

# Flooding in Dolgellau



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## **Background**

Flooding has historically been a cause for concern in Dolgellau. Following a serious flood in December 1964 when shops in Bridge street were inundated (illustrated above), a flood defence scheme was implemented by the local authority. The main feature of this scheme was the construction of masonry walls to a height of approximately 3m above river level along the stretch of river bank from the Arran confluence to the eastern end of the Marian Mawr fields. The scheme has been successful for over 40 years in preventing flooding of the town centre, but there is concern that the river wall at the Bont Fawr car park has come close to overtopping during recent major flood events. It is now considered necessary to re-examine flood defences for Dolgellau, and a proposal for a major new scheme by the Environment Agency has reached a consultation stage (Environment Agency, 2010).

Some concern has been expressed locally that the Environment Agency scheme relies entirely on the construction of flood defence walls, set back from the current river banks. The proposed walls are considered by some residents to be intrusive and out of character with the historic town centre, and to be potentially disruptive to leisure and sporting activities on the Marian Mawr fields. A further concern is that the scheme takes no account of continuing gravel accumulation in the river, which is likely to increase the severity of overbank flooding in future years through raising river bed elevation. As a consequence, the effectiveness of the new flood defence scheme may be reduced.

Following a consultation meeting between representatives of the Environment Agency, Dolgellau Town Council, and local organisations who are users of the Mawr Mawr fields, I have been asked to comment on the proposed flood defence scheme and review possible alternative approaches.

## **Geomorphology**

The town centre of Dolgellau is constructed on a glacial/periglacial sand and gravel fan deposited by the Afon Arran (fig.1). Since deposition, the fan has been incised by the Arran stream, which now follows a noticeable valley between the Arran Road bridge and the Wnion confluence next to the Leisure Centre. There is evidence, however, that the stream formerly followed a more westerly course in a shallow valley along the present line of Bridge Street.

The Afon Wnion descends by some 4 metres over its course through Dolgellau, but the river gradient is not constant along this section. Steeper gradients are observed at and downstream from the two main confluences at the Leisure Centre and Pandy'r Odyn (fig.2).

### **River bank characteristics**

A series of photographs were produced on 29 December 2010 to illustrate the changing characteristics of the riverbank through the Dolgellau section of the Afon Wnion (figs 3 – 10). At this time the river level was moderately high due to extensive snowmelt in the surrounding mountains. River level effectively remained constant during the period of photography, so it is possible to compare the relative heights of the banks at different points along the section.

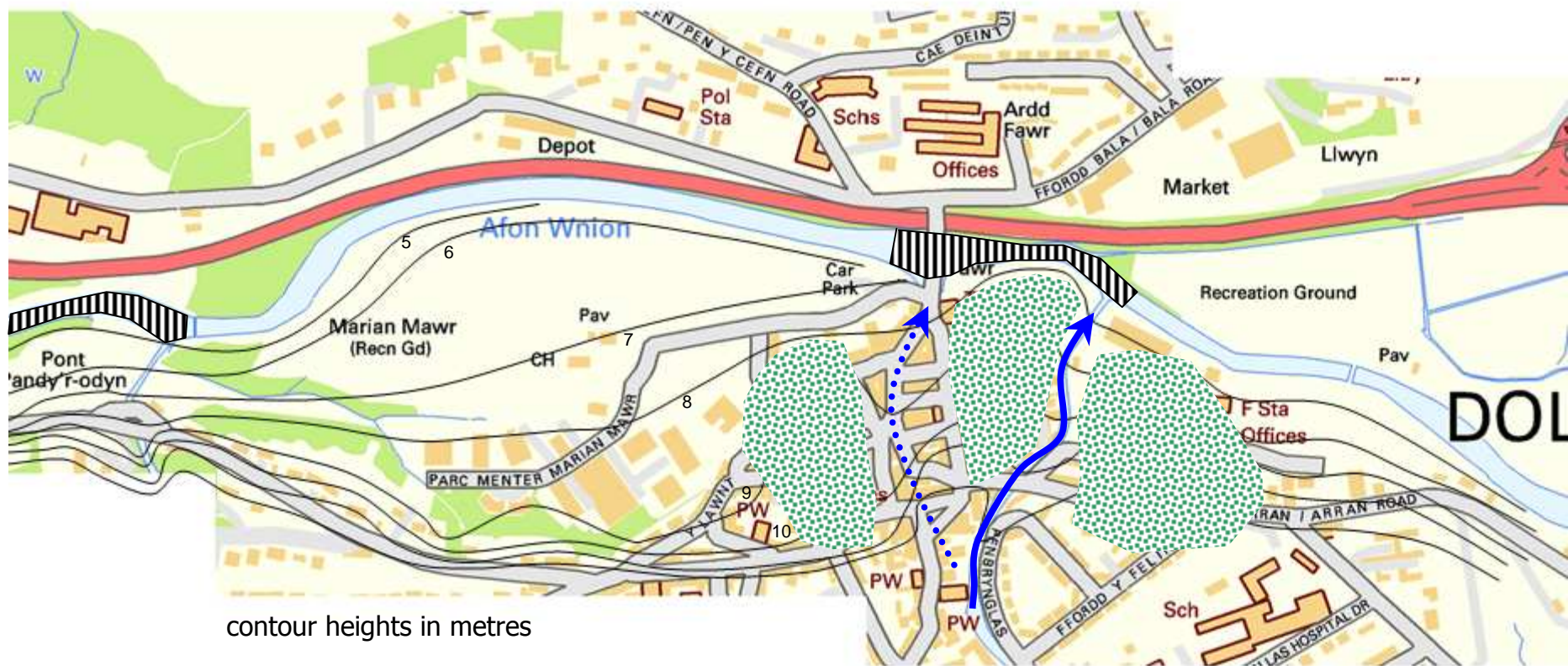
The following description refers only to the southern bank of the Afon Wnion, since no flood defence measures are planned for the north bank.

At the upstream boundary of the town on Arran Road, glacial/periglacial deposits produce a natural rivercliff approximately 3m in height.

The banks are relatively low along the reach between the rivercliff and the confluence with the Arran stream. The banks are semi-natural, built up in places with large rocks, but no systematic construction of flood defences has been attempted. This section of bank is overgrown in places and appears to be unused.

The section between the Arran confluence and the Bont Fawr car park is the location of the masonry flood defence walls constructed in the 1960's. These are in good condition, and extend to approximately 3.5m above river level.

Alongside the Marian Mawr fields, the river bank is constructed from rock-filled gabions, with large rocks forming the bank further to the west.



relict areas of  
glacial/periglacial  
sand and gravel  
deltaic fan



current drainage  
route of the  
Afon Arran



possible former  
drainage route  
of the Afon Arran



sections of  
steeper gradient  
of the Afon Wnion

Figure 1: Morphological map

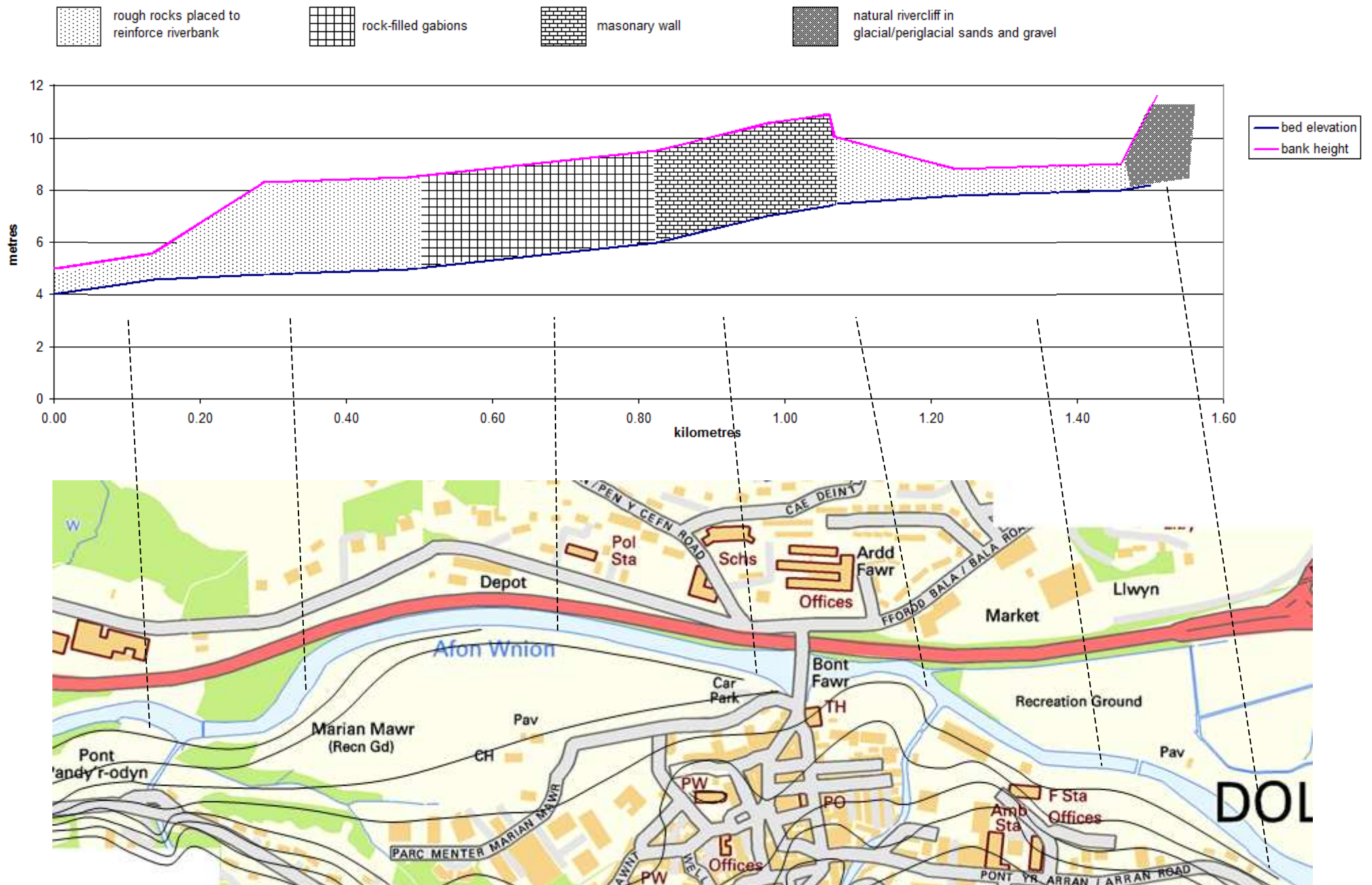


Figure 2: River and river bank characteristics



Figure 3:

Natural rivercliff in  
glacial/periglacial sands  
and gravels.

Arran Road



Figure 4:

Downstream limit of the  
rivercliff feature.

Arran Road



Figure 5:

Semi-natural riverbank of rocks and pebbles, overgrown with scrub woodland in places.

Arran Road



Figure 6:

Semi-natural riverbank of rocks and pebbles at the rear of the Fire Station. The bank is unused, and overgrown with scrub woodland.

Arran Road



Figure 7:

Confluence of the Arran stream, with the leisure centre building beyond.

Downstream of the confluence are the substantial masonry walls of the 1960's flood defence scheme. The ground above, now occupied by the park, appears to have been built up at the time of the wall construction.



Figure 8:

Gabion walls alongside the Marian Mawr fields.

The walls extend to approximately 2m above the level of the fields. Their purpose may be to stabilise the river channel, realigned as part of the Dolgellau by-pass road scheme in the 1980's, rather than to provide flood defence.



Figure 9:

Boulder walls alongside the Marian Mawr fields.

The banks alongside the downstream section of Marian Mawr are constructed of large loose boulders, piled in places onto a concrete footing. It is uncertain whether water is able to flow through this construction at high river levels.



Figure 10:

Confluence at Pandy'r Odyn.

Large loose boulders reinforce the river bank and have been placed to deflect the main channel flow at the confluence.

## **Gravel accumulation**

A significant geomorphological feature of the Afon Wnion is the erosion, transport and deposition of large amounts of coarse gravel during flood events. This gravel raises the elevation of the river bed through the town of Dolgellau, contributing to the severity of flooding.

Gravel is derived from easily eroded glacial and periglacial deposits which infill the valleys of the upper Wnion catchment, particularly on the slopes of Rhobell Fawr and the Aran mountains.

There is evidence that the rate of deposition of gravel along the Dolgellau reach has increased over the past 100 years, and is continuing to increase. This is due largely to a change in land use, which has removed broad leaf woodland from river banks in the upper catchment. This woodland stabilised and protected river banks.

A contributory factor in the increased gravel erosion is climate change. There is strong evidence that a change in rainfall patterns is occurring, with heavier frontal rainfall during winter months and the risk of more violent summer thunderstorms. This change is increasing the severity of flood events on the Afon Wnion.

Gravel transported downstream past Dolgellau accumulates at the tidal limit of the estuary, beyond which it is unable to move due to insufficient water flow velocity. This deposition is raising the river bed elevation, both at the tidal limit and upstream towards Dolgellau.

Computer modelling and field observations have been carried out (Hall, 2008) to estimate the amounts of gravel transport during individual flood events. Major floods in June 2001 and February 2004 were analysed in detail. Gravel trains released by bank erosion moved downstream along the river bed, progressing by approximately 1km during each major flood event.

It is predicted that large volumes of gravel will be added to the Dolgellau reach over the next 10 years, leading to a raising of the river bed by between 0.5m and 1.0m through the town. This deposition will reduce the effective height of existing or proposed flood defences by an equivalent amount.

Gravel deposition is greatest in the sections of the Afon Wnion with lowest gradient, notably on the eastern outskirts of the town at Arran Road, and along the reach between Bont Fawr and the western end of the Marian Mawr fields (figs 11 and 12).



Figure 11:

Recent sediment accumulation downstream from Bont Fawr



Figure 12:

Sediment accumulation alongside the Marian Mawr fields

## **Overbank flooding**

Overbank flooding is controlled strongly by river gradient and relative bank elevation. Flooding is seen to occur particularly where water flow is reduced in low gradient sections of the channel – and water depth correspondingly increases to maintain constant discharge. Overbank flooding occurs most readily where the bank height is low and the land beyond has a gentle cross-floodplain gradient.

A small number of points of vulnerability to overbank flooding can be identified in the Dolgellau section (fig. 14):

A: Waterflows over the shallow banks in the Arran Road area, causing risk to the Fire Station, Leisure Centre and residential properties.

B: Flooding by overtopping of defences in the Bont Fawr car park. Water will initially flow downslope onto the Marian Mawr fields, but may make an incursion into Bridge Street along the former route of the Arran stream.

C: The current normal route for flooding of the Marian Mawr fields is through overtopping of low banks around the Pandy'r Odyn confluence.

D: Flood waters from the Marian Mawr fields may impinge on buildings of the Marian Industrial Estate.

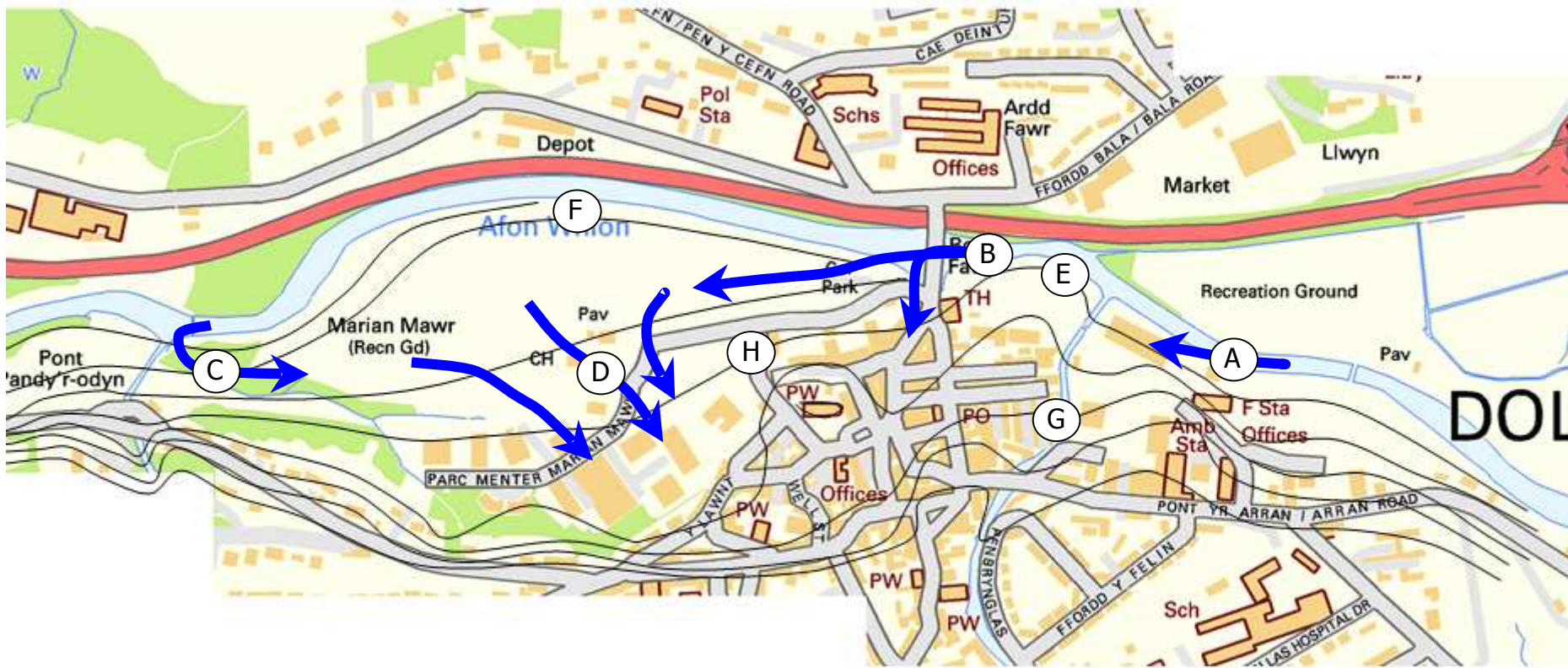


Figure 14: Overbank flooding

The following flow routes (fig. 14) are **not** considered to constitute a flood risk:

E: The Park. Land has been built up to an elevation of more than 3m above typical river level and is well protected by the very substantial masonry flood wall. At this point, water flows are fast due to the river gradient, and flood water depth is consequently reduced.

F: Marian Mawr. The current gabion and rock walls, backed by earth embankments to a height of 3m have come nowhere near to overtopping during any recent flood.

G: Afon Arran. Computer modelling (Hall, 2008) indicates that there is no conceivable rainfall event which could cause overtopping of the banks of the Afon Arran and flooding of Dolgellau town centre under current channel conditions. However, gravel transport on the Aran is considerable, and the clearance below the Aran Bridge is being progressively reduced. This could cause a local obstruction to flow which might result in flooding at some future date if left unchecked.

H: Upper Marian Mawr. It is not considered feasible for the town centre of Dolgellau to be flooded by water flowing eastwards from the Marian Mawr fields. This is due to blocking by the low spur of land running from the Church towards Bont Fawr.

The Marian Mawr fields appear to have a neutral role in respect to flooding in Dolgellau. They lie downstream and at a generally lower elevation than the town centre, so cannot provide any useful flood water interception capacity to reduce the effects of flooding in the town.

## **Flood reduction strategy**

Taking into account the evidence presented above, an integrated flood strategy is proposed for Dolgellau. This involves several elements, summarised in fig. 15:

- Interception of gravel before this enters the Dolgellau reach, in order to prevent further increase in bed elevation.
- Removal of gravel over an extended section of the river, to enhance the effectiveness of existing flood defences.
- Rebuilding of the identified vulnerable sections of the current river banks, notably: the Arran Road area, the Bont Fawr car park, and the Pandy'r Odyn confluence.
- Reinforcement of existing sections of river wall alongside the Marian Mawr fields.
- Enhancement of the flood interception capacity of the fields between the eastern boundary of the town and the by-pass viaduct.

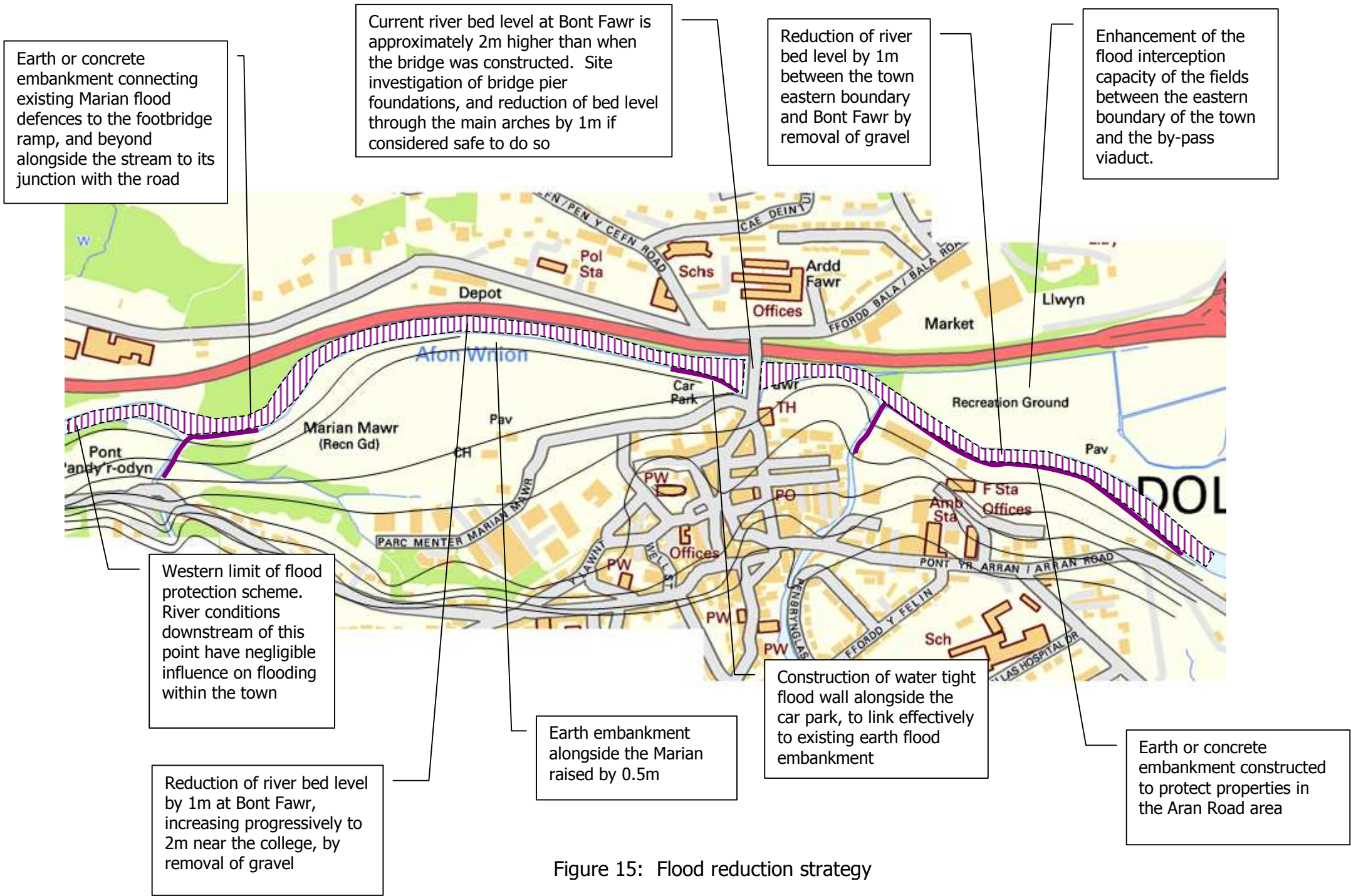


Figure 15: Flood reduction strategy

## Gravel interception

It is recommended that the supply of gravel to the Dolgellau reach of the Afon Wnion is reduced or eliminated by the construction of gravel interception weirs upstream in the area of Dolserau. Impounded gravel should be periodically removed to an area safe from river erosion.

Weirs should be of stone or concrete construction at a shallow angle, similar to that at Dolserau Bridge (fig. 13), to reduce any obstruction to fish migration.



Figure 16:

Weir at  
Dolserau Bridge

## Flood interception basin

During flood conditions, low lying fields to the east of Dolgellau are susceptible to flooding. The value of this land in reducing peak flood discharge can be enhanced by introduction of a side-weir in the river bank to direct flood waters into the basin under flood conditions. The outlet from the basin may use controlled drainage through pipes to allow emptying over the 24 hour period following the flood peak. This should not interfere unduly with normal agricultural activities on the land. Similar strategies have been adopted by the Environment Agency in Northern England (personal communication) as an effective addition to hard engineering solutions.

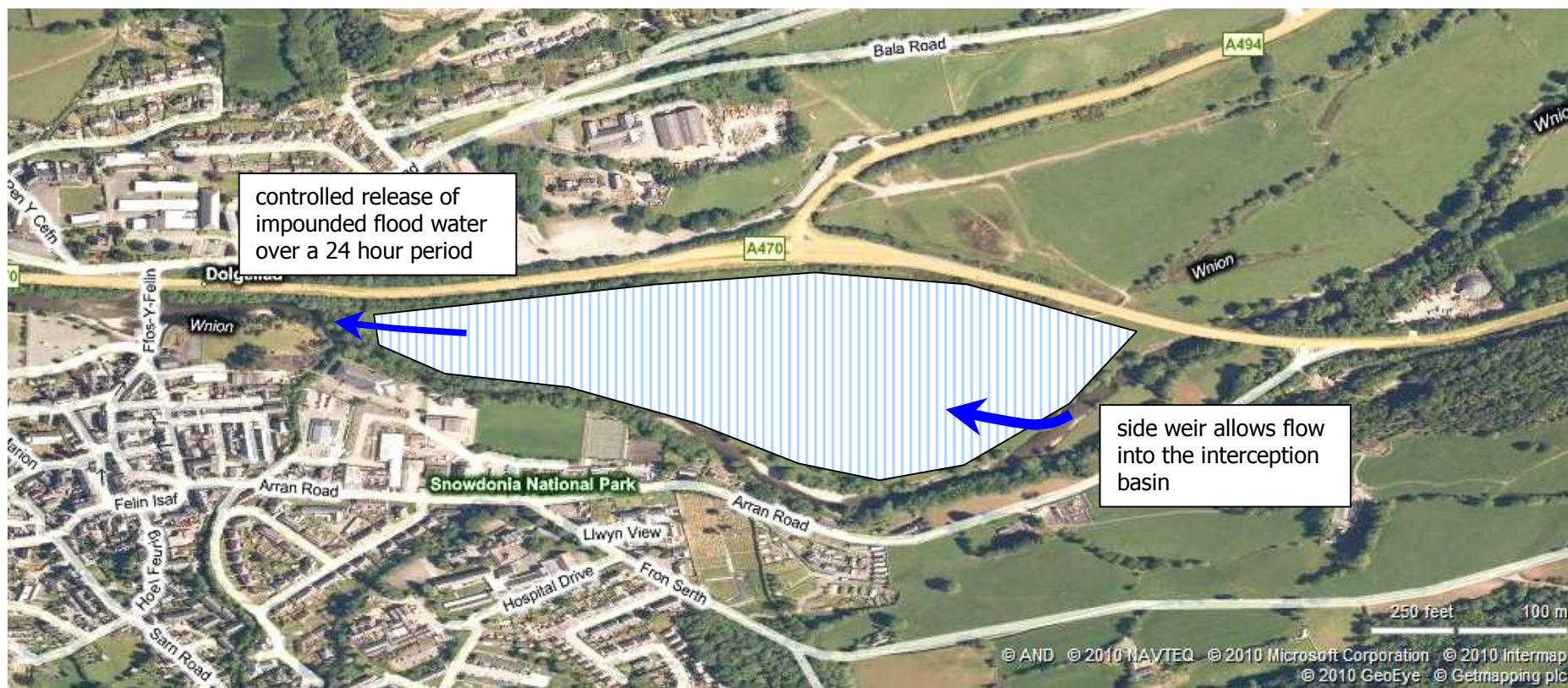


Figure 17: Proposed flood interception basin east of Dolgellau

## Computer modelling

Computer modelling has been carried out using RIVER-2D software:

- for current river conditions,
- for conditions after construction of the river bank defences, implementation of enhanced flow into the interception basin, and removal of river bed gravel proposed in fig. 16.

A peak flood discharge of  $600\text{m}^3\text{s}^{-1}$  was chosen, as exceeding a predicted 100 year flood maximum for the Afon Wnion in Dolgellau. Results for maximum flood extent are shown in figs. 18 and 19.

Comparison of the models shows:

- Flooding of the Marian Mawr fields and incursion into the Industrial Estate would occur under current river conditions. Enhancement of defences around the Marian Mawr fields and gravel removal reduces flooding substantially, and no incursion into the Industrial Estate is predicted.
- The flood interception basin appears to operate as planned in providing temporary storage and reducing peak flood level by a small amount - perhaps 20cm. This may be significant in reducing overtopping of flood defences in critical areas.
- Within the limit of resolution of the model, it appears that encroachment by flood waters into the Arran Road properties will be reduced.

This modelling exercise should be treated as a first feasibility study, and more detailed work would be needed to investigate particular small sections of the river bank under flood conditions.

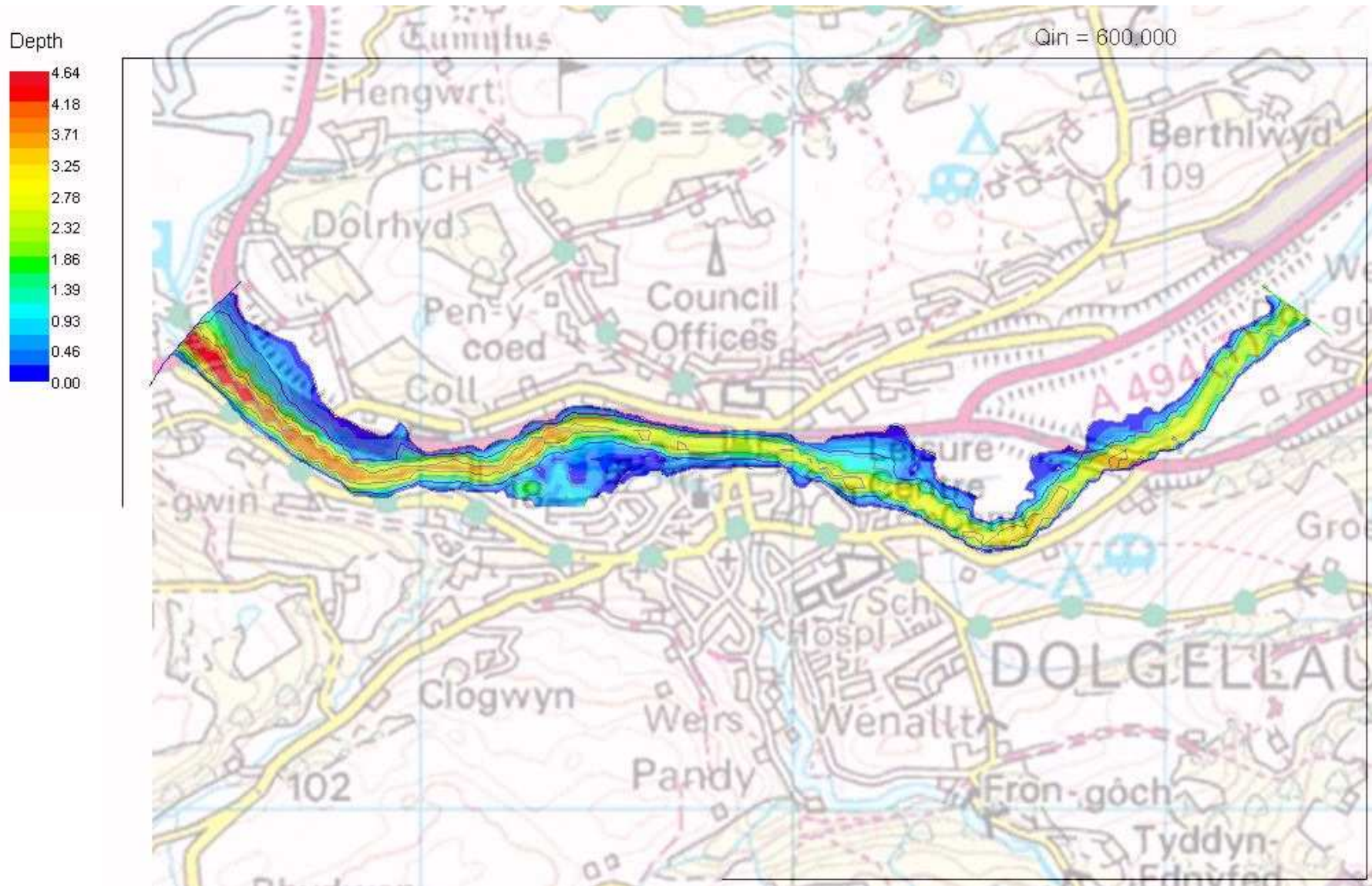


Figure 18: Peak flood model under current river conditions

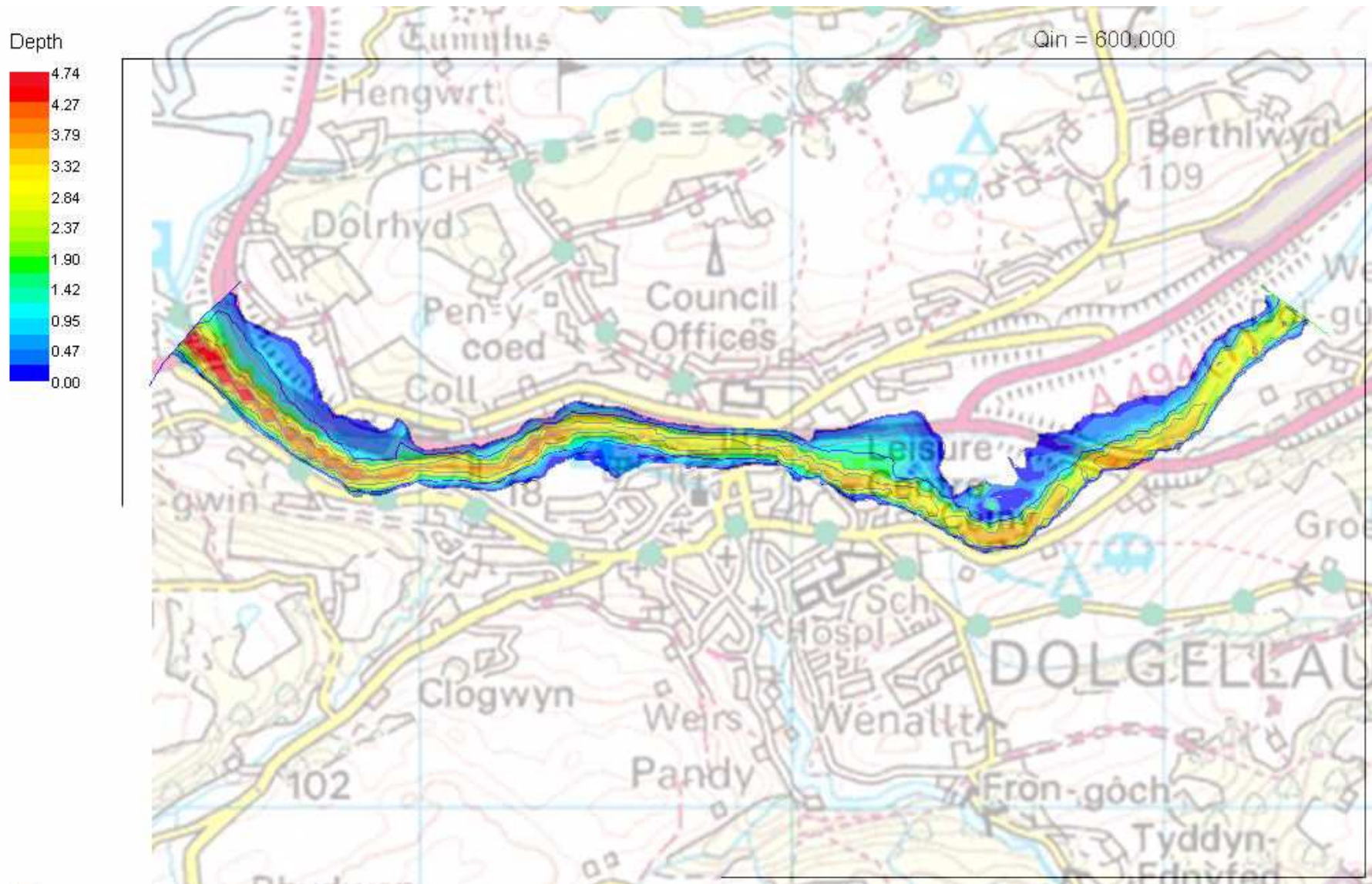


Figure 19: Peak flood model after gravel management and riverbank enhancement

## References

- Environment Agency (2010) Dolgellau Flood Alleviation Scheme Environmental Impact Assessment Scoping Consultation Document. Environment Agency. Available on-line at: [http://www.environment-agency.co.uk/static/documents/Leisure/01-06-10\\_Dolgellau\\_Scoping\\_Consultation\\_Document\\_Final.pdf](http://www.environment-agency.co.uk/static/documents/Leisure/01-06-10_Dolgellau_Scoping_Consultation_Document_Final.pdf)
- Hall, G. (2008) An Integrated Meteorological /Hydrological Model for the Mawddach Catchment, North Wales. Unpublished PhD thesis, University of Wales, Bangor. Available on-line at: [www.grahamhall.org/mawddach](http://www.grahamhall.org/mawddach)