Afon Claerwen, Rhyader

Geomorphological Survey and WFD Assessment

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Revision B

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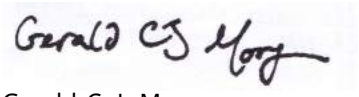
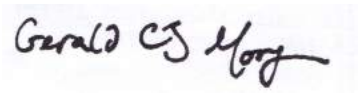
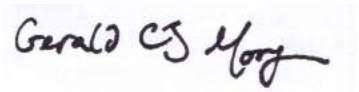
Written by	 Gerald C. J. Morgan	25th July 2018
Checked by	 Gerald C. J. Morgan	17th August 2018
Approved by	 Gerald C. J. Morgan	22nd August 2018

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1 Introduction

1.1 Study Area

Edenvale Young Associates (EVY) have been commissioned to undertake a geomorphological assessment of Afon Claerwen, Powys, in connection with a proposed hydroelectric generation scheme. This report details the results of the geomorphological walk-over survey conucted by staff from EVY and Natural Resources Wales (NRW).

The site is located in the River Wye catchment, upstream of the Dolymynach Reservoir. Afon Claerwen flows in an south-east direction and is a tributary of the River Elan. It is a headwater stream fed by the upstream Claerwen Reservoir and Afon Arban watercourse as well as lateral inflows from the surrounding hill slopes. The site location and key features are shown in figure 1.1.

1.2 Proposed Scheme

The proposed hydroelectric scheme involves construction of an intake structure across Afon Claerwen 1.5km downstream of the Claerwen Reservoir. This will allow water to be diverted into a buried pipeline, and taken to a turbine house 1.7km downstream of the intake structure. The turbine house will be located just upstream of the confluence with the Rhiwnant watercourse and the Dolymynach Reservoir. Water would return to the Afon Claerwen almost adjacent to the turbine house. The scheme intends to take advantage of a 34 metre drop between the intake and outfall and will result in a derogated reach of approximately 1.7 km. A detailed map showing the intake and outfall locations and the proposed route of the pipeline is shown in figure 1.2.

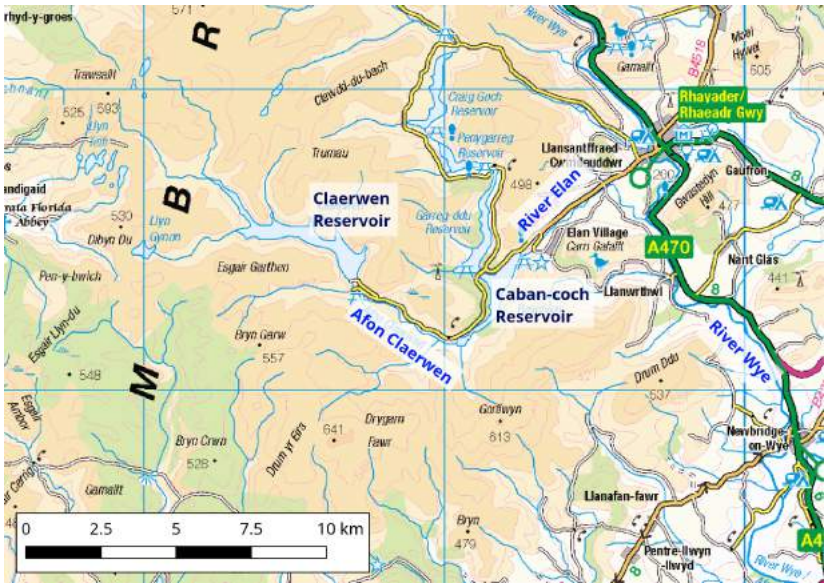

Figure 1.1: Site location and key features

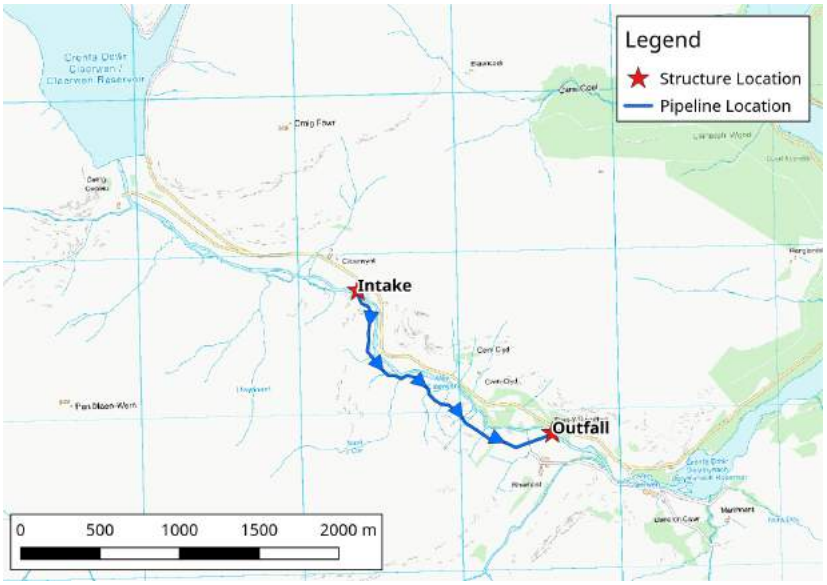

Figure 1.2: Map of proposed scheme

The flow abstractions for this scheme would follow the following conditions set out by NRW:

- Flows will be abstracted only when water is being discharged from the Claerwen Reservoir, upstream.
- The "hands off flow" would match the flow of the Afon Arban tributary.
- The maximum turbine intake would be 3.7 m³/s.

1.3 Designations

The intake is located within the Elenydd Site of Special Scientific Interest (SSSI) and the Elenydd Area of Conservation (SAC) for biological and physical interests.

Afon Claerwen flows into the Dolymynach Reservoir which then flows into the River Elan, a designated SSSI (Upper Wye Tributaries) and SAC (River Wye). The River Wye and Tributaries SSSI includes the following species listed in the EC Habitats and Species Directive: Atlantic Salmon, bullhead and otter. This area is also a Special Protection Area as it has an unique habitat for Red Kite, Peregrine Falcon and Merlin.

1.4 Consultation

EVY have undertaken consultations with NRW regarding the geomorphology of this reach and the suitability of this scheme in this location. NRW highlighted that there are local issues with gravel supply in the River Elan, located downstream of the Elan Reservoir system. A large amount of gravel is currently moved through the Afon Claerwen, and is deposited in the downstream Dolymynach Reservoir. This was evident on the site visit.

NRW further indicated that the Afon Claerwen river reach is quite stable, with gravel islands persisting over many years without movement. The reach is characterised by bedrock and boulders and set within a confined valley. This valley has little potential for geomorphological adjustment which makes it relatively resilient to change and the current flow regime shows that sediment dynamics are unlikely to experience major change.

NRW indicated that:

- any gravel build-up behind the intake structure should remain in place for the life of the structure and the intake weir should therefore be carefully designed to prevent gravel build-up or reach an equilibrium that does not affect the functioning of the scheme.
- flow from the Afon Arban be measured in order to correctly limit the abstracted flow amounts (this measurement could be taken as a difference between flow from the Claerwen reservoir and flow at the intake structure)
- the left-bank gully/tributary at the intake structure location be considered and incorporated/managed by the intake structure design

2 Survey Methodology

2.1 Study Scope

EVY were commissioned to undertake a Geomorphological Survey in support of the scheme application and in accordance with the NRW's requirements. The study aims to identify where the proposed scheme is likely to have a hydrological and/or morphological impact and the degree of any such impact. As such, it focuses on the proposed derogated reach of approximately 1.7 km. This report will cover the following areas:

- Flows
- Sediment dynamics
- Bed/bank erosion
- Riparian zone
- Scale of geomorphological impacts
- Ecological impact

The objectives of the study are to identify any risks from the proposed abstraction on the geomorphology and flow regime of Afon Claerwen. To achieve this, the methodology described in the following sections has been adopted.

2.2 Desk-based Study

A desk based study has been undertaken to draw together existing sources of data relating to Afon Claerwen and analyse how these might inform the investigation of the potential for changes in sediment dynamics. These sources include:

- Drift and solid geology using British Geological Survey (BGS) maps.
- Catchment descriptors from the Flood Estimation Handbook (FEH) CEH-Web Server.
- Details of associated studies undertaken in support of the proposed development such as ecological studies or low flow analysis.
- An evaluation of the proposed flow changes.
- Existing or historical uses of the river such as impoundments, abstractions and discharges.

2.3 Site Visit

A site visit was undertaken during which EVY and NRW staff inspected the length of the proposed derogated reach in a walk-over survey, as well as upstream and downstream of the derogated reach. This survey facilitated direct investigation of the sediment types present in

the watercourse, potential for habitat along the reach and provided a photographic record of key features.

Hydraulic and hydromorphological features and structures along the study reach were appraised during the visit. Notable areas of erosion and deposition along with indicators of the stability/dynamism of the existing channel were also identified.

2.4 Analysis

Information from the desk-based study and site visit was brought together and evaluated in this report, covering the following key areas:

- Likely changes to the channel in response to alterations in flow regime and identification of whether sediment transfer through the derogated reach will be affected by reduced flows.
- Likely impacts to the broader geomorphology of the derogated channel (e.g. bank or bed erosion, channel deposition) and the effects of the proposed abstraction on sediment transport rates and implications for gravel habitats.
- Possible ecological responses associated with any geomorphological impacts.
- How are habitats likely to change with the proposed flow abstraction and how will fish migration be impacted.
- Potential design modifications or additional measures which could be incorporated to address any adverse impacts that are identified.
- Will flow abstraction have an impact on a larger scale, including the River Wye.

3 Catchment and Hydrology

3.1 Geology

The BGS bedrock and superficial deposits mapping show that the catchment bedrock is predominantly mudstone and siltstone formations. There is a distinct feature of harder bedrock material reaching the surface near the intake (shown by the green and orange area in figure 3.1) which forms the bedrock step at the intake location.

The superficial deposits are predominantly glacial till, with some alluvial deposits, along the valley. Peat is present in the upland areas.

3.2 Catchment Descriptors

The FEH Web Service from the Centre for Ecology and Hydrology (CEH) was used to delineate the catchment area for Afon Claerwen, as shown in figure 3.3 and extract some key hydrological catchment descriptors presented in table 3.1. The catchment for the proposed abstraction point is shown in red whilst the additional catchment that feeds the derogated reach and the outfall location is shown in green. The catchment areas from the web service have been compared to OS Mapping and appear reasonable.

The catchment descriptors are very similar between the two catchments which is to be expected given the relatively small intervening catchment area. The descriptors are typical of catchments in this area of the country.

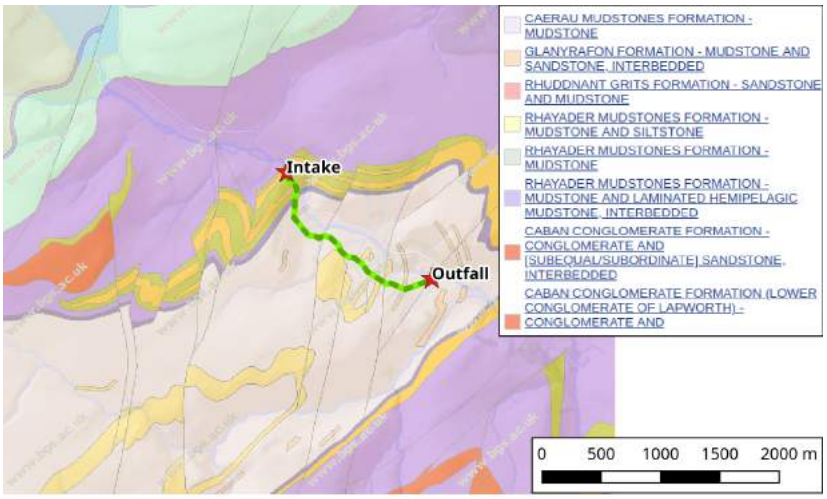

Figure 3.1: Bedrock map

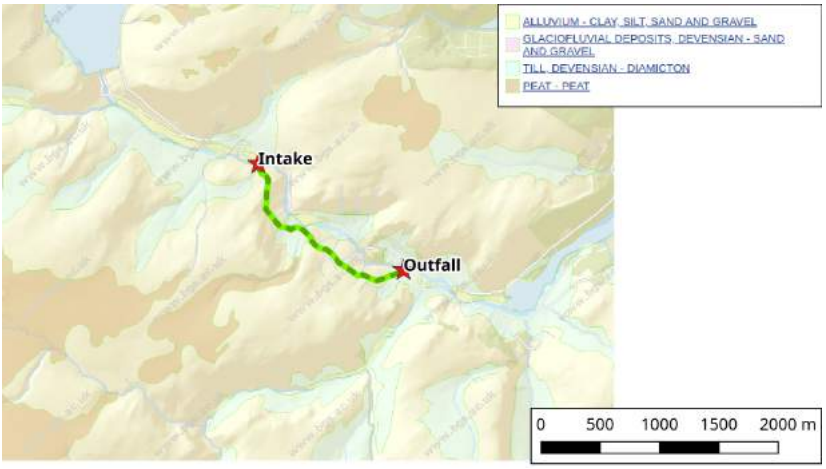

Figure 3.2: Superficial deposits map

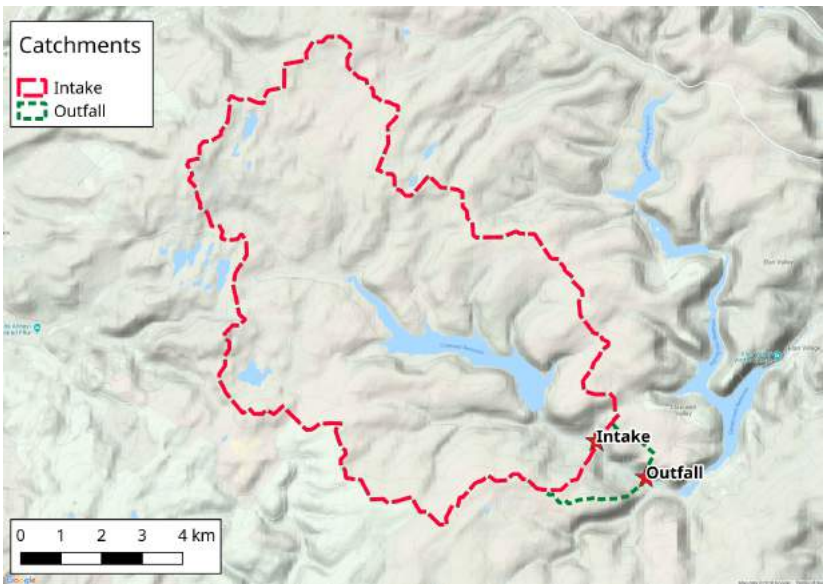

Figure 3.3: Catchment areas upstream of the intake and outfall locations

Descriptor	Intake SN 88350 62750	Outfall SN 89550 61850
AREA	69.49	72.11
FARL	0.803	0.809
PROPWET	0.65	0.65
ALTBAR	462	460
BFIHOST	0.317	0.322
DPLBAR	8.31	9.89
DPSBAR	118.5	122
SAAR	1845	1845
SPRHOST	53.02	52.69
URBEXT2000	0	0

Table 3.1: Catchment descriptors for the upstream catchments

Waterbody name	Afon Claerwen – conf. Afon Arban to Caban-coch
Waterbody type	River
Water body ID	GB109055042230
National Grid Reference	SN8745963012
River Basin District	Severn
Catchment name	Wye
Length (km)	7.251
Area (km2)	18.367
Hydromorphological	Supports Good
Protected Area Designation	Conservation of Wild Birds Directive, Habitats and Species Directive
Current Overall Status	Poor
Status Objective (Overall)	Good by 2027
Status Objective(s)	Good Ecological Status by 2027 (Poor currently), Good Chemical Status by 2015 (Good currently)

Table 3.2: WFD details for the waterbody containing the derogated reach.

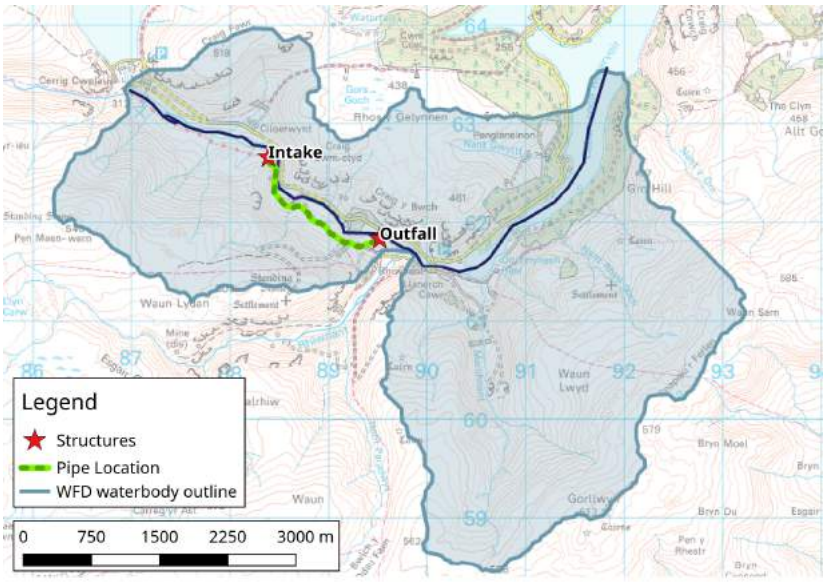

Figure 3.4: Catchment area of the "Afon Claerwen – conf. Afon Arban to Caban-coch" waterbody

3.3 Water Framework Directive

Afon Claerwen is integrated into a larger waterbody known as "Afon Claerwen – conf. Afon Arban to Caban-coch" for the purposes of the Water Framework Directive. The details of this waterbody are presented in table 3.2 and figure 3.4.

According to the Severn District River Basin Management Plan and the "Wales Water Body Objectives and measures" spreadsheet (2017 update), this waterbody is failing to reach Good ecological status due to a poor pH parameter and it is indicated that the waterbody's status will not recover to Good until 2027 due to the ecological recovery time. In addition to this, the pH parameter is designated as a failing element.

3.4 Fluvial Flows

NRW do not operate any river flow measurement stations in the Afon Claerwen catchment and flows have therefore been estimated using the CEH LowFlows software. The estimated low flow data for the catchment are shown in figure 3.5, with figure 3.6 showing more detail of the estimated curve for the Afon Arban.

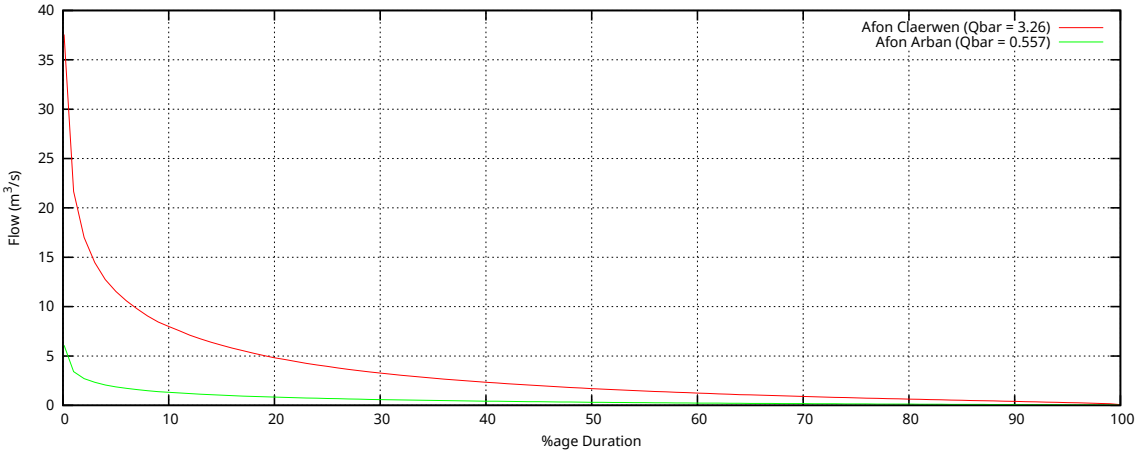

Figure 3.5: Estimated flow duration curves for the Afon Claerwen and Afon Arban

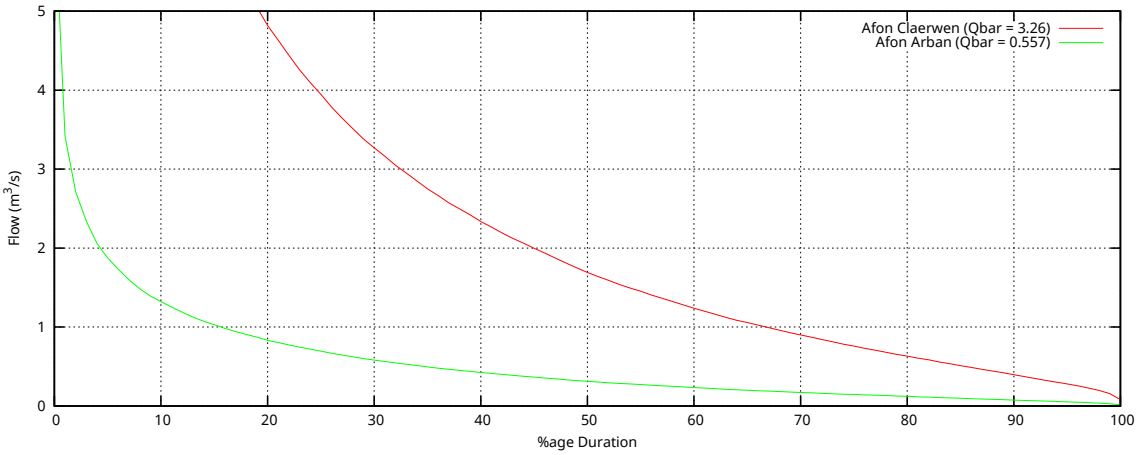

Figure 3.6: Estimated flow duration curves for the Afon Claerwen and Afon Arban

The proposed development will be subject to a Hands-off Flow condition based on the natural flow of the upstream Afon Arban. This would mean that the depleted section of the watercourse would be exposed to a more natural flow variation, albeit one derived from a much-reduced catchment, rather than including all of the reservoir released flows. Water abstraction will only occur when the Claerwen Reservoir is discharging water, and a maximum abstraction for this scheme will be set to 3.7 m³/s.

While the Afon Arban curve is significantly lower than the curve for the Afon Claerwen, it is important to bear in mind that the estimation method used does not account for the effect of the reservoir. It can be seen from the curves that the maximum abstraction from the scheme is equivalent to the expected Q25 of the Afon Claerwen catchment were the reservoir not present.

4 Site Survey

4.1 Overview

A site visit was undertaken by EVY on 7th June 2018. Conditions were clear and sunny and there had not been significant rainfall in the preceding days. The site visit was undertaken with the NRW geomorpholgist Anne Lewis, and sought to identify notable controlling bedrock features and areas of erosion or deposition including any existing sediment sinks or areas of active sediment supply.

Afon Claerwen flows from north-west to south-east and inspection of channel morphology started close to the Claerwen Reservoir and confluence of the Afon Arban (SN 87028 63373). The survey continued downstream to the Dolymynach reservoir (SN 90430 61429).

During the site visit there was no observed managed discharge from the Claerwen Reservoir. Thus, the majority of the flow observed in the Afon Claerwen during the site visit was flow from the Afon Arban tributary. This flow would represent the 'hands-off' flow of the scheme.

The Afon Claerwen is generally shallow sloped, with pools and riffles, and the occasional waterfall. The approximate gradient of the derogated reach has been calculated using the Ordnance Survey Terrain 50 dataset and are shown in table 4.1.

Proposed intake altitude	303 mAOD
Derogated reach length	1,700 m
Proposed outfall altitude	260 mAOD
Fall	43 m
Slope	2.53 m/100m

Table 4.1: Altitudes and gradients from the derogated reach

4.2 Upstream of Derogated Reach

The watercourse between the Claerwen dam and the proposed intake location has a shallow gradient with series of riffles and pools. There is also noticeably four islands in the watercourse, with three of them appearing to have remained in location even after the construction of the dam in 1952 (as per 1886 OS survey map, figure 4.1). The land immediately adjacent to the channel is relatively flat, although steeper hill slopes are located nearby.

The channel width averages approximately 4m and on the day of the site visit by EVY staff water depths were shallow (up to approximately 500 mm) although localised pools had depths of greater than 1 m. The channel is generally formed of a succession of pools and rock weirs/steps, typical of a headwater stream. The substrate is composed of gravels to boulders directly overlying the bedrock.

The primary source of sediments appeared to be from the surrounding hill slopes. There was some evidence of nearby bank erosion which may contribute additional sediments to the channel, although this was

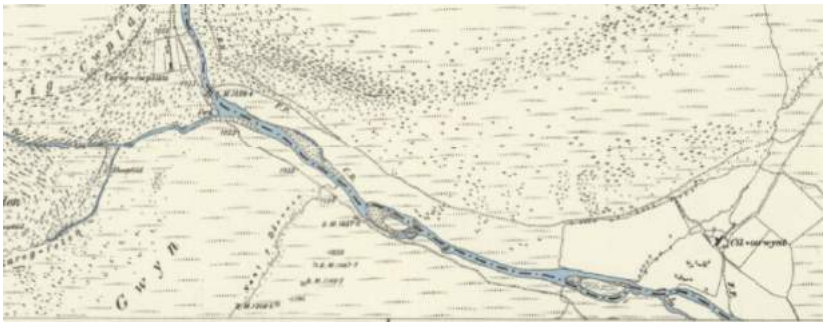

Figure 4.1: 1886 OS Survey map showing in-stream islands, reproduced from the National Library of Scotland

independent of the watercourse at the flows seen on the site visit. Representative photographs of this reach are shown in plates 4.1 to 4.5. The overall watercourse characteristic at this upstream location is a 15-metre wide channel flowing on bedrock substrate.

The two downstream islands were found not to be purely gravel deposits, but controlled by bedrock, indicating that they are likely to be stable long-term (as indeed they have been).

The wider catchment is composed of heath and blanket bog. A stone crossing was observed within this upstream reach across a narrower section of the stream around one of the islands. Most of the surrounding land was used for pastoral agriculture.

4.3 Derogated Reach

The proposed intake structure is proposed to be placed at a narrow bedrock island, just upstream of a significant waterfall. There is a small tributary entering the Afon Claerwen just at the left bank of the proposed intake structure.

The bed at the intake location is formed of shallow gravels on bedrock. Just downstream of the proposed intake location, there is a waterfall feature that would be difficult for fish to pass. Downstream of the waterfall, the watercourse becomes steeper sloped in a narrower valley. This reach is narrower (approximately 6m across), with a main substrate being made up of bedrock and boulders. Many of the underwater boulders are vegetation-covered which suggests that they have become permanent features following deposition.

The reach downstream of the waterfall becomes progressively more tree-lined through the derogated reach.

The reach of the proposed outfall was not accessible during the site visit, but it is understood to be very much like the rest of the derogated reach, an assertion that is supported by the available mapping and LiDAR data and the similarity of the reach downstream of the outfall.

4.4 Downstream of outfall

The reach downstream of the proposed outfall was accessible. This reach contained the same distribution of bedrock, boulders, and gravel as seen upstream. Additionally, where the Afon Claerwen met the Dolymynach Reservoir a large gravel bar was noted. This bar appeared to be well established with multiple wildlife habitats present.

Plate 4.1: Downstream view of the Afon Claerwen just downstream of the confluence with the Afon Arban

Plate 4.2: Bedrock control on the channel viewed from the left bank view of the upstream in-line island, showing bedrock control

Plate 4.3: The Afon Claerwen from the left-bank floodplain

Plate 4.4: Gravel tail at downstream side of the downstream in-line island.

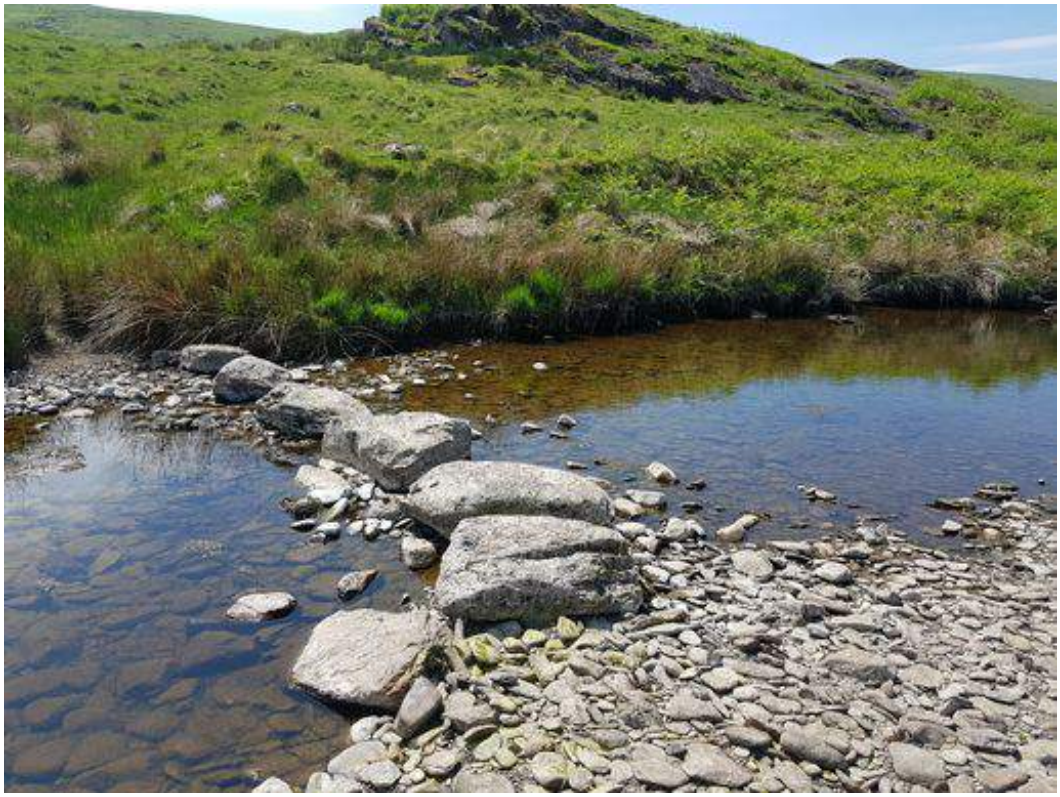

Plate 4.5: Informal stepping stone crossing from right bank to in-line island

Plate 4.6: Left bank of proposed intake weir location. The location of the tributary can be seen by the wetted rocks and gravel on the bank

Plate 4.7: Right bank of Afon Claerwen, midway between intake and outfall locations

Plate 4.8: View upstream from bridge crossing, downstream of the confluence of the Rhiwnant

Plate 4.9: View of gravel deposit upstream of Dolymynach Reservoir

5 Geomorphological Assessment

5.1 Overview

Afon Claerwen is a bedrock controlled headwater stream that drains an area upstream of the Elan Valley Reservoir system. For the purpose of this report, the Afon Claerwen has been divided into three smaller reaches; the upstream reach, the derogated reach, and the downstream reach. At the intake location, the watercourse is approximately 10 metres wide and as it does not change significantly in width as it goes downstream through the derogated reach except as it approaches and departs a series of gravel in-line islands.

Much of the derogated channel is confined in a V shaped valley which constrains lateral movement. Comparison to 1886 maps of the area reveals that the channel has not moved significantly, even with the construction of the Claerwen Reservoir upstream of the reach.

The upstream reach presents a greater frequency of notable depositional features such as bars and successions of small riffles and pools. In comparison, whilst there is some evidence of finer sediment along the channel bed in the derogated reach and downstream reach, the bed substrate in these locations is comprised primarily of boulders bedrock, and gravel. The presence of a a considerable waterfall at the top end of the derogated reach means that there is discontinuity within the channel which creates a natural obstruction to fish migration from downstream.

Water depths are generally shallow (< 0.25–0.5 m) in all of the reaches except for localised pools. Only the one waterfall was observed, forming a significant obstacle to fish migration within the derogated reach.

A road has been built all along the left bank of the watercourse. No river bank protection has been observed to have been implemented to ensure the stability and prevent any damage to the road from river erosion, presumably due to the long-term stability of the channel and because the road is generally offset from the watercourse.

5.2 Flows

Flows in Afon Claerwen are dependent on recent rainfall events, with overland flow running off the wet moorlands and tributaries from nearby hill slopes, however high flows are highly dependent on the release of stored water from the Claerwen Reservoir.

The proposed design of the intake weir will ensure a hands-off flow as the flow from the Afon Arban. This will ensure that a large range of flows occur no less frequently than is currently the case. While the current case is not completely natural due to the Claerwen reservoir, the Afon Claerwen has remained geomorphically constant if compared to old maps of the watercourse. While it is typically expected that flow abstraction will influence the sedimentation processes, in practice, the derogated reach will still receive a wide range of flows as the Afon Arban will be the hands-off flow, allowing some high flow velocities

with sufficient energy to move gravels, pebbles and finer sediments.

The proposed channel modification at the intake will result in a local change in water levels and flow regime. There is the potential for slightly increased depths of water immediately upstream of the weir installation. However, the size of the weir and relative steepness of the channel means that the backwater effect should be limited.

A number of tributaries provide additional inflow to derogated reach and this is unlikely to change with flow abstraction upstream. The morphology of the derogated channel is unlikely to move considering the steepness and influence of the bedrock. The relative absence of fine sediment within the reach reflects the energy of the watercourse to and its ability to transport sediments.

The outfall from the turbine house will increase the flow and velocities locally as the original flow is restored downstream. It should be noted that the very fine, suspended sediments are likely to pass through the HEP scheme without deposition or collection on any trash screen and the supply of these sediments to the Afon Claerwen will not be affected.

Considering the nature of the channel, 'flushing' or maintenance flows will not impact the quality of physical habitats, provided they do not also carry significantly increased sediment loads.

5.3 Sediment Dynamics

Sediment movement is initiated when flow forces (e.g. movement of water in a channel) exceed a sediment particle's resistance to movement (from sediment weight and cohesion). The flow required to initiate entrainment is influenced by a number of factors, but is generally accepted to be predominantly controlled by the velocity of the flow.

On this basis, the intake weir and outfall from the turbine house could have a localised impact on sediment processes. The construction of the intake weir could temporarily impede the downstream movement of gravel and other river bed materials by increasing deposition upstream of the weir. Due to the bedrock nature of the watercourse directly downstream of the weir means that there is little chance of erosion immediately downstream of the intake weir. If the structure of the intake weir is constructed with recommended backfill, the volume behind the weir would be smaller and would be quickly filled by transported sediments from the upstream catchments. The long-term effect on pass-forward sediments would be very limited. Any bank erosion or failure upstream of the intake, where there are currently high steep sediment banks, would most likely be localised and occur around the time of installation. Any scouring or erosion at the outfall will have to be considered in the detail design of the hydraulic structures associated with the scheme.

As observed during the site visit, the channel exhibited evidence of erosion, deposition and transportation in various locations. However, where sediment sources are available, the channel is mainly erosive in character at high flows. It is notable that the channel is flowing over bedrock and therefore erosion is restricted by the availability of sediment. Sediment processes will be impacted downstream of the intake as the frequency of medium to high flows will be reduced. The abstraction will result in a slight reduction in sediment transport; however, the cumulative contribution of inflow from smaller tributaries within the derogated reach will increasingly compensate for this further downstream.

5.4 Scale of Impacts

Geomorphological impacts must be considered at the waterbody scale and impacts to any other "connected" waterbodies.

At a wider scale, Afon Claerwen supplies sediment and flow to Dolymynach Reservoir. As discussed above, the overall effect of the proposed scheme on sediment transport, erosion and deposition on Afon Claerwen is considered to be minimal and the proposed scheme should therefore have a similarly negligible effect on sediment supplies to the Dolymynach Reservoir. The River Elan, downstream of the Dolymynach, which is already gravel deprived, will remain the same.

During construction, fine sediment may be released into Afon Claerwen and subsequently into the Dolymynach Reservoir. However, the scale of the proposed work means that this is unlikely to have a significant impact on either watercourse.

5.5 Ecological Impact and WFD Assessment

As previously described, the waterfall just downstream of the intake structure poses a major obstacle to upstream migration. Also, the current the lack of full flow diversity due to the Claerwen Reservoir does not properly support the indicator species expected by the WFD. However, the downstream 1.7km of the derogated reach is still accessible to fish assuming there there is no obstacle downstream of the outfall location; this was not assessed during the site visit.

WFD compliance assessment for this site requires that potential surface water and groundwater effects are identified and that these are then assessed to identify any areas of potential deterioration of any element of the water body status.

It should be highlighted that whilst Afon Claerwen would fail to comply with WFD objectives if assessed as an independent waterbody, this catchment contributes to a larger waterbody catchment. Afon Claerwen only comprises about 30% of the "Afon Claerwen – conf. Afon Arban to Caban-coch" catchment.

The potential effects at this site include:

- Disruption to surface water processes during the construction phase, potentially including pollution due to spillages or discharges, scour or disruption to sediment flows and noise/vibration during construction of foundations
- Permanent diversion of the tributary drain
- Disruption to groundwater, potentially including pollution due to discharges or spillages suring construction.

The potential impacts from pollution, both to surface water and ground water, can be mitigated by following an appropriate CEMP.

There is the potential for localised temporary impacts on water quality due to sediment mobilisation during construction. This, as with pollution, can be mitigated by using appropriate construction approaches. The impact of this sediment, however, is not expected to increase at the water body scale and any impact will be localised.

The diversion of the tributary drain has the potential to cause minor impacts on habitat and water quality local to this drain, however these impacts will be extremely localised and will not be significant at the water body scale.

Based on these assessments, the project is not expected to result in any significant or long-term deterioration of the water body status.

6 Conclusions & Recommendations

A hydro-power scheme is proposed on Afon Claerwen in the Elan Valley, Wales. The proposed scheme will involve a new weir and intake structure, a 1.8 km-long buried pipeline and a small turbine house with a tailrace to return water to the watercourse upstream of the confluence with the Rhiwnant.

This scheme is intended to take advantage of the 43 m vertical drop between intake and outfall. A Hands-off Flow will be determined as the full flow from the Afon Arban and will remain in the channel to ensure the scheme will not significantly affect low flows, sediment dynamics or river habitats.

The diversion of flow will result in a derogated reach of approximately 1.7 km on Afon Claerwen and a geomorphological assessment was requested by the NRW in order to asses the likely impact of the scheme on this reach.

A geomorphological survey undertaken in June 2018 by EVY and NRW staff allowed for the identification of areas of erosion and deposition, channel stability, barriers to fish migration and physical habitats. The site visit indicated that the channel ranges in width between approximately 10m at close to the intake and approximately maintains its width for the length of the derogated reach.

On the day of the site visit water depths were shallow and typically less than 25–50 cm except in local pools. Within the surveyed section, the reach upstream of the proposed intake has a shallower slope whilst the derogated reach is generally steeper, confined to a v-shaped valley. This is likely to have significant stream power and transport capacity at high flows.

Sediment observations show that channel substrate is largely comprised of pebble, cobbles, boulders and bedrock. The larger sediments on and near the river bank did not have a covering of moss which suggests that the watercourse is a high energy environment with velocities sufficient to transport bedload material of this size.

Due to the extremely high stream power of Afon Claerwen, even at low flows the key sediment transport and erosion precesses would not be significantly affected by an abstraction above the HoF.

The site visit and desk study did not indicate that the scheme as proposed would have a significant impact on the WFD status of the “Afon Claerwen – conf. Afon Arban to Caban-coch” waterbody.

The evidence from this study suggests that the impact from the proposed scheme on the geomorphological aspects of Afon Claerwen will be temporary as the Afon Arban is set as the HoF, and is already the typical flow for the Afon Claerwen. This means that only the pulsed outflow from the Claerwen Reservoir will be altered throughout the

reach. Despite this, the scheme design should consider erosion/scour at the outfall location where the outflow may locally alter the existing balance of geomorphological processes.

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