

Case study 41. Nant Barrog

Author: Jacques Sisson

Main driver: Flood risk management

Project stage: Assessed; pending bid for implementation



Photo 1: River Elwy (source: AECOM, 2015)

Project summary:

In 2012, the city of St Asaph – located on a downstream reach of the Afon Elwy (Map 1) – suffered severe flooding which resulted in a fatality. Natural Resources Wales began an investigation into how traditional hard engineered approaches, such as those proposed for the St Asaph flood alleviation scheme, could be supported by Working with Natural Processes (WWNP) measures. The investigation also looked at how these measures could have multiple ecosystem benefits.

Llanfair Talhaiarn is a small village in the Elwy catchment, located at the confluence of Nant Barrog with the main river Elwy. The Nant Barrog is conveyed beneath the main street to the Elwy through the Water Street culvert. In periods of high rainfall the culvert is overwhelmed, resulting in flooding of properties in the village. Natural Resources Wales is reviewing the refurbishment of the culvert.

WWNP measures recommended for the Barrog in the Elwy Natural Flood Risk Management and Ecosystem Services Study (2015) were further reviewed at the subcatchment scale. WWNP measures for the Nant Barrog catchment were recommended in the Llanfair Talhaiarn Natural Flood Management Study (2015). A revision of the shortlisted options was further reviewed as part of the Llanfair Talhaiarn project appraisal report (2016) and the cost benefits of the different options were considered. The resulting recommended WWNP measures are listed in Table 1..

Coed Cymru, in partnership with Natural Resources Wales, the Woodland Trust and other organisations, will submit a bid in 2017 to the Welsh Government Rural Development Plan Sustainable Management Scheme for funding to implement the measures recommended in the Llanfair Talhaiarn report.

Key facts:

The Water Street culvert has an inlet capacity of $4.2\text{m}^3\text{s}^{-1}$. Flooding will occur at a return period of a 1 in 50 year event with a peak flow of $4.8\text{m}^3\text{s}^{-1}$. Modelling of 4 WWNP packages showed that, when considered separately, sufficient reductions would occur during the 1 in 50 year event for flow to remain within the channel at the culvert.



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Map 1: Elwy Catchment (source: Ordnance Survey from AECOM, 2016)

Table 1: Description of WWNP measures proposed for Nant Barrog

| WWNP measure | Code | Description |
|---------------------------|------|--|
| Palaeo channel | PC | Reconnection of remnant channels that have been either naturally or artificially cut off. These reconnected channels could create additional capacity in flood flows and backwaters under low flows. |
| Riparian tree belt | RT | Planting of trees along the riparian zone to increase interception, reducing the volume and speed of run-off. |
| Woody debris | WD | Installation or re-introduction of woody debris into the channel in already heavily wooded areas to encourage out of bank flow or slight impoundment of water upstream of features. This will need to be carefully considered to ensure no adverse impacts downstream. |
| Gully planting | GP | Damming or vegetating deep gullies in the upper catchment to slow the flow of water from the headwaters to the main channel. |
| Storage areas | DS | Areas where existing storage could be expanded or new storage created to reduce the volume of water in the channel. |
| Farm storage | FS | Multi-functional storage in farm areas, for example, building a bund for existing artificial drainage routes and piping the water for stock watering. |

1. Contact details

| Contact details | |
|---------------------------|--|
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2. Location and catchment description

| Catchment summary | |
|--|--|
| National Grid Reference: | SH 92156 68166 |
| Town, County, Country: | Llanfair Talhaiarn, Conwy Borough County Council, North Wales |
| Regional Flood and Coastal Committee (RFCC) region: | Not applicable |
| Catchment name(s) and size (km²): | Elwy catchment 253km ² |
| River name(s) and typology: | Nant Barrog, 4.7km ² , step pool channel |
| Water Framework Directive water body reference: | GB110066060020 |
| Land use, soil type, geology, mean annual rainfall: | Agriculture, urban; Argillaceous rocks and sandstone, interbedded; average annual rainfall 1,000mm |

3. Background summary of the catchment

Socioeconomic/historic context

The 16 farms associated with the Nant Barrog catchment largely graze sheep on improved grassland. Llanfair Talhaiarn, located at the confluence between the Barrog and the main river Elwy, is a small village and part of the 'Little Switzerland' area which attracts tourists to the local pubs and for fishing and walking.

Flood risk problem(s)

The Nant Barrog catchment is an upland, steep sided catchment falling from 360m to 150m over 3km. The catchment area is small, 4.7km² with an annual average rainfall of 1,000mm. The Nant Barrog is conveyed beneath the main street to the Afon Elwy via the Water Street culvert, which has an intake capacity of 4.2m³s⁻¹. At 1 in 50 year return period flows, the culvert is overwhelmed and village properties are flooded. Severe flooding occurred in April and November 2012 and previously in June 1935, June 1936, September 2008 and June 2009. A viability report for refurbishment of the culvert was completed in 2014 and the Llanfair Talhaiarn Natural Flood Risk Management Study (2015) identified and modelled WWNP measures likely to reduce flows to the culvert.

Other environmental problems

The Water Framework Directive status for the main river is 'good'. Although the Barrog has not been sampled, it is assumed that it is also of good ecological status as it does not affect the main river. There are salmonids in the Barrog but it is thought that the culvert restricts movement upstream. Part of the project for implementation will be to monitor fish numbers in the river. There is evidence in the middle of the catchment on steep slopes of landslide where thin soils have been washed away.

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood risk problem(s) and solution(s)

The Llanfair Talhaiarn Natural Flood Risk Management Study (AECOM 2015) presented an impact summary of the 4 shortlisted WWNP packages (see below and Figure 1).

Package 1: Woody debris Installation along lower reaches (WD1)

Reduction of flows downstream by ~0.1m³s⁻¹ for both the 1 in 25 and 1 in 100 design year events if installed over a limited reach length of ~400m.

Reduction of flows downstream by ~0.2m³s⁻¹ for the 1 in 25 year design event and by 0.3m³s⁻¹ for the 1 in 100 year design event if installed over a longer reach length of ~800m.

Package 2: Land use management (GP1, FS1, FS3, FS7)

Reduction of flow downstream of ~0.2m³s⁻¹ for both the 1 in 25 and 1 in 100 year design events.

Package 3: Palaeo-channel and storage area (PC2)

This would require more detailed topographic survey and hydraulic monitoring.

Package 4: Farm storage (FS5)

Based on topographic analysis of LiDAR (light detection and ranging) data, the south-eastern upper tributary of the Barrog has been identified as a possible site for a bunded leaky dam.

Reduction of flow downstream of ~0.2m³s⁻¹ for the 1 in 25 year design event and of ~0.4m³s⁻¹ for the 1 in 100 year design event.

Combined measures

By implementing some of these measures in combination, it would be possible to reduce peak flows by

between $0.3\text{m}^3\text{s}^{-1}$ (1 in 2 year event) and $0.9\text{m}^3\text{s}^{-1}$ (1 in 200 year event). A reduction of at least $0.3\text{m}^3\text{s}^{-1}$ would be required to prevent out of bank flow at the culvert inlet during the 1 in 50 year event. The combined implementation of WWNP measures is likely to achieve this.

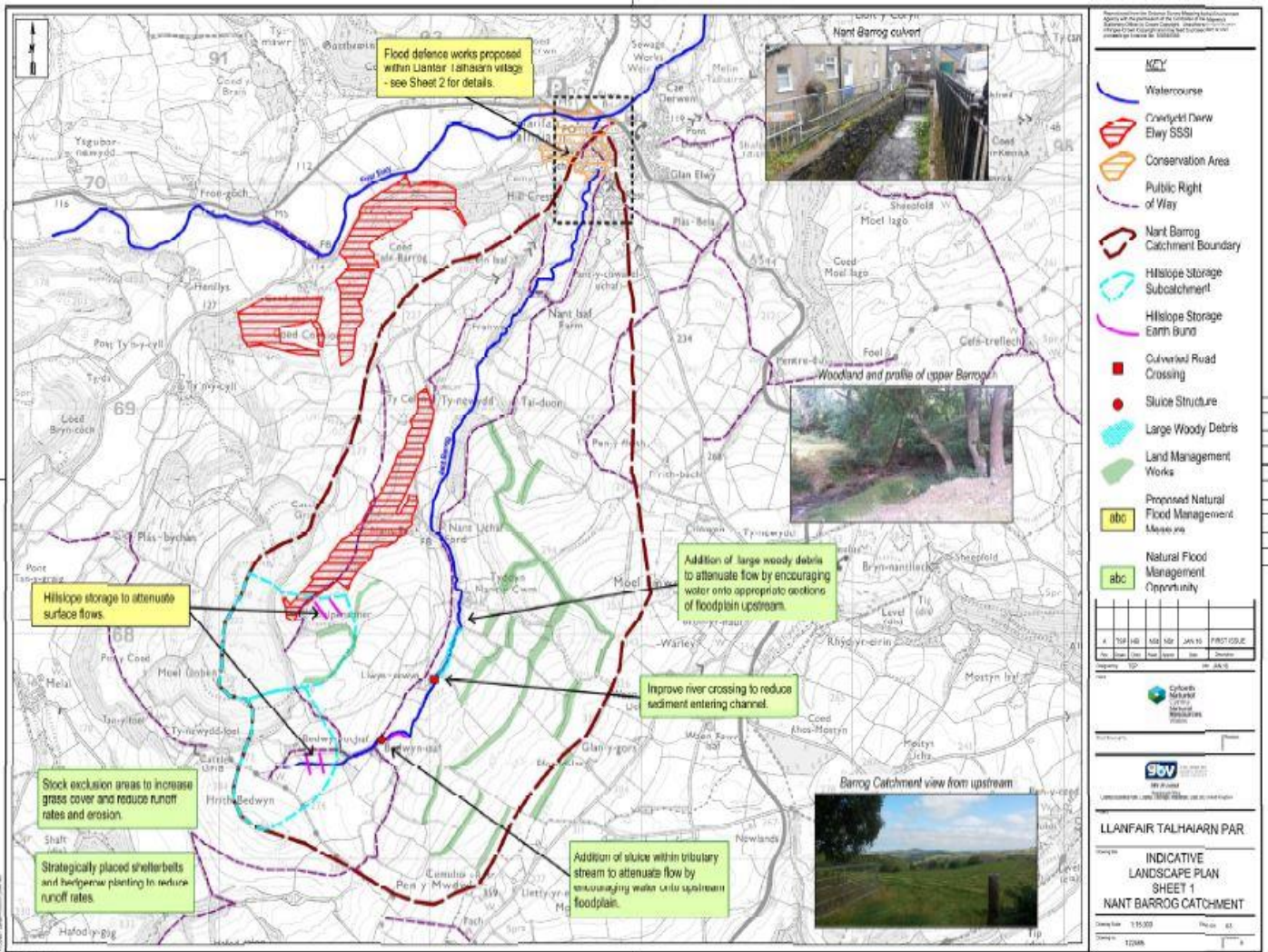


Figure 1: Shortlisted WWNP packages for Nant Barrog (source: Black and Veatch)

What was the design rationale?

The Elwy Natural Flood Risk Management and Ecosystem Services Study (2015) produced a one-dimensional routing model of the main river network based in ISIS-TUFLOW on Google Earth, Bing aerial imagery and digital imagery. LiDAR was used to define cross-sections and Revitalised Flood Hydrograph (ReFH) flow boundaries were developed based on catchment descriptors.

Modelled events used antecedent conditions and applied Flood Estimation Handbook CD-ROM Cini – considered crucial to deriving model outcomes.

The long list of measures recommended in the Elwy Natural Flood Risk Management Report and Ecosystem Services Study was further reviewed for the Nant Barrog subcatchment and a shortlist of measures recommended based on subcatchment scale modelling and field site investigations. The shortlist was further assessed based on cost benefits and feasibility, producing an opportunities map (Figure 1).

A ranking of the ecosystem services is provided in the Elwy Natural Flood Risk Management and Ecosystem Services Study (2015), giving the qualitative benefits and dis-benefits of a range of WWNP options.

| Project summary | |
|--|-----------------------------------|
| Area of catchment (km²) or length of river benefitting from the project: | Nant Barrog, 4.7km ² |
| Types of measures/interventions used (both WWNP and traditional): | To be implemented pending funding |
| Numbers of measures/interventions used (both WWNP and traditional): | To be confirmed |
| Standard of protection for project as a whole: | To be confirmed |
| Estimated number of properties protected: | 30+ |

How effective has the project been?

In 2017, Coed Cymru in partnership with Natural Resources Wales, Bangor University and the Woodland Trust will submit a bid to the Rural Development Plan Sustainable Management Scheme fund for implementation of WWNP measures in the Nant Barrog catchment.

The success of the project initially depends on the willingness of local landowners to agree to changes to land management practices and to allow WWNP to be implemented on their land. Engagement will be co-ordinated through an experienced Woodland Trust officer.

Coed Cymru will work with farmers to draw up Farm Management Plans to include WWNP and to explore funding opportunities for implementation and maintenance. The potential economic benefits of WWNP will also be investigated and, where possible, payments for ecosystem services will be employed.

Assessments will also include delivery of other ecosystem benefits such as improvements to grazing land, stock health and reduction in soil loss due to run-off.

The success of the project will be monitored by Bangor University in the following ways:

- measurement of surface flows
- effectiveness of shelter belt planting using electronic sheep
- water quality through measurement of sediment loading
- effectiveness of woody debris dams and leaky dams through drone surveys
- reduction in frequency of out of bank flooding at flows equivalent to design event flows

5. Project construction

How were individual measures constructed?

The Nant Barrog WWNP project will engage with local community groups to train and improve the skills of members in how to construct some of the WWNP measures, in particular the construction of woody debris dams and the planting of hedges and trees.

How long were measures designed to last?

Most of the proposed WWNP measures should become part of the day-to-day management of the farms.

Were there any landowner or legal requirements which needed consideration?

The Elwy Valley Woods Site of Special Scientific Interest (SSSI) covers a large area in the mid to lower catchment. The designated site is managed by Natural Resources Wales. A review of the site management plan will incorporate WWNP into the plan. This may include better management of the woodland to improve

diversity and implementation of small woody debris dams. Implementation of WWNP within the catchment will only be achieved through the co-operation of local farmers and landowners. The project partners will work with other stakeholders to secure additional funding for maintenance through existing streams such as Glastir.

6. Funding

| Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (NFM) measures | |
|--|--|
| Year project was undertaken/completed: | 2017 to 2020 |
| How was the project funded: | It is anticipated that 100% of implementation funding will come from Rural Development Plan Sustainable Management Scheme. |
| Total cash cost of project (£): | Not yet known – to be confirmed |
| Overall cost and cost breakdown for WWNP/NFM measures (£): | Not yet known – to be confirmed |
| WWNP/NFM costs as a % of overall project costs? | Not yet known – to be confirmed |
| Unit breakdown of costs for WWNP/NFM measures: | Not yet known – to be confirmed |
| Cost–benefit ratio (and timescale in years over which it has been estimated): | Not yet known – to be confirmed |

7. Wider benefits

What wider benefits has the project achieved?

It is anticipated that the project will improve grazing through the planting of shelter belts. Hedge restoration will provide new habits for wildlife and plants. In addition there will be:

- economic benefits to farmers through improved stock health
- reduction in soil erosion through reduced run-off through increased percolation and evapotranspiration
- improved river ecology through reduction of sediment loading

Ecosystem benefits for the wider Elwy catchment are presented in the Elwy Natural Flood Risk Management and Ecosystem Services Study 2015. The report presents WWNP as having a beneficial, neutral or dis-benefit impact on ecosystem services (see Table 2).

How much habitat has been created, improved or restored?

To be confirmed

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

- Maintenance of hedgerows by farmers, improved woodland management by Natural Resources Wales

Is the project being monitored?

Monitoring will be carried out by Bangor University. The type of monitoring will depend on the WWNP measures adopted. These will include over land flow, shelter belt efficiency, sediment loading and reduction in flows.

Has adaptive management been needed?

Not yet known – to be confirmed

| | | Backswamp/ Wetland | Riparian tree belt/ grassy buffer strip | Woody debris | Bed raising | Gully planting | Floodplain reconnection - paleo channel | Moorland grip-blocking | Dam/Storage areas | Farm Storage | Increasing sinuosity | Increasing bank irregularity |
|--------------------------------------|---|-----------------------|--|--------------|-------------|----------------|--|---------------------------|----------------------|--------------|-------------------------|------------------------------------|
| | Opportunity: | | | | | | | | | | | |
| | Goods/Service | | | | | | | | | | | |
| Provisioning | Food | -1 | 0 | 0 | -1 | 0 | 0 | 0 | -1 | -1 | 0 | 0 |
| | Wild collected food | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Fuel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Fibre | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Natural fluxes of energy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | Water | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| | Biochemicals and medicines | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Regulating | Genetic resources | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| | Abiotic Raw Materials | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Climate regulation - Local | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| | Climate regulation - Global | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| | Water regulation | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Regulation of water, air and soil quality | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Hazard (Erosion) regulation | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Disease and Pest regulation | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| | Pollination | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| | Waste assimilation | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| | Noise regulation | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cultural | Natural settings -Landscape and seascape | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| | Accessible Green Space | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Recreation & tourism | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | Nature and Wildlife appreciation | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Tranquillity | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Historic and cultural heritage | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | Spiritual and religious value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Education and scientific opportunity | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Supporting | Soil formation | | | | | | | | | | | |
| | Primary production | | | | | | | | | | | |
| | Nutrient cycling | | | | | | | | | | | |
| | Water cycling | | | | | | | | | | | |
| | Photosynthesis | | | | | | | | | | | |

NB. The supporting services defined are described in the Millennium Ecosystem Assessment, but are now considered to be ecosystem processes or intermediate services

Key: benefit neutral / na disbenefit

Table 2: WWNP characterisation (source: Elwy Natural Flood Risk Management and Ecosystem Services Study 2015)

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

The initial opportunities map (Figure 1) included farm storage at several locations within the Nant Barrog catchment when assessment was carried out at the Elwy catchment scale. LiDAR data were used to estimate cross-section geometry, roughness, reach lengths and slopes. This is a good approximation and a good model to try and apply to other catchments to save survey costs and enable network analysis. When increasing the resolution to the subcatchment level, however, some of the interventions originally proposed were found not to be possible due to, for example, actual gradients being steeper than estimated at the broad scale. This led to a second assessment for the Nant Barrog catchment and changes to the most effective potential WWNP measures.

10. Bibliography

AECOM, 2015. *Elwy Natural Flood Risk Management and Ecosystem Services Study*. Report for Natural Resources Wales.

AECOM, 2016. *Llanfair Talhaiarn Natural Flood Management Study*. Report for Natural Resources Wales.

BLACK & VEATCH CONSULTANTS, 2016. *Llanfair Talhaiarn Flood Risk Management Scheme project appraisal report*. Report for Natural Resources Wales.

Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's [Joint Flood and Coastal Erosion Risk Management Research and Development Programme](#).