ARUP

Natural Resources Wales

Salmon for Tomorrow 2 - Llanfair Talhaiarn

Flooding Technical Note

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1. Introduction

Natural Resources Wales (NRW) have appointed Ove Arup and Partners (Arup) to appraise and design fish passage improvements as part of the Salmon for Tomorrow 2 programme. The programme is funded by the Nature and Climate Emergencies Fund from Welsh Government. It aims to improve spawning along 1500 km of waterways which is currently being impeded by weir structures.

At Llanfair Talhaiarn, the proposed scheme comprises removal of the ~200 year old weir and associated re-grading of the river channel on the River Elwy. The weir has been raised or modified multiple times over its life and is currently in very poor condition. This report summarises the known information about the site in relation to the site, and the modelling carried out.

2. Site Description

The weir is situated on the River Elwy, downstream of the School Lane Bridge and the A544 Road Bridge, at Ordnance Survey National Grid Reference (NGR) SH 93052 70474. On the left bank of the River Elwy is a public footpath alongside agricultural fields that are regularly inundated during flood events. On the right bank, immediately upstream of the weir is a disused leat which has been blocked off. A wastewater treatment plant and private residential property are also located on the right bank

Figure 1: Site plan showing the Wastewater Treatment Plant and private property

3. Proposed design

The proposed design is full removal of the weir and wing walls. This includes the following components:

- The concrete weir, base and wing walls will be demolished. There is uncertainty over the composition of the weir due to the lack of record drawings.
- Once removed, the wing walls are to be regraded at a suitable slope angle (likely between 1 in 2 and 1 in 3). Protection will be added to these slopes to reduce the risk of excessive erosion and slippage of the bank. A low-flow channel will also be built in once the weir has been removed.
- The leat on the right-hand bank will be retained and kept in the same state as existing where it has been blocked by the landowner.
- Due to the lack of information regarding the construction of the weir, it may be prudent to use an observational approach during wing wall removal. The stability of the slope would be assessed throughout demolition whilst the wing wall is removed in stages from the top. This may result in some of the wing wall being left in or other support added. Any instability can be assumed at this stage to be localised to the riverbank.
- There will be one blockstone check weir, 10m downstream of the DCWW water main. Banks will be regraded at to a suitable slope angle. This will protect the upstream road bridge from erosion. Protection will be added to these slopes to reduce the risk of excessive erosion and slippage of the bank. Location will be fenced to allow the bank vegetation to reestablish.
- Reprofiling of material in the channel is to be minimised. This is to allow the material to redistribute naturally whilst minimising in-river working. Material directly upstream of the weir will be excavated as necessary to allow for removal of the weir. Sampling and testing of the material in accordance with waste disposal regulations has confirmed that the material is suitable for onsite reuse.
- Riverbed material will be able to move freely over time downstream of the check weir.
- Toe stabilisation of either rip rap or rock roll is required at the check weir location and at the weir location. The riverbanks will be graded with biodegradable coir matting for erosion protection around the check weir banks.
- Banks are to naturally re-grade over time following weir removal, following the conclusion drawn in a geotechnical initial assessment of the weir removal option (Arup, 2022). This is possible due to the topography of the site. There is however, a risk of slope instability during construction and in the following years. NRW would need to monitor the area over several years and allow for reactive mitigation works were risks to materialise.
- Downstream of the weir, the eroded left hand bankside will be reprofiled to minimise future erosion. Brash will be used to reinstate the bank and to be sourced from the coppicing of one small tree upstream and a larger tree downstream as well as the removal of a tree on the opposing bank's gravel bed. By coppicing, the roots will remain in the bank for stability but the above ground portion of the trees will be removed as they are currently deflecting water flow and promoting erosion. A layer of gravel will be taken from the gravel bar opposite the eroded riverbank and willow harvested from a sustainable source downstream. This area would be fenced off to allow the vegetation to establish and stabilise the riverbank.

An extract from the General Arrangement drawing is shown in Figure 2.

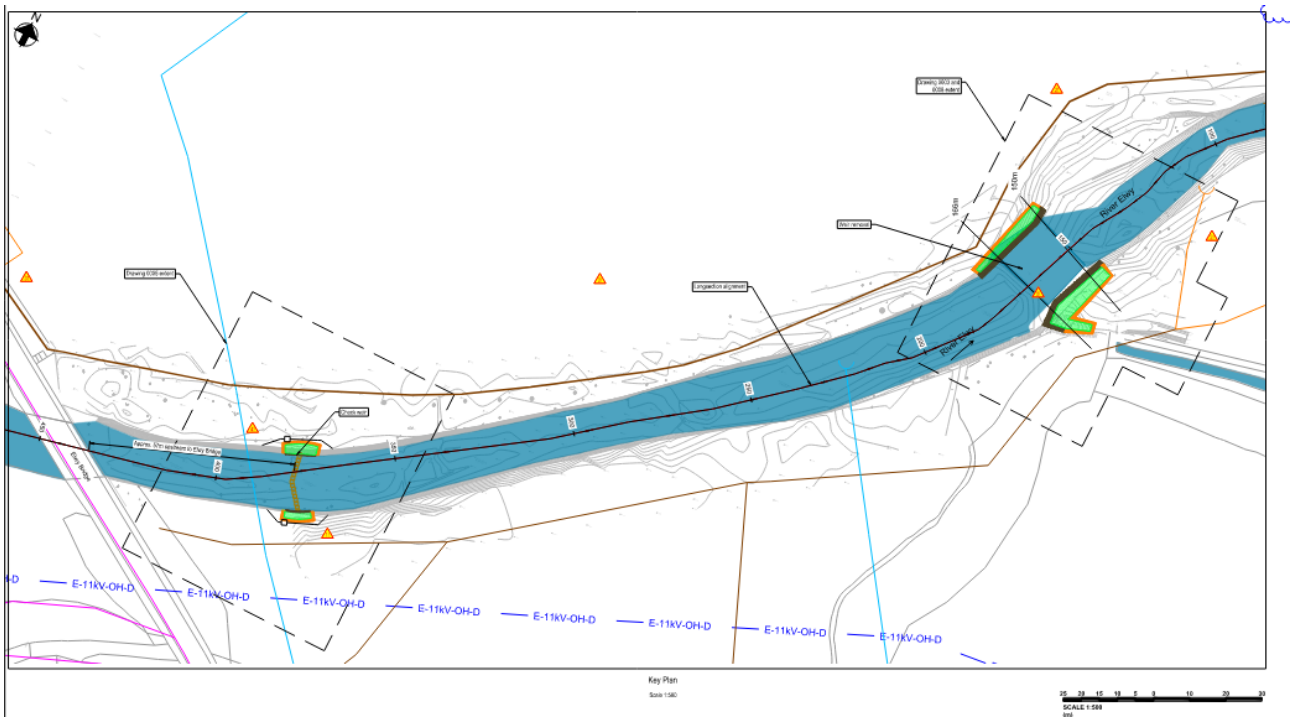

Figure 2: Extract from general arrangement drawing

4. Flood Risk Assessment

Annual Exceedance Probability (AEP) is the chance that a naturally hazardous event will occur annually. AEP is typically expressed as a percentage will bigger rainfall events occurring less often thus are exceeded less often and therefore have a lower annual exceedance probability. For example, a 1% AEP has a potential frequency of 1:100 years, whilst a 0.1% AEP has a potential frequency of 1:1000 years.

Flood Zone mapping illustrates the risks that locations are under considering different types of flood events.

Flood Zone 3 refers to areas with a 0.1%-1% chance of flooding for a given type of flood event in a given year, including the effects of climate change.

Flood Zone 2 refers to areas with a greater than 1% chance of flooding for a given type of flood event in a given year, including the effects of climate change.

4.1 Review of Existing Flood Risk Data

The area surrounding Llanfair is in both the fluvial and surface water Flood Zones 2 and 3. Mapping illustrates this in Figure 3 and Figure 4 for fluvial and surface water respectively. Flood risk at this location is summarised in Table 1.

Figure 3. Fluvial flood extents around the weir (circled in red) [1]

Figure 4: Surface water and small watercourse flood extents around the weir (circled in red) extracted from NRW mapping [1]

Table 1. Flood risk summary

Source of Flooding	Onsite Presence	Description
Fluvial	Yes	The site is in Flood Zone 3 and Flood Zone 2.
Tidal	No	The site is not within tidal reaches.
Surface Water	Yes	The surrounding areas are within Flood Zone 3 and Flood Zone 2. It is not likely however, that the weir removal will influence this.
Groundwater	No	There is no evidence to suggest that the site is at risk of flooding from groundwater.
Reservoirs	No	There is no risk of flooding due to reservoirs.
Sewers	No	There is no evidence to suggest that the site is at risk of flooding from sewers.

4.2 Historical Flooding

Llanfair has historically flooded to the extents shown in Figure 5. This flooding would have arisen from fluvial and surface water/small watercourse sources.

It should be noted that in June 2021 Conwy County Borough Council appointed Arup to undertake a flood investigation related to a sudden flood event at the village of Llanfair Talhaiarn. The event took place in February 2020 and was found to have two causes following a long period of heavy rainfall.

The first cause of the flooding was that the Nant Barrog tributary had high river flows exceeding the capacity of the culvert. There is also evidence to suggest that the River Elwy which recorded its highest historical level also flooded the village. The weir would not have had any influence on the flood event.

Figure 5: Recorded flood extents around the weir (circled in red) extracted from NRW mapping [1]

5. Assessment of Fluvial Flood Risk

It was detailed in Section 4 that flood risk from fluvial sources is most dominant at the site. Section 5 will now assess the fluvial flood risk in further detail considering the acceptability criteria and justifications.

5.1 Flood Modelling Update

Following a review of the flood model by Arup, updates were made to the baseline model incorporating topographic surveys carried out as part of the scheme, as well as updated LiDAR data. Changes were made in the hydraulic model to the representation of the leat based on topographic survey, and new initial conditions were generated for the model.

In addition, a weir removal scenario was created. This scenario was created by editing a baseline model as follows:

- The weir was removed from the baseline model;
- The Manning's n was adjusted to replicate how we expect the river to look after construction with perturbation and/or sediment traps made from timber and rocks;
- An additional section was created at the location of the check weir;
- The bed was adjusted to an approximate 1:140 gradient to represent the channel regrading itself over a period of time after construction.

5.2 Change in flood depths

The flood model was run for a range of return periods, from a 0.1% to 50% AEP. Full results are given in Appendix A. Figure 6 shows the baseline flood depths at the 10% AEP (illustrating the onset of flooding to the property garden on the right-hand bank) and Figure 7 shows the baseline 0.1% AEP event. The 0.1% AEP event causes more flooding of greater depth and extent on both banks. on the right bank, notably at the wastewater treatment works (at NGR SH 93148 70506) and the private property (at NGR SH 93244 70504) on the right bank.

Figure 8 shows the change in flood depth in the 10% AEP event once the weir has been removed. This shows a reduction in flood depths on the left-hand bank and upstream of the weir location, but localised increases in flood depths downstream, in particular on the right-hand bank. The effect becomes more pronounced for higher return period events until the 0.1% AEP event, which shows an increase in flooding extents and depths across the wastewater treatment works and private property, Figure 9. Values are given for the full range of return periods to the property in Table 2, comparing the baseline and post-scheme weir removal. Similar changes are experienced at the wastewater treatment works. It should be noted that the model was run with the leat channel blocked (as currently) and left open. This showed minimal difference in overall results, which are given in the appendix.

A range of measures to manage detriment at the property have been considered – subject to ongoing consultation with the landowner this is likely to comprise property flood resilience measures.

Table 2. Change in flood depth in a range of flood events at the residential property

Flood Event Annual Exceedance Probability (AEP)	Flood depths prior to weir removal/ cm	Flood depths following removal / cm	Average increase in flood depth / cm	Max increase in flood depth / cm	Increase in extent / new flooding
50%	No Flooding	No Flooding	No Flooding	No Flooding	No
10%	7	15	5	8	Yes
2%	42	52	7	10	Yes

1%	53	58	5	6	Yes
1%CC*	65	69	4	5	Yes
0.1%	73	76	3	6	Yes

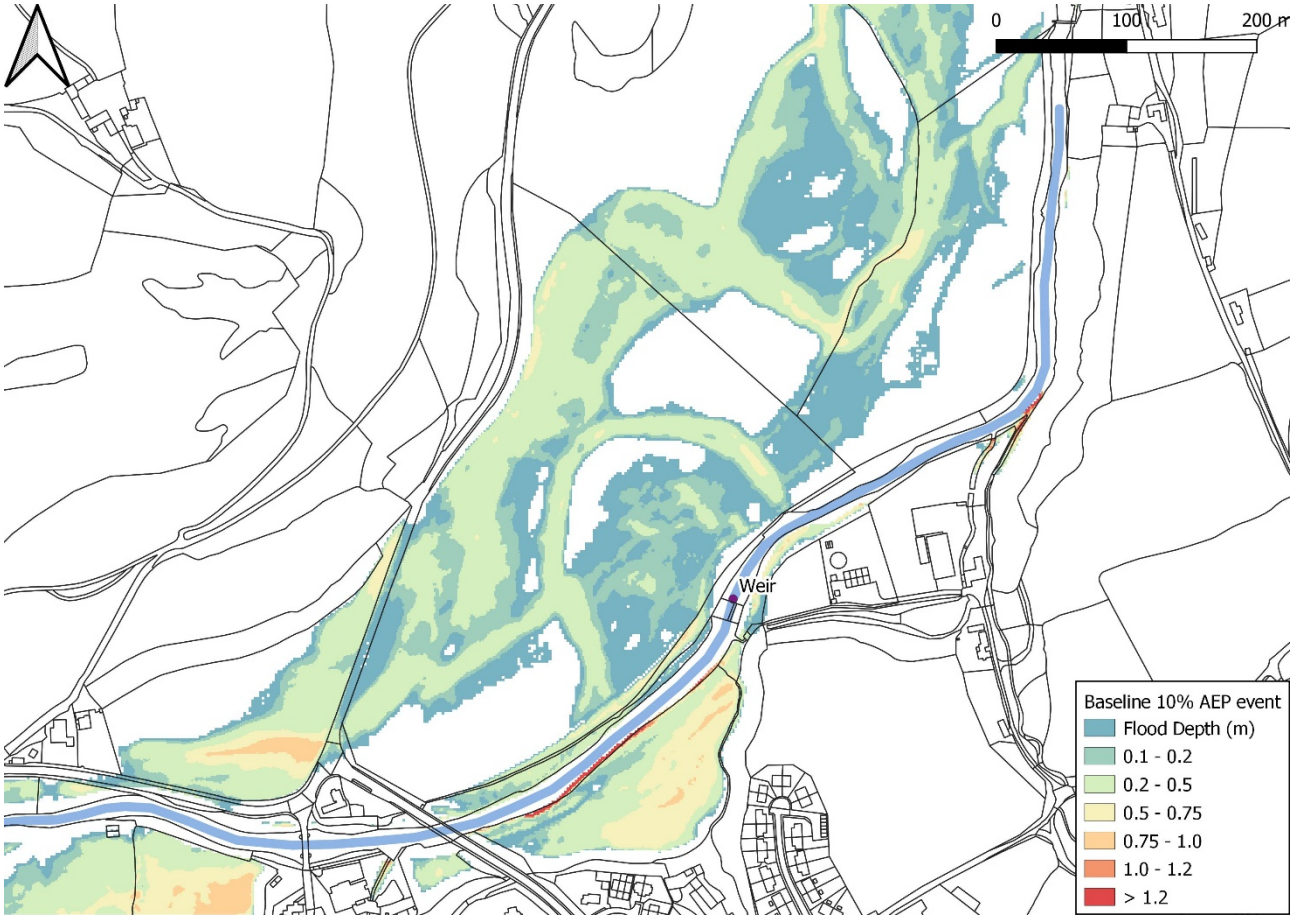

Figure 6: Baseline flood depths in the 10% AEP event

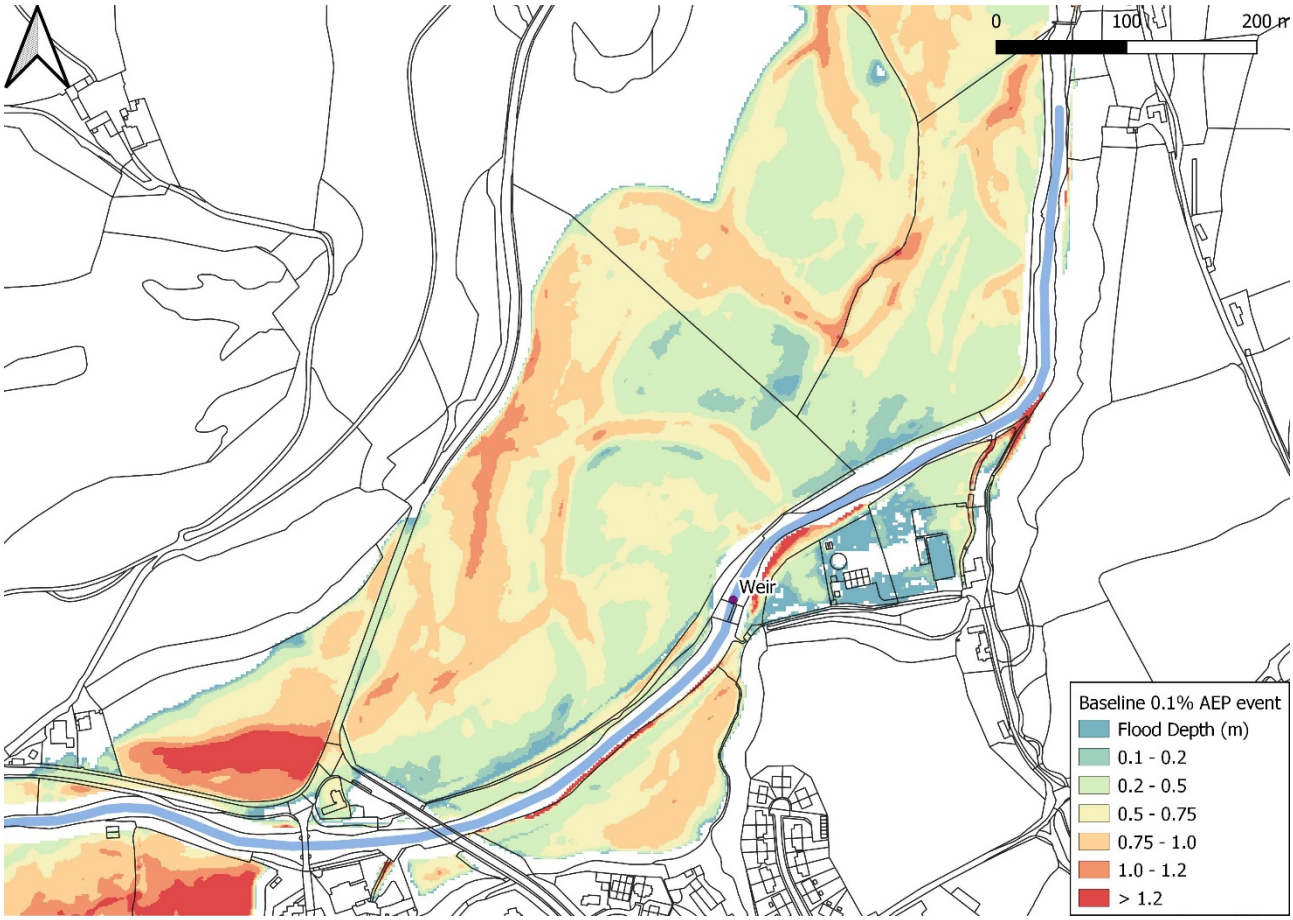

Figure 7: Baseline flood depths in the 0.1% AEP event

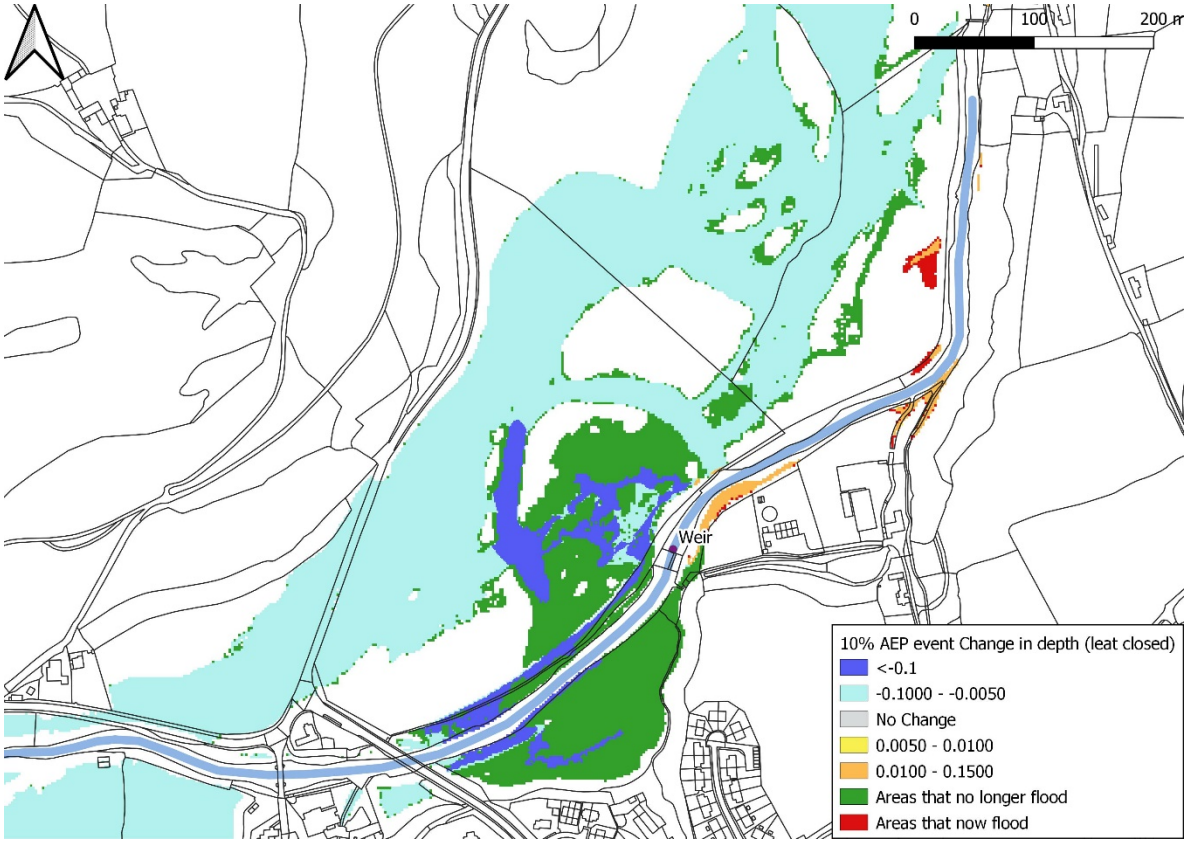

Figure 8: Change in flood depth in the 10% AEP event

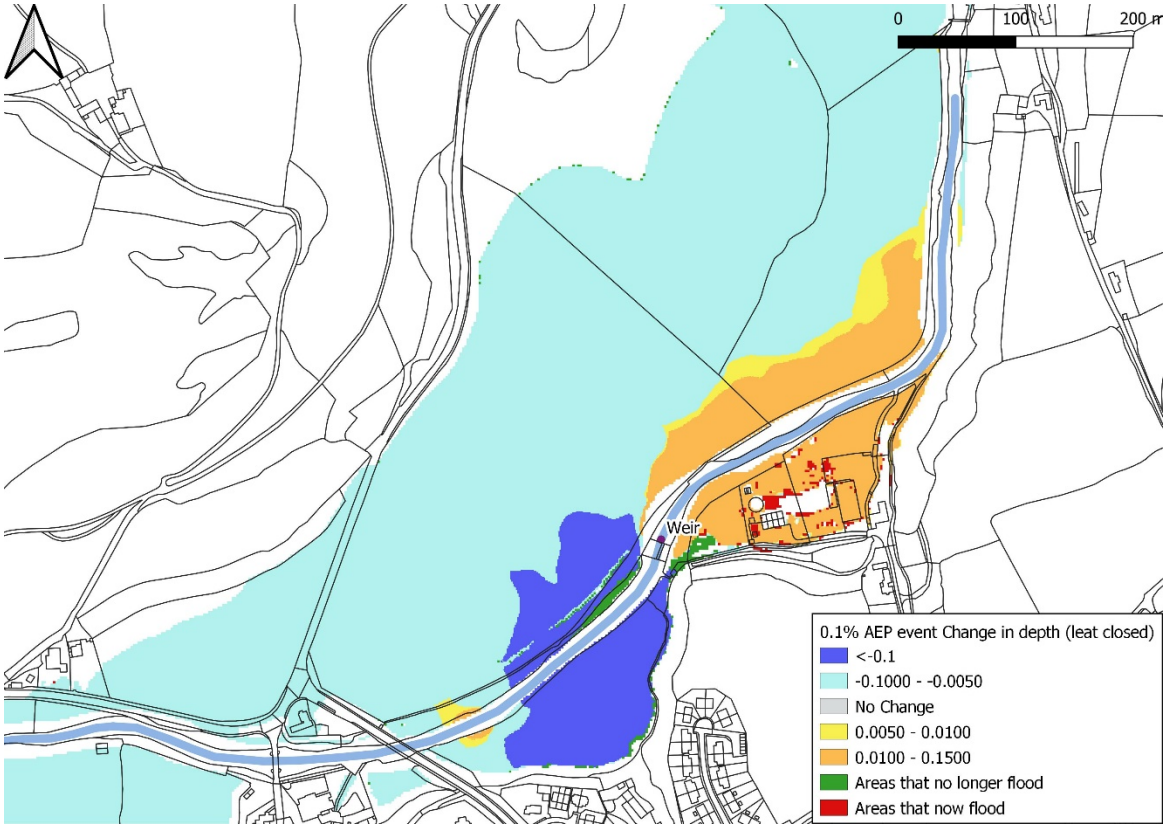

Figure 9: Change in flood depth in the 0.1% AEP event

5.3 Change in velocities

Figure 10 shows the expected change in velocity across the river in the baseline and following weir removal. Generally, velocities are very similar following removal other than immediately upstream of the weir as expected, and this pattern is repeated across events. Erosion protection measures will be incorporated around the removed weir and the new check weir to prevent adverse effects from these increased velocities. In addition, there is a known area of erosion downstream of the weir which will be repaired and strengthened.

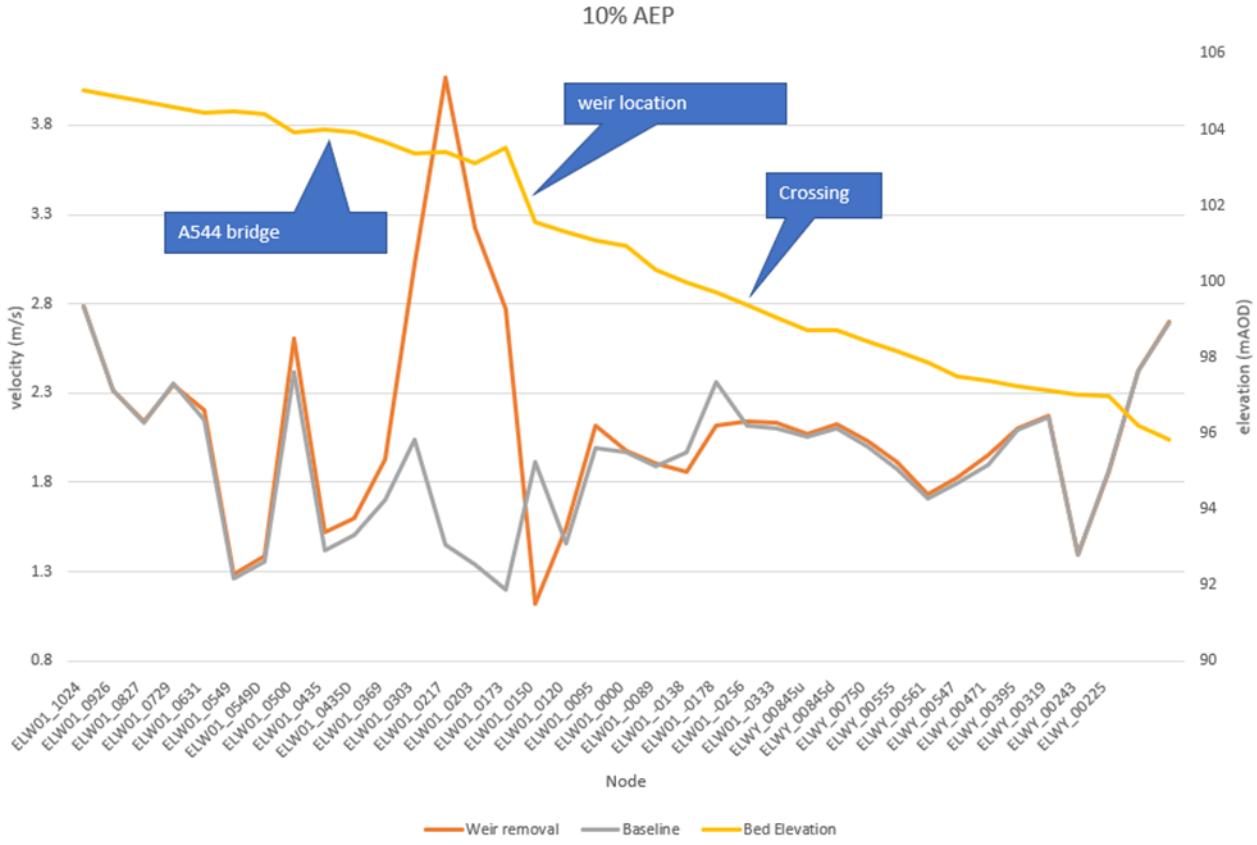

Figure 10: Change in velocity in the 10% AEP event

6. Conclusion

The existing flood model at Llanfair Talhairn has been updated, and a weir removal scenario created. This model was run for a range of return periods, and has shown that for all return periods removing the weir:

- Decreases flood depths upstream of the weir
- Increases flood depths downstream of the weir, including at the waste water treatment works and residential property
- Increases velocities for the area immediately upstream of the weir, with a slight reduction downstream. Three landowners are affected, shown in Table 3.

Landowner affected	Location	Status of negotiations
Mr Lloyd	Fields on left hand bank	Mr Lloyd has accepted small level of detriment to his fields that already flood.
DCWW	Right bank -affects more of the non-operational land. Assets in the operational zone are protected by walls or are higher than ground level	Verbal acceptance given during site visit – awaiting written confirmation
Mr and Mrs Faughnan	Garden on right bank	Acceptance of detriment with compensation.

Table 3: Affected landowners and status

As a result of this, NRW are in negotiation with the relevant landowners regarding detriment mitigation, and the design of the weir removal will mitigate the risk of increased erosion. It should also be noted that given the poor and deteriorating condition of the weir, it is likely that in the short to medium-term it would be likely to collapse in an uncontrolled manner. This would lead to the same effects on flood risk, without the mitigation measures in place.

Appendix A

Model results

A.1 Flood depths

A.2 Detriment