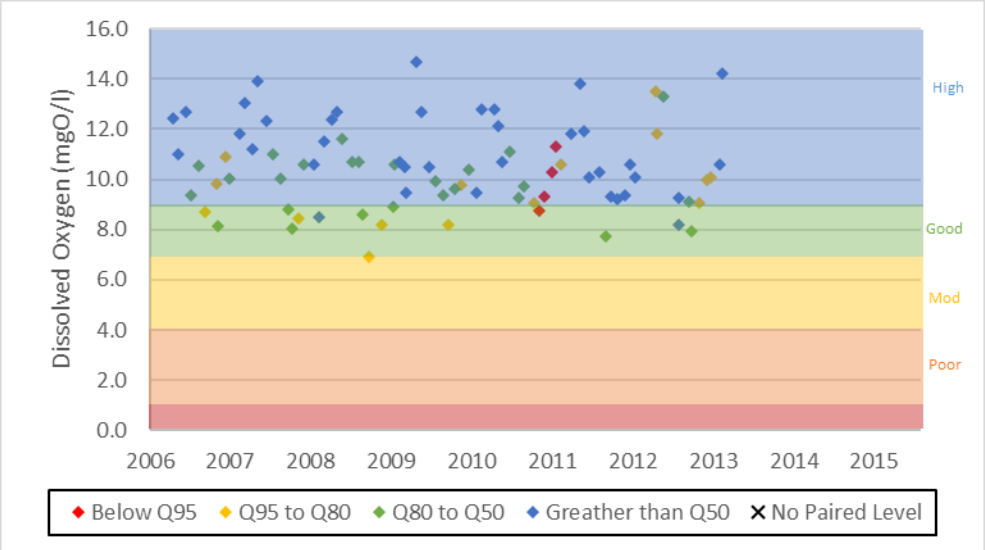
[4] The Water Environment (Water Framework Directive) (England and Wales) Directions 2015. ISBN 978-0-85521-192-9.

No trend is apparent between reservoir depth and ammonia concentration.

Dissolved Oxygen Concentration

Dissolved oxygen concentration data on the Llyn Alaw at Dam, Anglesey were reviewed and data are presented in **Figure B3.3** against the relevant WFD standards for lakes[5].

Figure B3.3: Dissolved Oxygen saturation at Llyn Alaw at Dam, Anglesey, Incorporating Appropriate WFD Status Bands



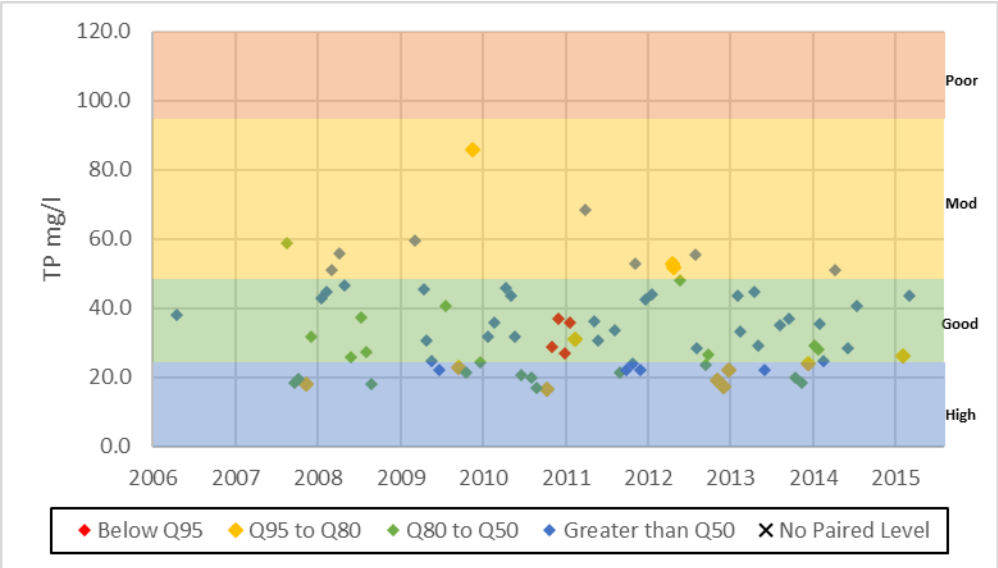
Dissolved oxygen saturation measurements on the Llyn Alaw at Dam, Anglesey (see **Figure B3.3**) were predominantly consistent with the WFD standard to support good status for fish and invertebrates (7mgO/l). One value is reported below this value with 6.92mgO/l on 02/07/2009. Seasonality is apparent with lower oxygen concentrations in autumn and higher concentrations in spring. A slight relationship is apparent between reservoir depth and oxygen concentration with lower levels leading to reduce oxygen concentrations.

Total Phosphorus

Total Phosphorus concentration in the Llyn Alaw at Dam, Anglesey was reviewed and data are presented in **Figure B3.2** against the relevant WFD site specific standards provided by NRW[6].

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

Figure B3.2 Total Phosphorus in the Llyn Alaw at Dam, Anglesey, Incorporating Appropriate WFD Status Bands

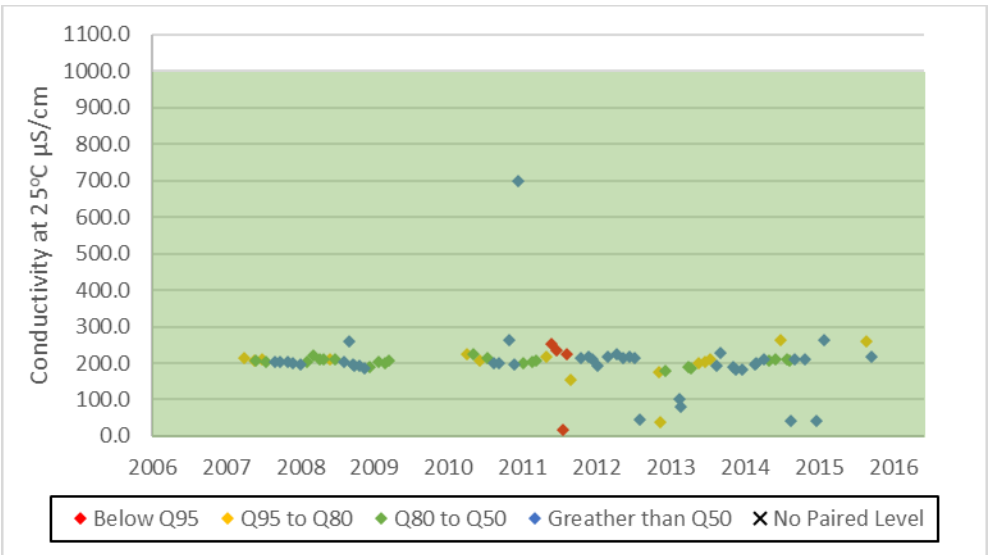


Total phosphorus concentration at the Llyn Alaw at Dam, Anglesey were mostly consistent with the WFD standard to support good status for fish and invertebrates (24.4mgP/l). Values below this standard were noted in 14% of instances (11 occurrences). No seasonality or relationship between total phosphorus and reservoir depth is apparent.

Salinity (Conductivity)

Conductivity data on the Llyn Alaw at Dam, Anglesey were reviewed and data are presented in **Figure B3.3** against the relevant WFD standard for lakes[7].

Figure B3.3: Conductivity at Llyn Alaw at Dam, Anglesey



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

Conductivity measurements on the Llyn Alaw at Dam, Anglesey (see **Figure B3.3**) were all consistent with the WFD standard to support good status for fish and invertebrates (1000µS/cm[3]). Some seasonality is apparent with reduced conductivity in early spring which increases into summer and early autumn. No relationship is apparent between reservoir depth and conductivity.

Reach 1 – Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)

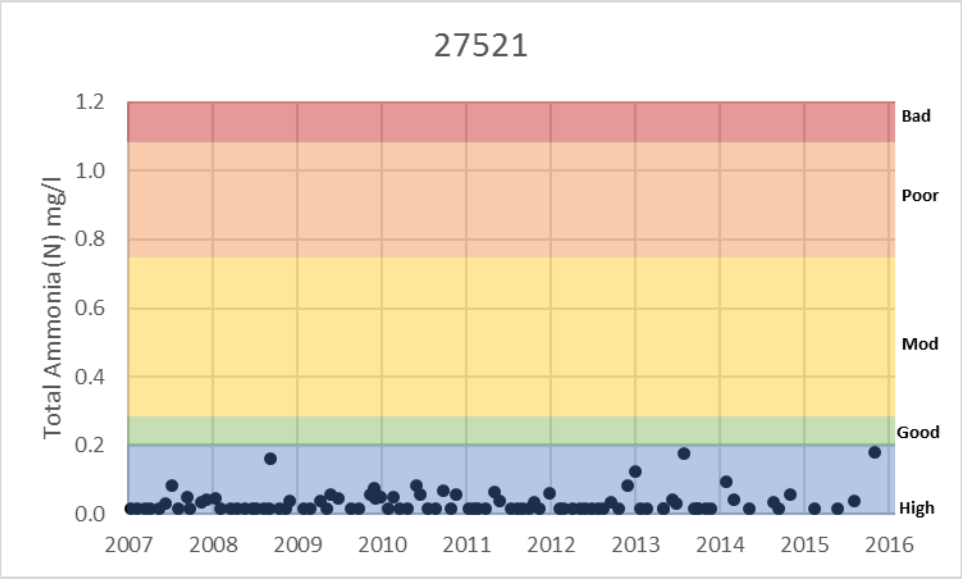
Water quality data are available for one NRW monitoring points on Reach 1 (major hydrological impact); River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey (site 27521).

The monitoring site 27521 represents the downstream section of Reach 1. The average pH in Reach 1 over the ten year review period has been 7.5 and the maximum water temperature has been 21.2°C.

Total Ammonia Concentration

Total ammonia concentrations on the River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey were reviewed and data presented in **Figure B3.1** against the relevant WFD standards for an upland low alkalinity river[8].

Figure B3.1: Total Ammonia at River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey, Incorporating Appropriate WFD Status Bands



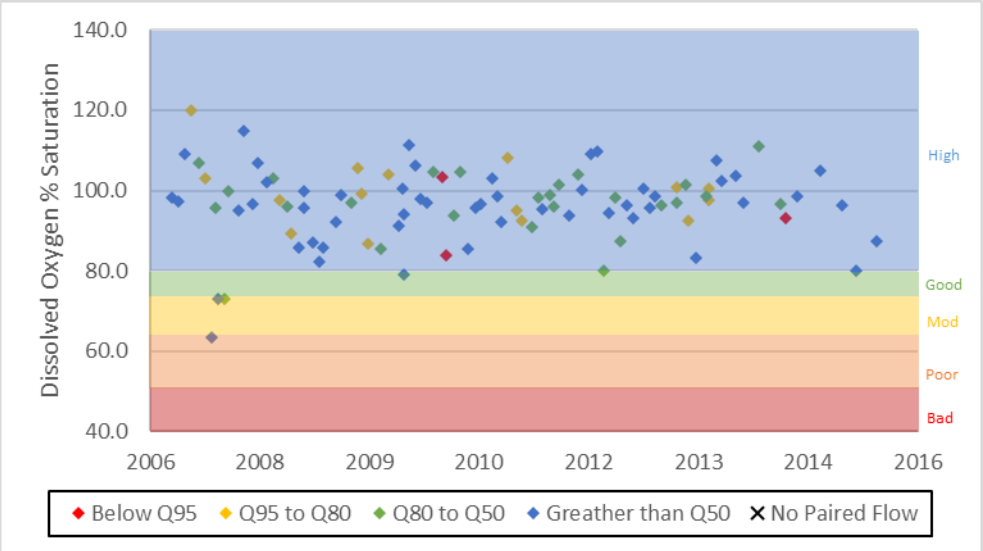
Total ammonia concentrations on the River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey (see **Figure B3.1**) were all consistent with the WFD standard to support high status for fish and invertebrates (0.2mg/l). No seasonality or change over time is apparent.

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

Dissolved Oxygen Saturation

Dissolved oxygen saturation data on the River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey were reviewed and data are presented in **Figure B3.3** against the relevant WFD standards for an upland low alkalinity river[9].

Figure B3.3: Dissolved Oxygen saturation at the River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey, Incorporating Appropriate WFD Status Bands



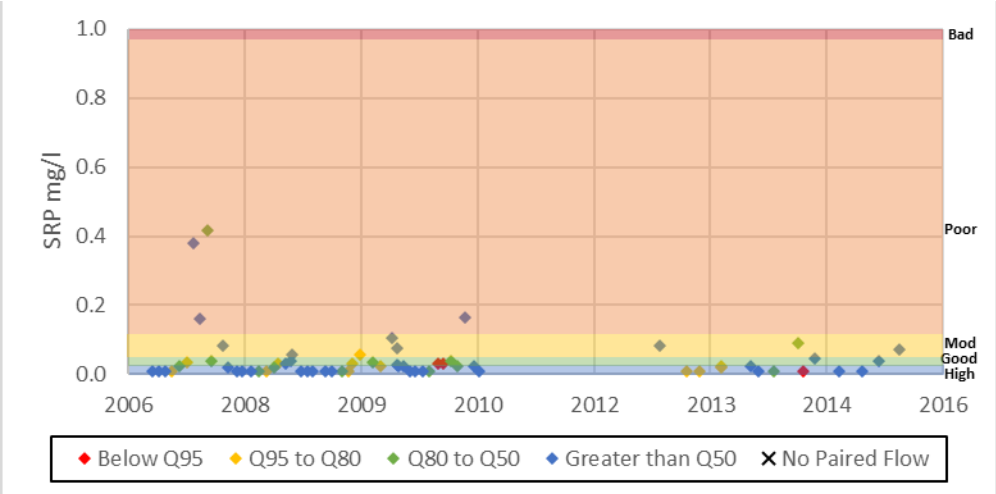
Dissolved oxygen saturation measurements on the River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey (see **Figure B3.3**) were all consistent with the WFD standard to support high status for fish and invertebrates (80%). Values below good WFD status were recorded on 3 occasions: 63.5% on 18/07/2007; 72.9% on 16/08/2007 and 72.9% on 19/09/2007. No seasonality or association with river flows is apparent at this location.

Soluble Reactive Phosphorus

Soluble reactive phosphorus concentration in the River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey was reviewed and data are presented in **Figure B3.2** against the relevant WFD site specific standards provided by NRW[10].

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

Figure B3.2 SRP in the River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey, Incorporating Appropriate WFD Status Bands



Soluble reactive phosphorus concentration at the River Alaw, Pont Llanfigael, Llanfachraeth, Anglesey were mostly consistent with the WFD standard to support good status for fish and invertebrates (0.05mgP/l). Values below this standard were noted in 19% of instances (12 occurrences). No seasonality of association with river flows is apparent at this location.

Water Quality Summary

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

Assessed water quality parameters within Llyn Alaw were all consistent within their corresponding WFD standards (where applicable) for either high or good status for fish and invertebrates with total phosphorus the only exception. Dissolved oxygen concentrations and temperature were both noted to respond noticeably to changes in water depth with lower levels resulting in reduced oxygen concentration and increased temperatures. Given the beneficial hydrological impact the risk to all water quality parameters in Llyn Alaw is **minor beneficial**.

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

Dissolved oxygen saturations were predominantly consistent with the standard to support high status for fish and invertebrates throughout the zone of influence of the Llyn Alaw drought order. The risk of the drought order to dissolved oxygen saturation levels within the zone of influence is therefore **moderate** in Reach 1 of the Llyn Alaw drought order.

Soluble Reactive Phosphorus concentration was mostly consistent with the standard to

support high status for fish and invertebrates throughout the zone of influence of the Llyn Alaw drought order. The risk of the drought order to SRP concentration levels within the zone of influence is therefore **major** in Reach 1 of the Llyn Alaw drought order.

B.3.3 Environmental Pressures

B.3.3.1 Flow Pressures

Surface Water Abstractions

There are no licensed surface water abstractions in the study area apart from Welsh Water's abstraction from the Alaw Reservoir intake, the subject of this assessment.

B.3.3.2 Water Quality Pressures

Discharges put pressure on water quality during a drought as lower than normal river flows mean that there is less water available to dilute discharges such as final effluent from Wastewater Treatment Works (WwTW). Discharges impacting the oxygen balance and ammonia concentration in the river reaches have been reviewed. Significant pressures (discharges of over 0.5Ml/d) are shown on **Figure B1.1**. Any discharges may be considered as beneficial to river flow but may also pose risks to water quality (noting that only abstractions are considered as flow pressures in the section above).

There are 3 consented discharges within the study area. These consist of Alaw WwTW (consent numbers CG0175601/CG0349801) which has a consented daily maximum discharge of 2.5Ml/d; and Llanddeusant WwTW (consent number CG0110301) which has a consented daily maximum discharge of 0.144Ml/d (0.048Ml/d maximum dry weather flow). Changes in the dilution and dispersion of these discharges in the Afon Alaw during operation of the drought permit are not considered significant (see **Table B3.2**).

Table B3.2 Summary of Water Quality Pressures

Permit no.	**Site name**	**Location**	**Max daily total (Ml/d)**	**Dry weather flow (Ml/d)**	**BOD: 5 Day ATU (mg/l)**	**Ammoniacal N (mg/l)**	**Suspended Solids @ 105 C (mg/l)**	**Zone of influence (<500m)**	**Consideration of water quality pressure** (during baseline low flow conditions)
CG0110301	Llanddeusant sewage treatment works	SH3494084620	0.144	0.048	Not specified	Not specified	55	8	Negligible
CG0349801	Alaw water treatment works, Llanerchymedd, Vnys Mon, Gwynedd	SH3744085380	2.5	Not specified	Not specified	Not specified	Not specified	35	Minor
CG0111901	Llanfachraeth sewage treatment works	SH3138082070	0.114	0.048	Not specified	Not specified	65	130	Negligible

B4 PHYSICAL ENVIRONMENT IMPACT SUMMARY

Potential impacts on the physical environment associated with the Alaw Reservoir reduced compensation 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 Alaw Reservoir Reduced Compensation Release Drought Permit

Afon Alaw (Reach 1)	
Flows in the Afon Alaw *Major impacts for up to six months during the period from July to December inclusive*	• Reductions of up to 47% in river flows with corresponding reductions in wetted depths/wetted widths (potential marginal habitats), at any time of year
Water quality in the Afon Alaw *Major risk during the period from July to December inclusive*	• Minor risk to ammonia, moderate for dissolved oxygen and major risk to soluble reactive phosphorous
Consented discharges *Minor risk during the period from July to December inclusive*	• Minor risk from Alaw WTW and two other consented discharges which pose negligible risk
Geomorphology *Moderate impacts during the period of drought permit implementation (most likely during July to December inclusive).*	• The impact on increased siltation is likely to be minor, due to the low concentration of suspended sediment in transport during a drought. Further, the river is adapted to larger bedload and any siltation that does occur will be removed when normal flow resumes, siltation is not expected to increase around the normal natural low flow conditions. Wetted width and depth will be more affected in shallow areas, where a moderate impact on habitat availability is expected.

B5 CUMULATIVE IMPACTS

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

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

Table B5.1 Cumulative Impacts of the Alaw 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	8001-2 (Removal of Llyn Cwellyn 10Ml/d abstraction rate) – The impacts of this option do not occur within the same catchment and therefore no in-combination effects are anticipated.	No
	8001-4 (Reduction of Ffynnon Llugwy Compensation water) – The impacts of this option do not occur within the same catchment and therefore no in-combination effects are anticipated.	No
	8001-5 (Reduction of Cefni Compensation water) – 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].

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

Continuously flowing watercourses

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

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

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

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

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

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

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

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

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

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

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

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

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

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

alkalinity rivers[5].

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

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

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

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

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

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

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

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

Ephemeral watercourses

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

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

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

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

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

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

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

WATER FRAMEWORK DIRECTIVE STATUS: FISH

Potential Effects
For WFD river waterbodies within the zone of influence of the drought option, where screening of the drought option has identified that the fish element of biological status is *High* or *Good*, the potential impact is to be investigated. This investigation is specific to the risk of deterioration below the *Good* status band to the *Moderate* status band, as advised by NRW / Environment Agency.
Definition of Impacts
In order to define the potential WFD status impacts for fish in a readily understandable manner, a series of criteria have been defined. The assessment will use the following criteria, based on the potential severity of the drought option impacts during an ongoing drought. • Major: A major impact is one that results in deterioration in the WFD classification of the waterbody, or specifically the fish biological element of the classification. • Moderate: A moderate impact on fish status occurs when the fish population is predicted to be materially influenced, including effects on density, abundance or community composition, but where no deterioration in WFD classification is predicted. Consideration should be given to the scale of the impact and the potential for recovery of the populations. • Minor: A minor impact occurs when there is a predicted impact on fish abundance, density or community composition that is within the usual variability for the site and which will recover within a short timescale. • Negligible: A negligible impact is one where the predicted impact will not result in a detectable change in the fish population.
Data Requirements
Fish status baseline assessment requires data from standard NRW / Environment Agency monitoring programmes in the potentially impacted zone, and preferably in a control site outside of the zone of influence. Fish data should include species presence, abundance and density. Environmental supporting data should include habitat availability, hydrology (flow, velocity, wetted area (width and depth) as follows: • Relevant study area (as identified in the screening report) • Hydrology at or close to the monitoring sites to link to fish data, including full flow hydrograph, wetted width and depth, velocity profile. Will include daily gauged flow and spot flow surveys, all available records • Meteorology (where flow data insufficient) from available NRW / Environment Agency rain gauges • Habitat data for the monitoring sites, which may include recent RHS or Habscore surveys • Routine NRW / Environment Agency water quality monitoring data (dissolved oxygen, BOD, ammonia, pH, hardness, water temperature, conductivity) representative of the study area.

Assessment Methodology and Uncertainty
The WFD classification for the waterbody will be identified and the reasons for classification established from the NRW / Environment Agency. The data used to support the assessment will be reviewed to ensure that the classification is accurate. Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These will include graphing the hydrology, water quality, habitat and fish variation temporally over the monitored period. The analysis will consider the relationship between fish status and the supporting environmental variables over the period, with an emphasis on changes to fish status and environmental conditions between low, average and high flow years. The purpose of the analysis is to establish whether fish status responds to changes in flow and associated environmental variables inter-annually relating to changes in flow, climate, quality (dissolved oxygen and temperature) and/or habitat quality and availability. Having established the baseline conditions and variability outside the drought option conditions (care will be taken to avoid using periods in the baseline analysis within which a drought option may have been in operation), a prediction will be made of the changes in the supporting environmental variables (flow, habitat and water quality) resulting from application of the drought option. This will be undertaken for the hydrological data by overlaying the drought option flows over the baseline flow hydrograph, and, where cross sectional data are available, how the wetted width and depth will vary with the drought option. This can be extrapolated to the habitat data to consider whether the key features are compromised by the change in water depth. Once the flow, habitat and water quality drought option predictions have been established, their implications for existing fish species will be assessed. The flow and habitat environmental envelope of the key fish species is known. The predicted changes in supporting environmental variables (flow, depth, velocity, habitat quality, dissolved oxygen levels and temperature) due to the drought option will be assessed against the fish population data. Where the supporting environmental variables for fish species are modified to take them outside of their preferred envelope it can be assumed that there will be a moderate or major impact on that fish population. Consideration will be given to the potential for density dependent mortality where data show that the fish population has an existing good density, and where the drought option reduces habitat availability significantly The assessment will consider the scale and longevity of any fish status impacts. The WFD classification is calculated on a 3 year rolling basis. A deterioration in classification would require a long term (2+ breeding seasons) and significant effect on fish population structure to allow prediction of a deterioration in status. Where data are not available the assessment will be undertaken using expert judgement and drawing on broad-scale evidence from other similar catchments if applicable. The prediction of impacts of hydrological and water quality changes on aquatic ecology remains subject to significant uncertainty. This is exacerbated where few data or

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

WATER FRAMEWORK DIRECTIVE STATUS: MACROINVERTEBRATES

Potential Effects

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

Definition of Impacts

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

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

Data Requirements

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

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

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

rain gauges

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

Assessment Methodology and Uncertainty

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

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

Baseline conditions for sites within the zone of influence of the drought option will be established through existing data. These will include graphing the hydrology, water quality, and macroinvertebrate (ASPT and LIFE scores) variation temporally over the monitored period.

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

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

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

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

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

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

NOTABLE SPECIES, DESIGNATED SITES AND OTHER SENSITIVE FAUNA AND FLORA

Potential Effects

Where screening of the drought option has identified that a notable species or designated site is present within the zone of influence of the drought option and screening has indicated that it is sensitive to the impacts of the drought option, the potential impact is to be investigated. Notable species are defined as Environment (Wales) Act Section 7 species or species with significant ecological sensitivity in the specified locality including species listed on IUCN red list and those not included in the red list which are nonetheless uncommon. This investigation will consider the habitat preferences of the species and its lifestages (if appropriate) and the impacts of the variation in flow (and consequent physical habitat and ecosystem) on these preferences. Potential effects are associated either 1) directly to a reduction in river flow; or 2) a reduction in water quality; 3) secondary effects of reduced velocity, for example on sediment characteristics.

Definition of Impacts

In order to define the potential impacts for sensitive ecological features in a readily understandable manner, a series of criteria have been defined. The significance of impacts upon the sensitive ecological feature will be identified following the Institute of Ecology and Environmental Managements (CIEEM) Ecological Impact Assessment (EcIA) guidance[10]. The potential significance of the impacts is identified using the following:

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

Table 1 Value of Ecological Receptor

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

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

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

otherwise stated in the feature assessment.

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

Table 2 Magnitude of Impact

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

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

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

Data Requirements

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

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

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

Assessment Methodology and Uncertainty

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

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

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

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

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

drawing on broad-scale evidence from other similar catchments.

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

Habitat Preferences

Habitat Preferences		**Unfavourable Habitat**	**Potential Impacts**
Type/ Age Class	**Description**		
Atlantic salmon *Salmo salar* and Brown/Sea trout *Salmo trutta*			
Spawning	• Clean and unconsolidated gravels typically in the transitional area between pools and riffles where the flow is accelerating and depth is decreasing	-	Deposition of silt
			Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
Nursery (fry and parr life stage)	• Shallow areas with a low water velocity and pebble substrate, often at the margins of riffles	• Deep and/or high velocity habitats.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	Deep habitats that provide shelter including one or more of the following: • submerged structures • undercut banks • overhanging vegetation < 50cm above the water surface • water surface turbulence causing a broken surface • Deep pools downstream of obstacles and sufficient water quantity through structures to enable passage across obstacles.	• Open and shallow habitats, but will use these during migration to reach spawning gravels. • Habitats upstream of significant obstructions.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Increased significance of barriers to impede migration as a result of decreased flows
			Deterioration in water quality
Brook lamprey *Lampetra planeri*			
Spawning	• Clean, unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	- -	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. • Variation in depth between 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**		
			Deterioration in water quality
Adults	• Cover (stones and vegetation) in the vicinity of spawning gravels.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
River lamprey *Lampetra fluviatilis*			
Spawning	• Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	• Suitable estuarine conditions, that is free from pollution and with suitable prey species available. • Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.	• Areas with significant pollution or limited prey availability. • Habitats upstream of significant obstructions.	Increased significance of barriers to impede migration as a result of decreased flows
			Increased risk of entrainment into water intake
			Deterioration in water quality
Sea lamprey, *Petromyzon marinus*			
Spawning	• Clean and unconsolidated spawning gravels with suitable sheltering areas, usually located at the tail end of pools where flows are increasing.	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Areas of sandy silt with slow water velocity, often in the margins of watercourses, above the estuary. Variation in depth between 2cm and 30cm (>15cm is optimal) with a relatively high organic content.	-	Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	• Suitable estuarine conditions, that is free from pollution and with suitable prey species available. • Clear migration routes from the estuary to spawning grounds with suitable river flows and no barriers.	• Areas with significant pollution or limited prey availability. • Habitats upstream of significant obstructions.	Increased significance of barriers to impede migration as a result of decreased flows
			Increased risk of entrainment into water intake
			Deterioration in water quality
Bullhead, *Cottus gobio*			
Spawning	• Coarse, hard substrate of gravel and stones.	• Deep, silty watercourses with high flow velocities and little or no cover.	Deposition of silt
			Reduction in velocity, depth and/or wetted width
			Increased water velocity and depth

Habitat Preferences		Unfavourable Habitat	Potential Impacts
Type/ Age Class	**Description**		
Nursery	• Shallow, stony riffles		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adult	• Sheltered sections created by woody debris, tree roots, leaf litter, macrophyte cover or larger stones.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
European eel, *Anguilla anguilla*			
Juvenile (<30cm)	• Wetland habitats within 30km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.	• Low productivity watercourses with dominance of coarse substrates and low macrophyte cover and diversity. • Habitats upstream of significant obstructions.	Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adult (>30cm, female >45cm)	• Deep, slow flowing watercourses and wetland habitats within 80km of tidal limit with high diversity and cover of vegetation, soft substrates and high productivity.		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased significance of barriers to impede migration as a result of decreased flows
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Barbel *Barbus barbus*			
Spawning	• Run/glide flow • Less than 50cm deep • Velocities greater than 0.5m/s • Substrate composed of clean and uncompacted gravel	-	Deposition of silt
			Reduction in velocity, depth or wetted width resulting in exposure of river bed
			Increased water velocity and depth
Nursery	• Marginal shallow bays set back from or within margins of main channel • Depths between 1cm and 30cm • No discernible to minimal flow • Substrate composed of >30% gravel and sand with low silt content • Lack of or very little riparian shading		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Increased water velocity and depth
			Increased risk of entrainment into water intake
			Deterioration in water quality
Adults	• Commonly associated with stretches of clean gravel and macrophyte beds, showing a preference to relatively fast-flowing stretches in the middle reaches of large rivers. • The species also occupies deep water habitats at the foot of weirs,		Reduction in velocity, depth and/or wetted width, possibly resulting in exposure of river bed
			Impedance to movement upstream
			Increased water velocity and depth
			Increased risk of entrainment into water intake

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

APPENDIX D – 8001-3 ENVIRONMENTAL FEATURES ASSESSMENT

D1 INTRODUCTION

This appendix presents information regarding the environmental features associated with the Alaw Reservoir 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 Appendix B).

Points of interest referred to throughout the text in Appendix D are indicated on **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).

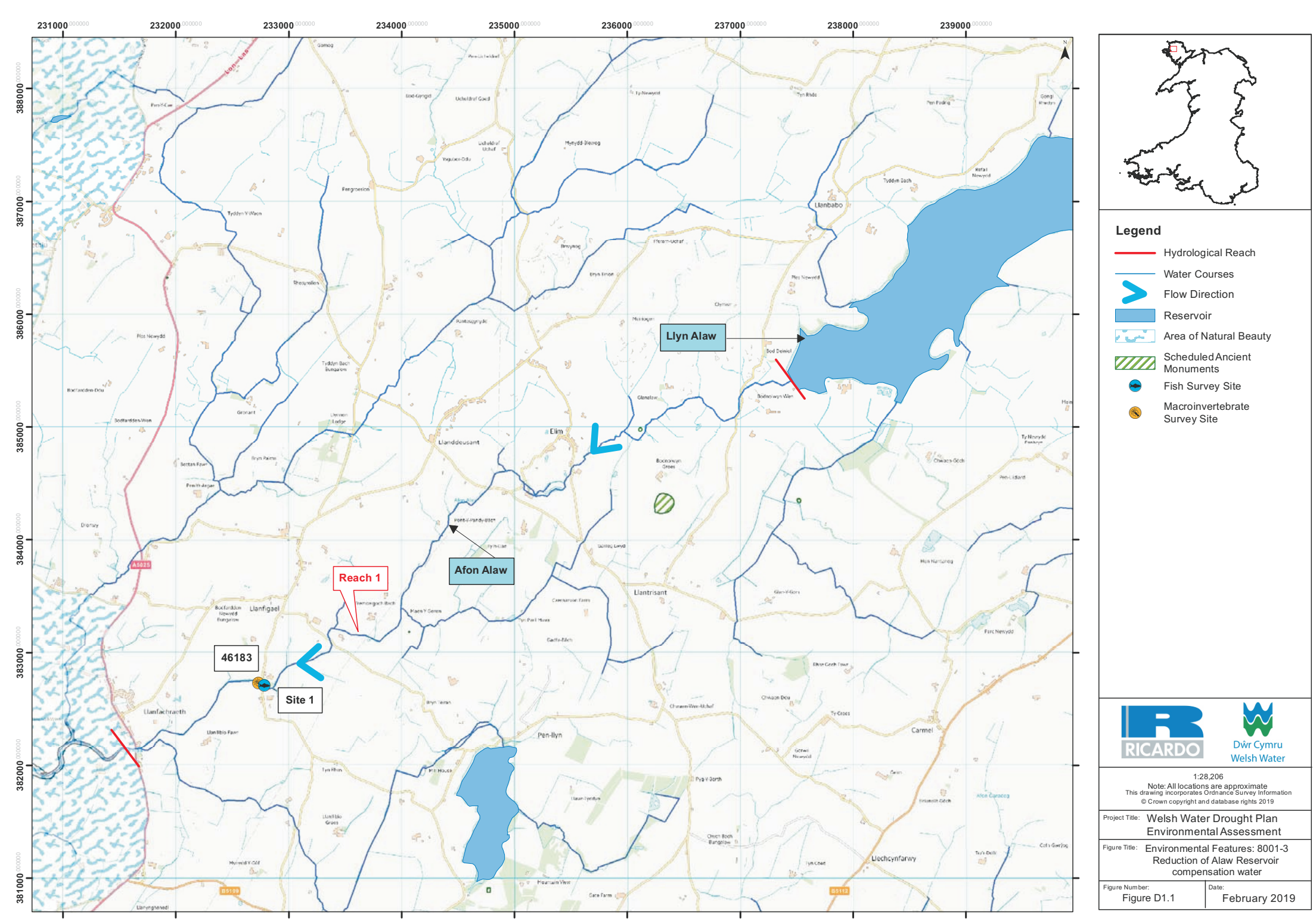
The assessment of environmental features is informed by the assessment of the physical environment (which includes hydrology and hydrodynamics; geomorphology; and water quality), this is presented in **Appendix B**.

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

Desk-based assessments have been completed for each of the sensitive receptors, where applicable, in order to determine the magnitude of impact in the relevant lake / river reaches for the Alaw Reservoir 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:

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



Legend

- Hydrological Reach
- Water Courses
- Flow Direction
- Reservoir
- Area of Natural Beauty
- Scheduled Ancient Monuments
- Fish Survey Site
- Macroinvertebrate Survey Site

RICARDO

Dŵr Cymru Welsh Water

1:28,206

Note: All locations are approximate

Project Title: Welsh Water Drought Plan Environmental Assessment

Figure Title: Environmental Features: 8001-3 Reduction of Alaw Reservoir compensation water

Figure Number: Figure D1.1

Date: February 2019

D2 DESIGNATED SITES

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

D.2.1 Beddmanarch Cymyran SSSI

D.2.1.1 Baseline

This SSSI is designated for a variety of coastal habitats between Holy Island and 'mainland' Anglesey and is selected primarily for its ornithological and botanical interest. There are large areas of sandbank, mudflat and saltmarsh, as well as two stands of dune heath. The site also has marine biological interest. A wide range of water birds, both on passage and in winter, are associated with the site which is especially important for overwintering ringed plover *Charadrius hiaticula*, greenshank *Tringa nebularia*, red breasted merganser *Mergus serrata,* and goldeneye *Bucephala clangula*[4].

D.2.1.2 Assessment

The Beddmanarch Cymyran SSSI is formed by estuary habitats below the tidal limit as such it is outside of the reach of the hydrological impacts and will not be adversely affected by the implementation of the drought permit.

D.2.2 Llyn Alaw SSSI

D.2.2.1 Baseline

The SSSI is designated as the largest mesotrophic open water habitat in Gwynedd (covering approximately 360 ha), primarily for its ornintological interest, especially for overwintering wildfowl. The numbers of teal *Anas crecca*, shoveler *Anas clypeata* and whooper swans Cygnus cygnus at times are around 1% of the British population. Other wildfowl species which occur include mallard *Anas platyrhynchos*, wigeon *Anas penelope*, goldeneye *Bucephala clangula*, pochard *Aythya ferina* and tufted duck *Aythya fuligula* and more recently ruddy duck *Oxyura jamaicensis* and sometimes pink-footed goose *Anser brachyrhynchus*. Common terns *Sterna hirundo* and black-headed gulls *Larus ridibundus* nest on islands in the reservoir while tufted duck, great crested grebe *Podiceps cristatus* and coot *Fulica atra* also nest. In autumn, large flocks of waders, in particular, curlew *Numenius arquata*, lapwing *Vanellus vanellus* and golden plover *Pluvialis apricaria*) visit the exposed mud areas[5].

[4] Countryside Council for Wales: Anglesey Beddmanarch-Cymyran Site of Special Scientific Interest: citation. http://angleseynature.co.uk/webmaps/beddmanachdesc.html (1 of 2) [05/01/2016 12:05:13]
[5] Cascade Consulting (2007) Environmental Monitoring Plan for Alaw Reservoir. Technical Report to DCWW

In addition to the considerable ornithological interest, the occurrence of the uncommon marginal species slender spike rush *Eleocharis acicularis* in the reservoir margins is included in the list of "special features" for the site, and the exposed muddy shore supports several unusual mosses, including the Nationally Rare species Atlantic pocket-moss *Fissidens monguillonii* and Nationally Scarce beaked beardless-moss *Weissia rostellata*, and sessile earth-moss *Ephemerum sessile*.[6]

D.2.2.2 Assessment

Operation of the drought permit would result in a marginal increase in lake levels within Llyn Alaw, relative to the position without the drought permit and therefore the duration of shoreline exposure would be slightly shorter, compared to the baseline drought scenario, as the reservoir would reach top water level slightly earlier during the winter refill period. The hydrological impact on the reservoir is therefore considered to be minor beneficial.

In relation to the SSSI, changes in hydrological regime could potentially affect the nature conservation interests of the site, primarily overwintering and migratory birds, if quantity or access to food sources, or timing of such access is affected. Management advice for the SSSI states that "marginal muddy feeding rounds should continue to be exposed by annual changes in water level by reservoir management for migrating birds to feed"[6]. In addition, shoreline vegetation, including slender spike rush and bryophyte species of interest will occupy niches constrained by the normal hydrological regime of reservoir drawdown.

However, although operation of the drought permit would result in a change in the hydrological regime from that experienced during drought under normal operating conditions, the change is minor and levels would remain within the general envelope of lake level drawdown experienced during normal operating conditions (e.g. in non-drought years). Therefore, the effect on the biota of the reservoir, including marginal plants and abundance and availability of food sources for resident, migrating and overwintering birds is expected to be negligible. The impact of the drought permit on the Llyn Alaw SSSI is, therefore, **negligible**.

[6] Natural Resources Wales. Llyn Alaw "Your Special Site and its future" Document SSSI_0009_SMS_EN0011

D3 WFD STATUS AND COMMUNITY ASSESSMENT / NOTABLE SPECIES

D.3.1 Macrophytes

D.3.1.1 Baseline

Limited baseline macrophyte monitoring information was available from Natural Resources Wales (NRW), within the reach of the Afon Alaw subject to hydrological impacts. Baseline macrophyte data received within the impacted reaches consisted of only one site, which was located near Llanfigael at the downstream end of Reach 1. However, this site is not considered to provide sufficient spatial extent to characterise the whole watercourse and thus care must be taken in their interpretation. As a result of the limited data, collection of baseline data on macrophyte communities of the Afon Alaw is recommended to help inform the assessment of impacts of the drought permit.

Macrophyte results were provided by NRW using the standard LEAFPACS methodology. This methodology is based on the principle that different combinations, quantities, and numbers of macrophytes are associated with different nutrient availability in a river.

RMNI and RMHI are biotic indices used to determine the nutrient preference and flow preference of macrophyte communities respectively and are updated versions of the MTR and MFR biotic indices.

To calculate RMNI scores, macrophyte communities are identified and assessed on a scale of 1 to 10 based on individual species cover values and their combined preference for nutrient enrichment. High scores are associated with communities in eutrophic waters, low scores are associated with oligotrophic waters. Following the same premise communities with high RMHI scores are associated with low energy flow velocities and low scores are associated with high energy flow velocities.

Mean Flow Rank (MFR) scores provide an indication of the flow preferences of the macrophyte community ranging from 1 (preference for slow flow velocities) to 5 (preference for higher flow velocities). MTR scores provide an indication of the nutrient enrichment / eutrophication in the river, ranging from <25 (site is badly damaged by eutrophication, organic pollution, toxicity or is physically damaged) to >65 (site is unlikely to be eutrophic) (see Table D 3.1 and D 3.2)

Table D 3.1 Interpretation of MFR scores used for this assessment

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

Table D3.2 Interpretation of MTR scores (from Holmes *et al.*, 1999[7])

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

Twelve macrophyte species were recorded at the Llanfigael site in 2004 with 18 taxa observed in 2005. The samples taken at the Llanfigael site indicated similar conditions with a RMNI scores of 7.6 and 7.41 recorded in 2004 and 2005 respectively. These scores are indicative of mesotrophic to eutrophic conditions. The relatively high RMHI scores observed in 2004 and 2005 of 7.66 and 7.47 respectively is indicative of a macrophyte community with a preference for moderate to slow flowing conditions.

The MFR score for the samples identified in the baseline data for the Afon Alaw was indicative of a plant community showing a preference to moderate flow velocity, with a score of 2.18 and 2.45 observed in 2004 and 2005 respectively. The MTR scores on the Afan Alaw are indicative of a sites which are likely to be either eutrophic or at risk of becoming eutrophic with a MTR of 41.9 and 44.1 observed in 2004 and 2005 respectively.

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

Table D 3.3 LEAFPACS and MTR Nutrient and Flow Scores for NRW Macrophyte Sampling Sites on the Afon Alaw

Site	Date	MFR	MTR	RMHI	RMNI
Llanfigael	27/07/2004	2.18	41.9	7.66	7.6
	27/07/2005	2.45	44.1	7.47	7.41

Typical species identified during both the 2004 and 2005 surveys included *Callitriche obtusangula*, *Ranunculus penicillatus* subsp. *penicillatus*, *Sparganium erectum* and *Sparganium emersum*. *Alisma_lanceolatum*. Species that were observed in low cover percentages includes *Alisma plantago-aquatica*, *Amblystegium riparium*, *Apium nodiflorum*, *Chiloscyphus polyanthos*, *Lemna minor*, *Myriophyllum alterniflorum* and *Oenanthe crocata*.

D.3.1.2 Assessment

Llyn Alaw

Hydrological impacts on Llyn Alaw have been assessed as minor beneficial, with operation of the drought permit lessening the extent and duration of drawdown and increasing winter refill speed from what would be expected during a drought under normal operating conditions. The resultant extent and pattern of drawdown and shoreline exposure is expected to be within the envelope experienced during normal operating conditions. Therefore, impacts of the drought permit on the ecology of Alaw reservoir are deemed negligible and are not considered further. This screening decision, along with the nature conservation interest of the reservoir (including slender spike rush and bryophyte species of interest) is discussed in more detail in Section D2.2 in regard to the Llyn Alaw SSSI.

Afon Alaw

The assessment of impacts on the macrophyte community should be considered in the context of the watercourse under baseline conditions, i.e. the macrophyte community present under normal operating conditions and flow regime. As a result of the limited data, collection of baseline data on macrophyte communities of the Afon Alaw is recommended to help inform the assessment of impacts of the drought permit.

Reduction in flows could reduce the overall extent of habitat favoured by lotic species present within the study area and favour those species more adapted to lentic and marginal / riparian conditions. However, the limited baseline data available suggests that the macrophyte community associated with the Afon Alaw are adapted to moderate to slow flowing water.

Reduction in flows could affect macrophyte communities in a number of ways:

- Reduction in abundance and distribution of flow sensitive macrophytes as a result of reduced flow velocities;

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

The additional risk of water quality deterioration associated with Soluble Reactive Phosphorus (SRP), which is major for Reach 1, could encourage macrophyte growth and increase the occurrence of more opportunistic taxa, epiphytes and filamentous algae. In turn, this could affect macrophyte condition and potentially community composition if slower growing species or those that prefer lower nutrient conditions are outcompeted. Given the major reduction in flows teamed with the potential increase in SRP, the potential for proliferation of filamentous algae is of particular concern during the spring and summer period.

Hydrological impacts as a result of drought permit implementation in Reach 1 are anticipated to be major adverse all year round when the reservoir is below spill level, including a reduction of 47% of low flows (Q_{95}) and extreme low flows (Q_{99}) with corresponding reductions in wetted depths / wetted widths.

Available data indicates that the macrophyte community associated with the Afon Alaw is adapted to moderate to slow flowing conditions, likely to be either eutrophic or at risk of becoming eutrophic. It should be considered that the baseline information is based on data from a single site located in the lower reaches of the hydrological zone of influence with surveys limited to 2004 and 2005. Given the data limitations a precautionary approach should be applied in the assessments. Due to the potential extent of change to wetted area, depth and flow velocities during the main macrophyte growing season, operation of the drought permit has the potential to affect the condition, composition and extent of macrophyte communities. Low flows may also favour the proliferation of filamentous algae species due to changes in velocity, water temperature, and concentrations of nutrients (SRP). The impacts of the drought permit (above and beyond those of drought under normal operating conditions) on the macrophyte communities are therefore assessed as **moderate** adverse, short term and reversible during the growing season and **minor** adverse, short term and reversible during the winter.

Summary

The potential impacts of the Alaw Reservoir compensation flow drought permit on the macrophyte community are summarised in **Table D3.4**. The impacts, and their magnitude, are based on the hydrological impacts (see Appendix B), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Appendix B) and the sensitivities of the macrophyte community. The impacts presented in **Table D3.4** represent the worst case scenarios of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D3.4 Summary of Impacts on Macrophyte Community

Reach 1 - (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)		
Feature	**Impact**	**Significance of Impact**
Macrophytes	• 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 increase in nutrients (SRP) and habitat loss due to reduction in wetted width. • Increase in filamentous and epiphytic algae levels due to increased nutrients (SRP) or water temperature and decreased velocity.	**Moderate** (June to September) **Minor** (October to December)

The macrophyte subcomponent of the Alaw – downstream Llyn Alaw (GB110102058981) waterbody was not classified during either 2015 cycle or 2018 interim cycle.

Without macrophyte data or current classification with regard to macrophytes it is not known how potential changes to the macrophyte community are likely to affect the WFD classification, e.g. by causing a drop from good status. There is a **moderate** risk of short term deterioration in WFD status of the macrophyte subcomponent of the Alaw – downstream Llyn Alaw (GB110102058981) water body. This is based on a precautionary approach and has taken into account in particular, the potential for relatively large decreases in flow, teamed with increases in SRP to encourage rapid proliferation of filamentous algae (a key factor in WFD classification for macrophytes).

D.3.2 Macroinvertebrates

D.3.2.1 Baseline

Baseline information received from NRW included one site on the Afon Alaw; Llanfigael in Reach 1. Data presented covers the period 2005 to 2015 inclusive (see **Figure D1.1**).

Sampling was conducted following the standard NRW / Environment Agency protocol involving a three-minute kick/sweep sample encompassing all the available instream habitats in proportion to their occurrence[8]. For data collected between 2006 and 2015

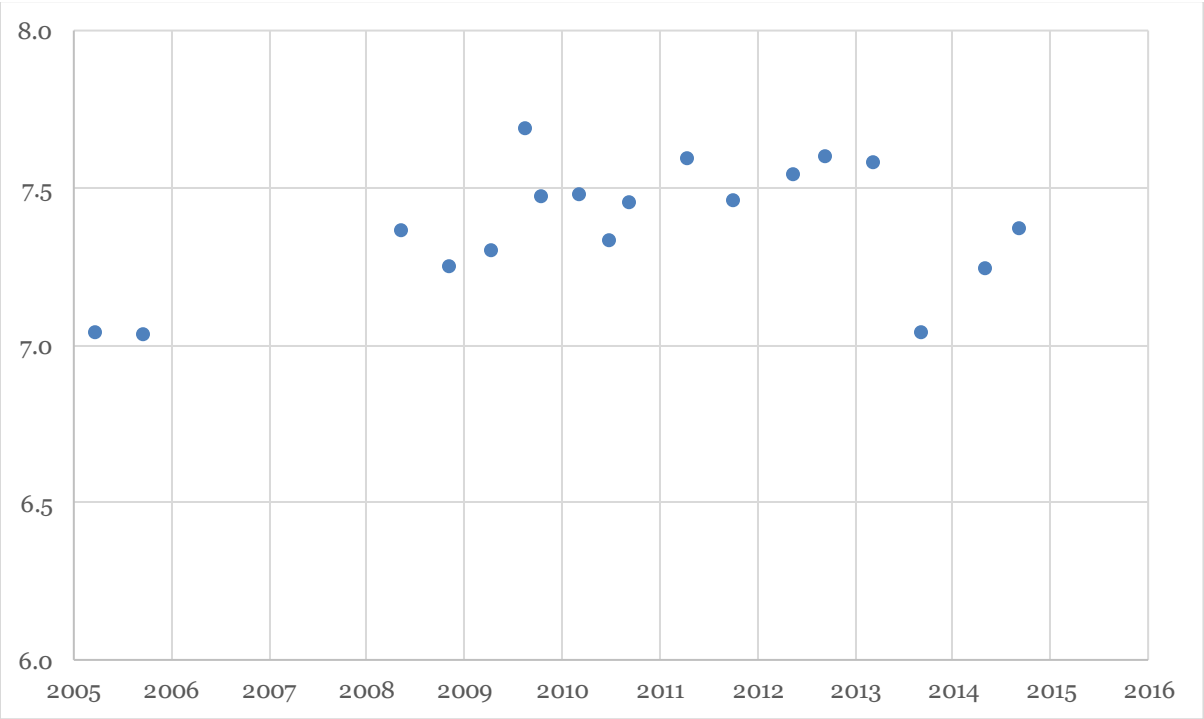
[8] Environment Agency (1999) *Procedures for Collecting and Analysing Macroinvertebrate Samples* (Issue 2.0), Environment Agency BT001.

macroinvertebrates were identified in some cases to species level and the abundances recorded as actual values. These datasets are used to calculate a series of standard biotic indices; Biological Monitoring Working Party (BMWP) scores, Average Score Per Taxon (ASPT) scores, Lotic Invertebrate Flow Evaluation (LIFE) and number of taxa. There are no quality bands for BMWP scores and ASPT scores. However, as a guide, BMWP scores of 200 with ASPT values above 6 are indicative of rivers of exceptionally good quality, while BMWP scores of 100 with ASPT values of 5 are indicative of reasonably good water quality. Data for LIFE, ASPT and BMWP are graphically presented in **Figures D3.1, D3.2** and **D3.3** for the Afon Alaw.

The data shows a relatively diverse macroinvertebrate community including taxa common to fast flowing streams and rivers such as mayflies (phemeroptera, stoneflies Plecoptera and caddisflies Trichoptera, riffle beetles Elmidae and freshwater shrimp Gammaridae. Taxa usually preferring slower flows and more tolerant of organic pollution are also represented, including water hog-louse *Asellus* sp.) and molluscs, in particular the non-native New Zealand mud snail *Potamopyrgus antipodarum* which was present at relatively high numbers on some sampling occasions.

LIFE scores at Llanfigael in the Afon Alaw ranged from 7.03 to 7.69 with an average of 7.38. The LIFE scores indicate the presence of invertebrate families that favour predominately moderate to fast velocity habitats with a community that has high sensitivity to reductions in flow velocity.

Figure D3.1 Observed Family LIFE Scores within the Afon Alaw at Llanfigael (46183)



The ASPT scores in the Afon Alaw range from 5.23 to 6, with between 23 and 31 taxa recorded per sample, this indicates moderate to good water quality. This is supported by the presence of invertebrate taxa that favour clean water with high oxygen levels.

The BMWP scores for the Llanfigael site on the Afon Alaw fall within the range 133 to 179 with an average of 151, indicating good water quality.

ASPT and Number of taxa values show some variation across the monitoring period with evidence of a relatively stable invertebrate community associated with good water quality in Reach 1. Overall the baseline data for the Afon Alaw provide evidence for a macroinvertebrate community which is subject to minor anthropogenic impacts.

Figure D3.2 Observed ASPT Scores within the Afon Alaw at Llanfigael (46183)

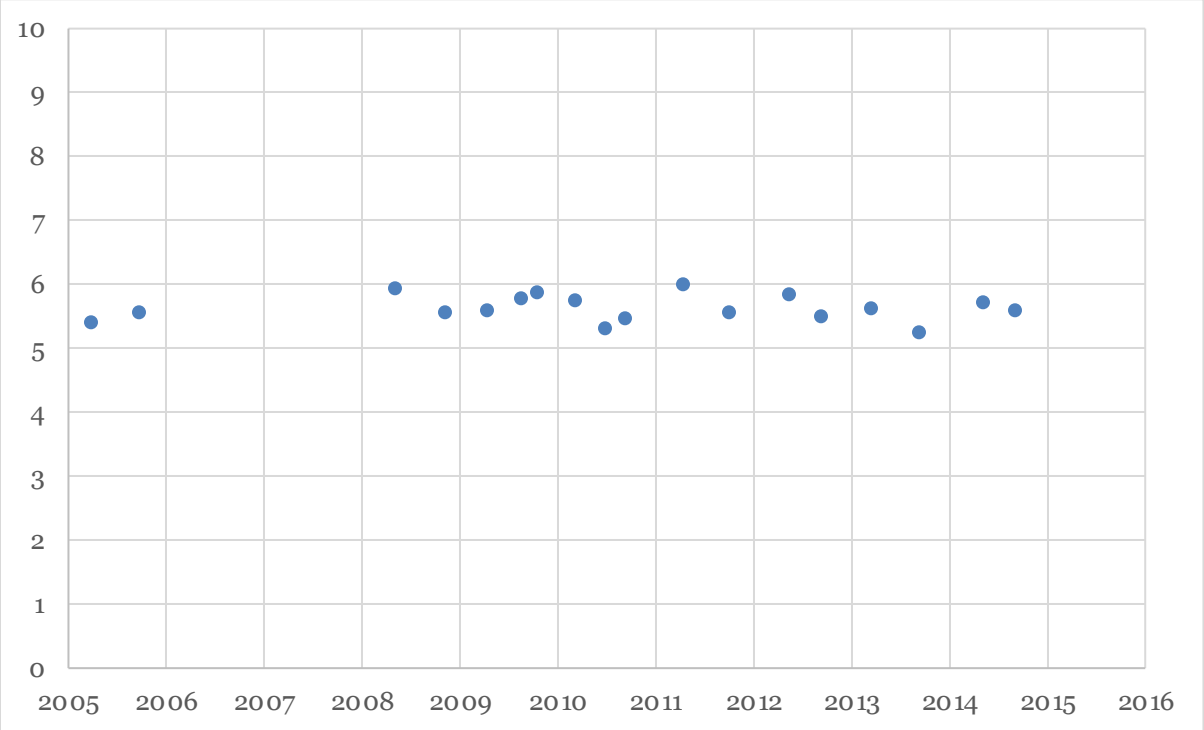
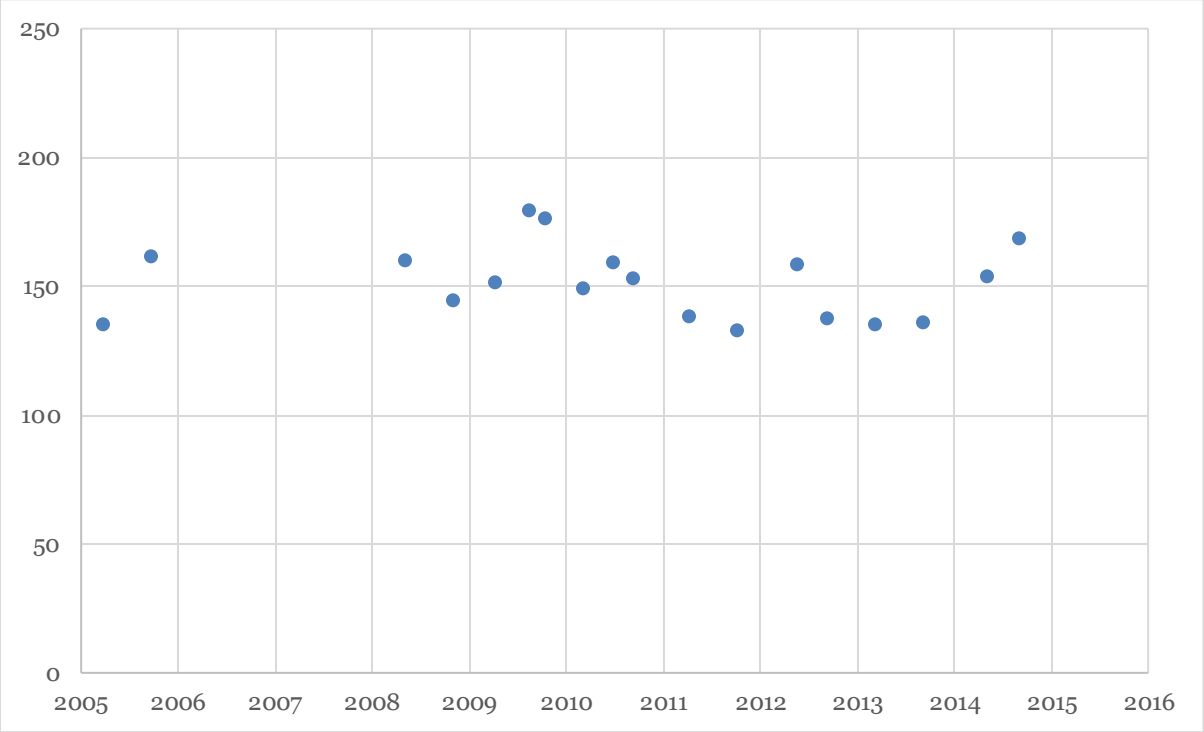


Figure D3.3 Observed BMWP Scores within the Afon Alaw at Llanfigael (46183)



D.3.2.2 Assessment

Llyn Alaw

Hydrological impacts on Llyn Alaw have been assessed as minor beneficial (as outlined in Section 3.1.2).

Afon Alaw

Operation of the drought permit will result in a major reduction in flows (47% of low and extreme low flows (Q95 and Q99 respectively)), resulting in a moderate reduction in wetted depth/width (**Appendix B – 8001_3**), with an associated loss of marginal habitats and reduction in habitat area and quality. Due to the reduction in velocity it is possible that some of the flow sensitive taxa may be temporarily lost from the reach, including stonefly, mayfly, and caddisfly taxa such as Heptageniidae, and Rhyacophilidae. The LIFE scores for the sites in all reaches indicated taxa with a preference for moderate to 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 proliferation of invertebrate taxa which favour slower flows. However, in lotic environments macroinvertebrates can quickly recolonise once suitable flow conditions are restored through immigration from upstream habitats and local refugia (e.g. pools, subsurface habitats, tributaries).

Marginal habitats are sensitive to flow reduction, with many slow-flow favouring species such as molluscs utilising this habitat. Depending on the rate of flow reduction, species in these

marginal sediments may become stranded and ultimately die.

The reduced flows could also result in a short-term change to composition of the substrate, with finer substrates potentially deposited. Although this is a temporary impact, in the short-term, this could result in the smothering of individuals[9] and changes to habitat suitability for taxa that require stony substrates free from fine sediments, which could result in a reduction in species diversity. However, significant increases to sedimentation are considered unlikely (see **Appendix B – 8001-3**, Section B.2.1.4 geomorphology), as such the magnitude of the related impacts are not considered to be above low for the impacted reach.

There is a moderate risk of water quality deterioration associated with dissolved oxygen and minor risk associated with ammonia in Reach 1. The BMWP and ASPT scores indicate the presence of macroinvertebrate communities with a high proportion of taxa sensitive to decreases in dissolved oxygen. Consequently, it is likely that in the short-term this impact will modify the macroinvertebrate community with a moderate reduction in abundance of species which require high oxygen levels (such as stonefly and mayfly species) and proliferation of taxa which can tolerate lower dissolved oxygen levels, such as water hog-louse. A number of crustacean taxa such as the freshwater shrimps Gammaridae are particularly sensitive to ammonia. Consequently, there is the potential that in the short-term this impact will modify the macroinvertebrate community with a reduction in abundance of ammonia sensitive species. The impacts due to water quality deterioration are considered to be moderate.

Overall, considering the composition of the baseline macroinvertebrate community, the short-term, temporary and reversible hydrological impacts of the drought permit and the effective recolonisation strategies of macroinvertebrate species, impacts are on the macroinvertebrate community are assessed as **moderate**.

Summary

The potential impacts of the Alaw Reservoir drought permit on the macroinvertebrate community are summarised in **Table D3.5**. The impacts, and their magnitude, have been based on the hydrological impacts (see Appendix B), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Appendix B) and the sensitivities of the macroinvertebrate 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.

[9] 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.

Table D3.5 Summary of Impacts on Macroinvertebrate Community

Reach 1 – Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)		
Feature	**Impact**	**Significance of Impact**
Macroinvertebrates	• 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. • Reduction is species abundance and/or diversity due to water quality deterioration.	**Moderate**

The Afon Alaw - downstream Llyn Alaw (GB110102058981) waterbody has been classified as having good ecological status for macroinvertebrates during the 2015 cycle and as good during the 2018 (interim) cycle.

Consequently, there is a **moderate** risk of short term deterioration to the WFD status macroinvertebrate component of the Afon Alaw - downstream Llyn Alaw (GB110102058981) water body.

D.3.3 Fish

D.3.3.1 Baseline

Information regarding fish populations within the potential zone of influence on the Afon Alaw is limited to the data resulting from semi-quantitative fish surveys undertaken by NRW (and previously Environment Agency Wales, EAW) at one site. The available data are sufficient to provide a general understanding of the fish population in the potential zone of influence but are **not** adequate to allow a detailed or robust assessment of the impact of a drought permit.

Existing data

Semi-quantitative fish survey data from 2004, 2011 and 2014 for one site (called Site 1), located near Llanfigael (SH3278282712), were made available and have been analysed as part of this assessment. The data consists of juvenile salmonid (brown trout *Salmo trutta* and Atlantic salmon *Salmo salar*) densities and counts of other species in 2011 and 2014.

A fisheries monitoring programme was recommended as part of the EMP process[10], however, no additional monitoring has been undertaken since 2007 with the exception of the routine NRW fish surveys discussed above.

The 'Alaw - downstream Llyn Alaw' waterbody (GB110102058981) was assessed as being at high status for fish in 2015.

[10] Cascade Consulting (2007). Provision of an Environmental Monitoring Plan. Environmental Monitoring Plan for Alaw Reservoir (N4). Final. 29th May 2007. A report for DCWW by Cascade Consulting in association with APEM.

Species composition

Five fish species have been recorded in the Afon Alaw within the potential zone of influence; Atlantic salmon (NERC Act Section 41 and Habitats Directive Annex II species), brown / sea trout (NERC Act Section 41 species), European eel *Anguilla anguilla* (NERC Act Section 41 species and IUCN Red List species) along with unidentified lamprey and stickleback species.

The available data from Site 1 suggest above average juvenile trout densities (Grades B and C[11]) but juvenile Atlantic salmon were absent in 2011 and 2014. No area (m^2) data was made available for the surveys so it is not possible to investigate the density of the other species recorded in these NRW surveys.

Records of lamprey and stickleback species are not speciated in the data so it is not known which of the protected lamprey species (brook lamprey *Lampetra planeri*, river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus*) are present.

The available data does not allow any meaningful investigation into the status of fish populations within the zone of influence.

Data limitations

The available data is not sufficient to adequately describe the fisheries baseline. There is considerable uncertainty surrounding the status of fish populations present including protected species (e.g. lamprey species). Further monitoring would be required in order to assess the potential impacts of a drought permit over and above those of a natural drought.

The precautionary principle has therefore been used in the following assessment which is based on a conservative approach assuming that significant populations of protected species exist.

In order to obtain a suitable baseline, a suite of electric fishing surveys (including lamprey-specific surveys) in one year with adequate coverage of the hydrological reach would be required as a minimum.

Ecological value of fisheries receptors

Atlantic salmon and the lamprey species are NERC Act Section 41 and Habitats Directive Annex II species and are considered to be of National importance. Brown/sea trout (NERC Act Section 41 species) and European eel (NERC Act Section 41 and IUCN Red List 'Critically Endangered' species) are also considered to be of National importance. Stickleback species are considered to be of Local importance only.

[11] 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).

D.3.3.2 Assessment

Hydrological variability in rivers can have a significant influence on the distribution of fish. When extreme low flows, or prolonged periods of low flow, are experienced, for example under continued water abstraction during drought conditions, the resultant changes in the hydrological regime can have significant impacts on resident fish communities. Abstraction of water from a river or stream reduces the wetted area and volume with the potential for subsequent impacts on fish populations as a result of, for example, intra- and inter-specific interactions (e.g. increased competition for optimal habitat and food)[12,13], reduced water quality and reduced reproductive success, growth and condition[14].

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 potential year-round impact period.

The reach is predicted to undergo a reduction in flow of up to 53% with a drought permit and, whilst mortality under these conditions may be significant, fish species have evolved mechanisms in order to cope with low flow conditions, for example, avoidance behaviour (i.e. moving downstream as water levels drop) or the ability to persist in pooled areas of deeper water. However, flow sensitive species such as Atlantic salmon and brown trout are, nonetheless, susceptible to reduced flows.

Atlantic Salmon

Atlantic Salmon Migration

Atlantic salmon have been recorded in the lower Afon Alaw, however, the status and range of the species within this river is not known. The precautionary approach suggests that Atlantic salmon may be utilising spawning and nursery habitat throughout Reach 1. The majority of Atlantic salmon migration into Afon Alaw is likely to occur from October to December and a drought permit may affect this migration. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature and therefore a drought permit is unlikely to interact with this migration.

Adult Atlantic salmon migrations are linked to flow increases and river flow is considered to be a primary cue. Very low flows are likely to delay migration, thereby increasing mortality due to increased predation and stress. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on adult Atlantic salmon migration is therefore considered to be **moderate** adverse in Reach 1, due to potential delays

[12] 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
[13] 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.
[14] 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.

caused by a reduction in flow.

Water Quality

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in habitat to increase stress and subsequent loss of condition. Atlantic salmon are susceptible to poor water quality and particularly dissolved oxygen and water temperature. The effects of reduced water quality are likely to impact particularly sensitive juvenile life stages. The impact is therefore considered to be of medium magnitude, short-term, temporary and reversible. The impact on Atlantic salmon is therefore considered to be **moderate** adverse in Reach 1, due to a potential reduction in water quality.

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. Gravels containing alevins and / or early-stage fry (likely to occur in April and May) will not be affected. However, fry and parr populations are susceptible during the drought permit implementation period. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on juvenile Atlantic salmon is therefore considered to be **major** adverse in Reach 1, due to potential habitat loss.

Brook, river and sea lamprey

Migration of river and sea lamprey

Mature river lamprey migrate upstream into freshwater in the autumn (from October to December[15]). 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. The impact is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on river lamprey migration is therefore considered to be **moderate** adverse in Reach 1.

Mature sea lamprey migrate upstream into freshwater in April and May prior to spawning. Sea lamprey ammocoetes metamorphose after approximately five years in freshwater and then descend to marine environments between July to September[16]. Similar to river lamprey, adult

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

sea lamprey require reasonably high flows between April and June in order to aid upstream passage, and are therefore not at risk of impacts associated with a drought permit. The impact is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on the upstream migration of sea lamprey considered to be **negligible,** while impacts on the downstream migration of post metamorphic individuals are considered **minor** adverse in Reach 1, as only the latter parts of the migration period would be effected.

Spawning and juvenile (ammocoete and transformer) brook, river and sea 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 are likely to relocate to areas of suitable habitat if river levels decrease, however, competition and stress would likely increase. Nests with incubating eggs (likely to occur in April and May prior to hatching) are unlikely to be effected. The impact is considered to be of high magnitude, short-term, temporary and reversible. The impact on lamprey juvenile habitat is therefore considered to be **major** adverse in Reach 1, due to potential habitat loss.

Water quality

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

<u>Brown / Sea Trout</u>

Sea Trout Migration

It is not known whether sea trout are currently migrating into the Afon Alaw. However, the precautionary approach suggests that sea trout *may* be utilising spawning and nursery habitat within Reach 1. The majority of any sea trout migration into the Afon Alaw is likely to occur from September to November and there is the potential for a drought permit to interact with this migration. The majority of out-migrating smolt would be likely to migrate between mid-March and mid-May depending on water temperature and therefore is unlikely to be affected by a drought permit. Adult and smolt-stage sea trout migration, like Atlantic salmon, is linked to flow increases and river flow is considered to be a primary cue. Very low flows are likely to delay migration, thereby increasing mortality due to increased predation and stress. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on sea trout migration is therefore considered to be **major** adverse in Reach 1, due to potential delays caused by a reduction in flow.

Water Quality

Potential water quality impacts (e.g. reduced dissolved oxygen and increased water temperature) as a result of a reduction in flow are likely to act in tandem with a reduction in habitat to increase stress and subsequent loss of condition. Brown / sea trout are susceptible to poor water quality and particularly dissolved oxygen and water temperature. The effects of reduced water quality are likely to impact particularly sensitive juvenile life stages. The impact is therefore considered to be of medium magnitude, short-term, temporary and reversible. The impact on brown / sea trout is therefore considered to be **moderate** adverse in Reach 1, due to a potential reduction in water quality.

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) are unlikely to be effected Fry and parr populations which are, however, likely to be particularly susceptible during the drought permit implementation. The impact is therefore considered to be of high magnitude, short-term, temporary and reversible. The impact on juvenile brown / sea trout is therefore considered to be **major** adverse in Reach 1, due to potential habitat loss.

<u>European Eel</u>

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 have a significant impact on migration. The downstream migration of mature (silver) eel tends to occur between September and December in most rivers and there is therefore the potential for a significant impact on this life stage. European eel of a wide age range are likely to be present in low densities throughout Afon Alaw but the species is tolerant of high temperatures and relatively poor water quality and is considered resilient to drought conditions. The impacts on European eel are therefore considered to be limited to silver eel migration and this is considered to be **moderate** adverse in Reach 1.. Impacts on other European eel life stages are considered to be **negligible**.

<u>Other fish species</u>

Stickleback spawning and egg incubation may be affected by drought permit implementation. This species is therefore susceptible to impacts associated with low flows. However, the stickleback specie are considered particularly tolerant of poor habitat and water and the impact is therefore considered to be of low magnitude, short-term, temporary and reversible. The impact on other fish species is therefore considered to be **minor** adverse in Reach 1.

Summary

The potential impacts of the Llyn Alaw drought permit on the fish community are summarised in **Table D3.6**. The impacts, and their magnitude, have been based on the hydrological impacts (see Appendix B), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Appendix B) and the sensitivities of the fish community. The impacts presented in **Table D3.3** represent the worst case impacts of implementing a drought permit, over and above the impacts potentially caused by a natural drought.

Table D3.6 Summary of Impacts on Fish Community

Feature	Impact	Significance of Impact
Reach 1 – Afon Alaw (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)		
Atlantic salmon	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Moderate**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
Brook, river and sea lamprey	• Migration of river and sea lamprey adults and transformers affected or halted by a reduction in flow.	**Moderate**
	• Loss of spawning and juvenile habitat as a result of reduced river levels.	**Major**
	• Reduced water quality	**Negligible**
Brown/sea trout	• Delays and potential cessation of adult and smolt migrations due to reduced flows.	**Major**
	• Reduced water quality	**Moderate**
	• Reduction in spawning and juvenile survival due to habitat loss.	**Major**
European eel	• Delays and potential cessation of silver eel migration due to reduced flows.	**Moderate**
	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Negligible**
Other species	• Habitat loss and reduced water quality. Reduction in survival due to potential cessation of flow.	**Minor**

There is a risk of short-term deterioration in status of the fish component of the 'Alaw - downstream Llyn Alaw' waterbody (GB110102058981) due to the drought permit. Impacts of drought permit implementation on the fish communities of the impacted reaches have been summarised as negligible to major adverse, short-term, temporary and reversible.

Consequently, the fish component of these waterbodies is considered to be at **major** risk of short-term deterioration.

D.3.4 Phytobenthos

D.3.4.1 Baseline

Phytobenthos data were provided by NRW for one sites located within the Afon Alaw located near Llanfigael at the downstream end of Reach 1. Monitoring was undertaken during spring and autumn during 2013 and 2014. Considering the temporal constraints on the baseline information, care must be taken in their interpretation.

The data provided were used to calculate TDI3 and TDI4 Scores according to the DARLEQ system. Percentage Motile Valves and Percentage Organic Tolerant Valves were also calculated using the DARLEQ tool. Scores are provided in **Table D3.7**

Table D3.7 DARLEQ Metrics for Phytobenthos Data from the Afon Taf Fawr

Site	Date	TDI3	TDI4	% Motile	% Organic tolerant
Llanfigael	20/05/2013	42.7		43	26
	06/09/2013	69.72		30	23
	05/05/2014	42.8	36.76	23	7
	03/09/2014	60.21	57.17	24	9

TDI3 and TDI4 scores suggest seasonal variation with low nutrient levels observed in spring and higher nutrient levels observed in autumn. This suggests oligo-mesotrophic conditions in spring and meso-eutrophic conditions in autumn. Relatively low proportions of phytobenthos tolerant of organic pollution suggests that organic enrichment is relatively low and other sources of phosphate such as diffuse pollution may account for the relatively high TDI scores observed in spring.

The diatom community was numerically dominated by *Achnanthidium minutissimum*, a species common and often abundant in upland streams with mobile substrates. This species is also relatively tolerant to high metal concentrations.*Cocconeis_placentula_var._euglypta* and *Cocconeis_placentula_var._lineata* was also present in high abundances. These species are cosmopolitan, occurring in standing and flowing waters on a variety of substrates with a moderate sensitive to pollution. Less abundant were taxa such as *Rhoicosphenia_abbreviata*, *Navicula_viridula*_var._*germainii*, *Navicula_cryptocephala*, *Nitzschia_dissipata*, *Achnanthidium_minutissimum*, *Amphora_pediculus*, *Navicula_gregaria* and *Gomphonema_minutum*. These taxa are all cosmopolitan with a moderate to high tolerance to pollution. A relatively high abundance of *Rhoicosphenia abbreviata* at this site suggests relatively high levels of filamentous algae may have been present at the time of sampling.

D.3.4.2 Assessment

Impacts on the phytobenthos assemblages of the Afon Alaw 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 Reach 1 is likely to result in changes to the phytobenthos communities present within the timeframe of the drought permit.

Furthermore, WFD EQR metrics for diatoms (TDI4 in DARLEQ)[17] are designed to detect differences in nutrient levels, particularly Soluble Reactive Phosphorus (SRP). Implementation of the drought order is expected to result in major impacts to SRP, which in turn is likely to affect the diatom community and associated WFD status. However, due to the rapid response of diatom communities to environmental variables, this effect is expected to be short lived, with communities recovering rapidly (i.e. within one season) following return to the normal hydrological regime, and therefore normal nutrient status. Therefore, the impact of the drought permit on WFD phytobenthos assessment for the Afon Alaw Reach 1 is likely to be **moderate,** short term and reversible**.**

Summary

The potential impacts of the Alaw Reservoir drought permit on the phytobenthos community are summarised in **Table D3.8**. The impacts, and their magnitude, have been based on the hydrological impacts (see Appendix B), their influence on the physical environment (including geomorphology, water quality and likely habitat availability) (see Appendix B) and the sensitivities of the 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 D3.8 Summary of Impacts on Phytobenthos Community

Feature	Impact	Significance of Impact
Reach 1-Afon Alaw - (Alaw Reservoir Outflow to tidal limit at Llanfachraeth)		
Phytobenthos	• Changes to community composition due to changes in velocity and water quality	**Moderate**

The phytobenthos subcomponent of the Alaw - downstream Llyn Alaw waterbody was classed as having moderate WFD status in 2015, and was not assed as part of the interim (2018) classification.

Consequently, there is a **moderate** risk of short term deterioration to the WFD status

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

phytobenthos sub-component of the Alaw - downstream Llyn Alaw water body.

D.3.5 Invasive Species

D.3.5.1 Baseline

Three non-native species were present in the macroinvertebrate data received from NRW; a freshwater shrimp *Crangonyx pseudogracilis*, New Zealand mud snail *Potamopyrgus antipodarum*, and a flatworm *Dugesia tigrina*. *C. pseudogracilis* and *P. antipodarum* are both widespread and naturalised across the England and Wales, as such changes to the hydrological regime are unlikely to increase the distribution and are not considered further in this assessment.

Dugesia tigrina was recorded in low numbers during three sampling occasions at Llanfigael in Reach 1 (see **Table D3.9**). It is a North American species that is increasing in range and numbers and has been noted to displace native *Polycelis* species due to competition for food in lakes in North Wales[18].

Table D3.9 Non-native macroinvertebrate species recorded by NRW monitoring on the Afon Alaw (N.B. data from semi-quantitative sampling; numbers should be considered as an indication of relative abundance only.)

Site/Station Name	Sample Date	*Crangonyx pseudogracilis*	*Potamopyrgus antipodarum*	*Dugesia Tigrina*
Llanfigael	08-Apr-09		150	4
	14-Oct-09	240	60	
	05-Mar-10	50	13	
	24-Jun-10		600	
	11-Apr-11	2	46	
	03-Oct-11	1	382	
	16-May-12		765	
	07-Sep-12	1	160	
	11-Mar-13	54	4	1
	06-Sep-13		47	
	05-May-14		50	
	03-Sep-14		1100	1

D.3.5.2 Assessment

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

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

Summary

The potential impacts of the Llyn Alaw drought permit on invasive flora and fauna are summarised in **Table D3.10**.

Table D3.10 Summary of Impacts on Invasive Species

Feature	Impact	Significance of Impact
Reach 1		
Invasive Species – *Dugesia tigrina*	• Implementation of the drought permit will do nothing favour proliferation of this species.	**Negligible**

D4 RECREATION AND ARCHAEOLOGY

D.4.1 Recreation

D.4.1.1 Baseline

The Afon Alaw provides recreational opportunities, especially for walkers, bikers, fishers and boaters.

D.4.1.2 Assessment

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. Any reduction in wetted width and depth may influence water-dependent activities such as angling and canoeing. However, water levels will be naturally low in times of drought and the impacts will be temporary in nature and will be ameliorated once the drought has passed. Therefore the recreational impacts are assessed with limited data as having a **negligible** risk.

D.4.2 Archaeology and Cultural Heritage

D.4.2.1 Baseline

No archaeological or cultural heritage features were screened in for potential impact as a result of the drought permit implementation.

Summary

The potential impacts of the Alaw Reservoir drought permit on recreation and archaeology 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 Recreation and Archaeology and Cultural Heritage

Feature	Impact	Significance of Impact
Afon Alaw		
Landscape	• Flows during a drought will be low such that further reduction in flows due to the drought permit would not result in a further loss of aesthetic value	**Negligible**
Recreation	• Impacts on recreation activities (e.g. angling, canoeing, walking) are not anticipated over those from the natural drought conditions	**Negligible**