Cyfoeth Naturiol Cymru
Natural Resources Wales

Dolgellau Flood Risk Management Scheme: GCSE Case Study

The Problem and Task

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Thanks

NRW would like to thank staff from Snowdonia National Park Authority and the North Wales branch of the Geography Society for casting an eye over this resource.

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Introduction

This case study can be used in conjunction with data and information from our website. It is regularly reviewed to ensure the data and information is correct.

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Background

Dolgellau has a population of 2,688 residents with a density of 0.8 people per hectare, living within the 3,501 hectares of the town. It is a small market town that serves as a local service centre for many of the surrounding settlements. The town's population swells in summer, with tourism and recreation playing an important part in the economy of the area, as the town provides a good base for the Cadair Idris mountain range and the southern part of Snowdonia National Park. Dolgellau lies on the confluence of the Afon Wnion and Afon Arran.

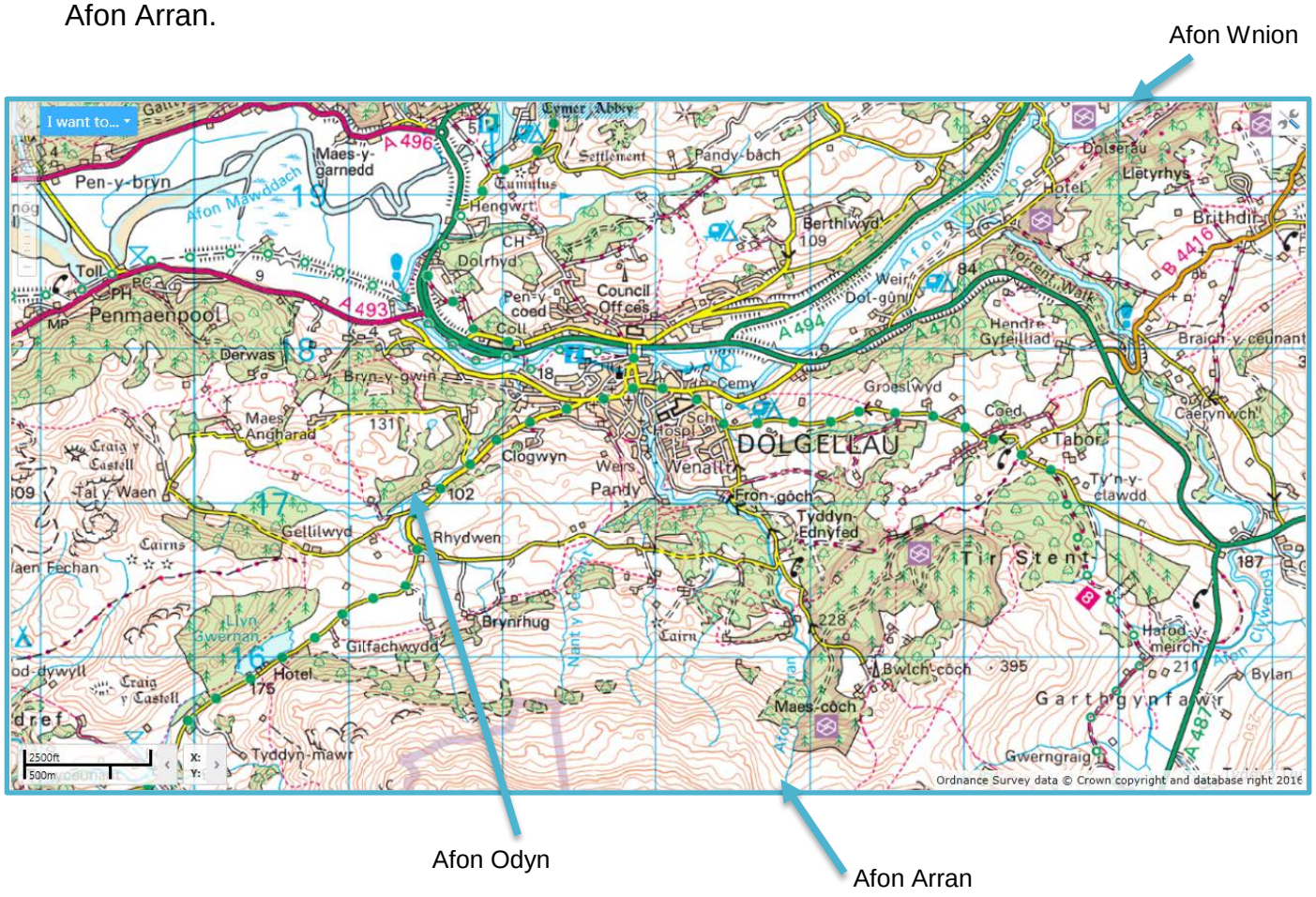

Fig 1 - OS Map showing Dolgellau and the rivers that run through the town

Afon Wnion

The source of the Wnion is at 850m to the north of the Aran Benllyn. The upper reaches of the Wnion catchment are steep and generate a rapid response to heavy rainfall, resulting in flooding of the largely undefended downstream floodplains. High flows are known to erode large and unconsolidated sediments. This material is transferred downstream during flood events, where shallower gradients allow it to be temporarily deposited.

3km downstream of Dolgellau the Afon Wnion joins the Afon Mawddach before flowing out into the Mawddach Estuary. The catchment is 11km long with a drop of 800m altitude over it's length. The catchment area of the Afon Wnion is 115 km^2.

The Afon Arran

The major tributary in the area, the Afon Arran descends from Cadair Idris, through Dolgellau. Although it only has an 8 km^2 catchment, it presents a significant flood risk to the town centre. The Afon Arran is a relatively steep, shallow and fast flowing river which is constrained through Dolgellau town centre by a stone and mortar wall. The confluence of the Arran and Wnion is 170m upstream of the Bont Fawr bridge.

The Afon Odyn

A second, but smaller tributary of note is the Odyn, which lies to the west of the town at the downstream end of the Marian Mawr recreation ground. It presents no flood risk to the town itself but adds to the flooding of the Marian Mawr recreation ground.

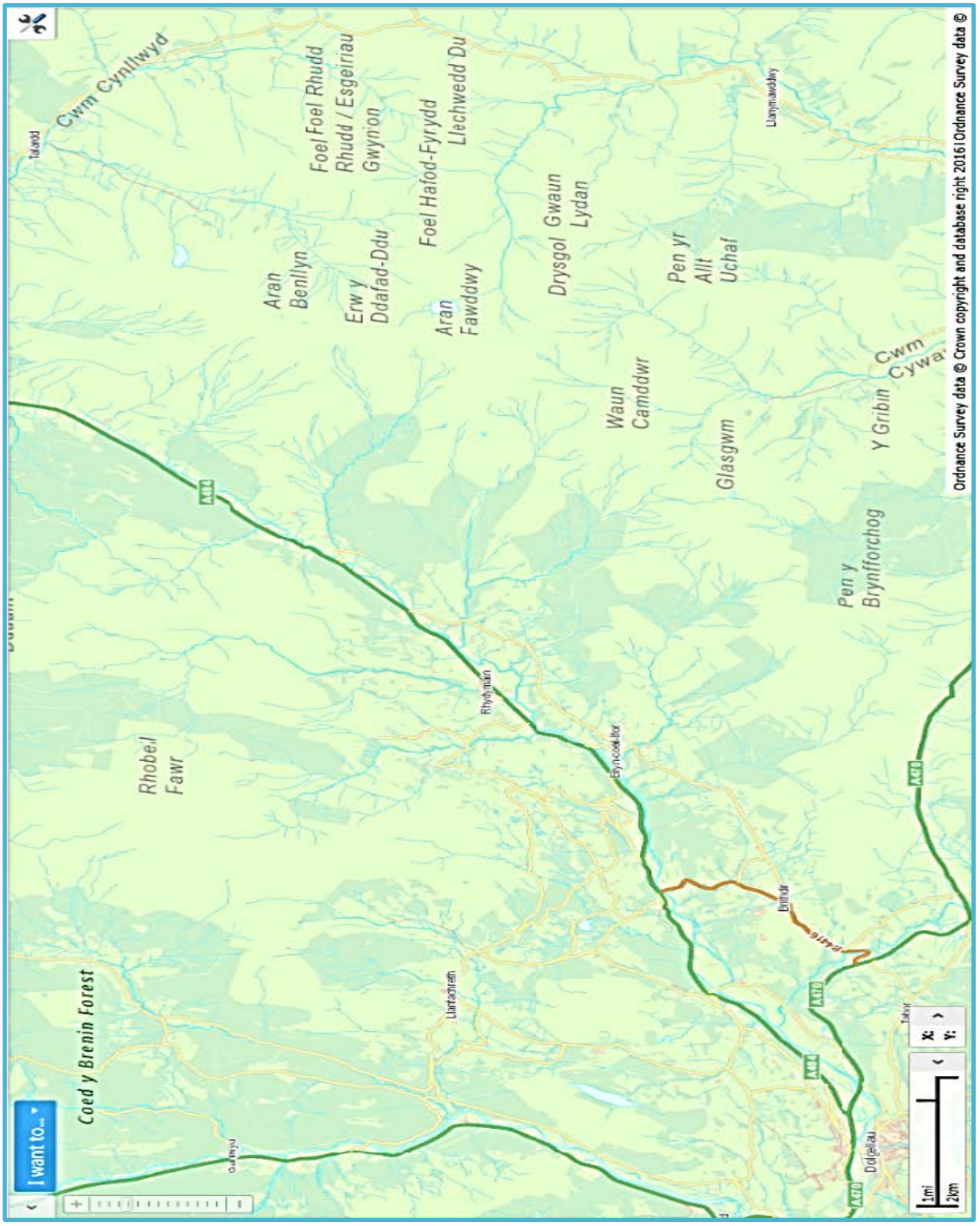

Fig 2 – The Afon Wnion catchment

What's the problem? Flooding at Dolgellau

Historically flooding has occurred in 1903, 1913, 1922, 1927 and 1964. Following the floods in 1964, a total of 73 properties were flooded. Masonry walls were built in 1970 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 recreation fields to try to stop future flood events.

Left, Fig 3 - The Bont Fawr after flooding in 1903

Right, Fig 4 – Dolgellau High Street, September 1922

Left, Fig 5 - The Afon Wnion by the Bont Fawr 2004

Although the town centre hasn't flooded for over 40 years, there is photographic evidence of flooding in the early 1980s, 1995, 2004 and 2011 at the Marian Mawr recreation ground. During November 2009 river levels rose to such an extent that a short section of the existing walls downstream of Bont Fawr were overtopped, but no properties were flooded.

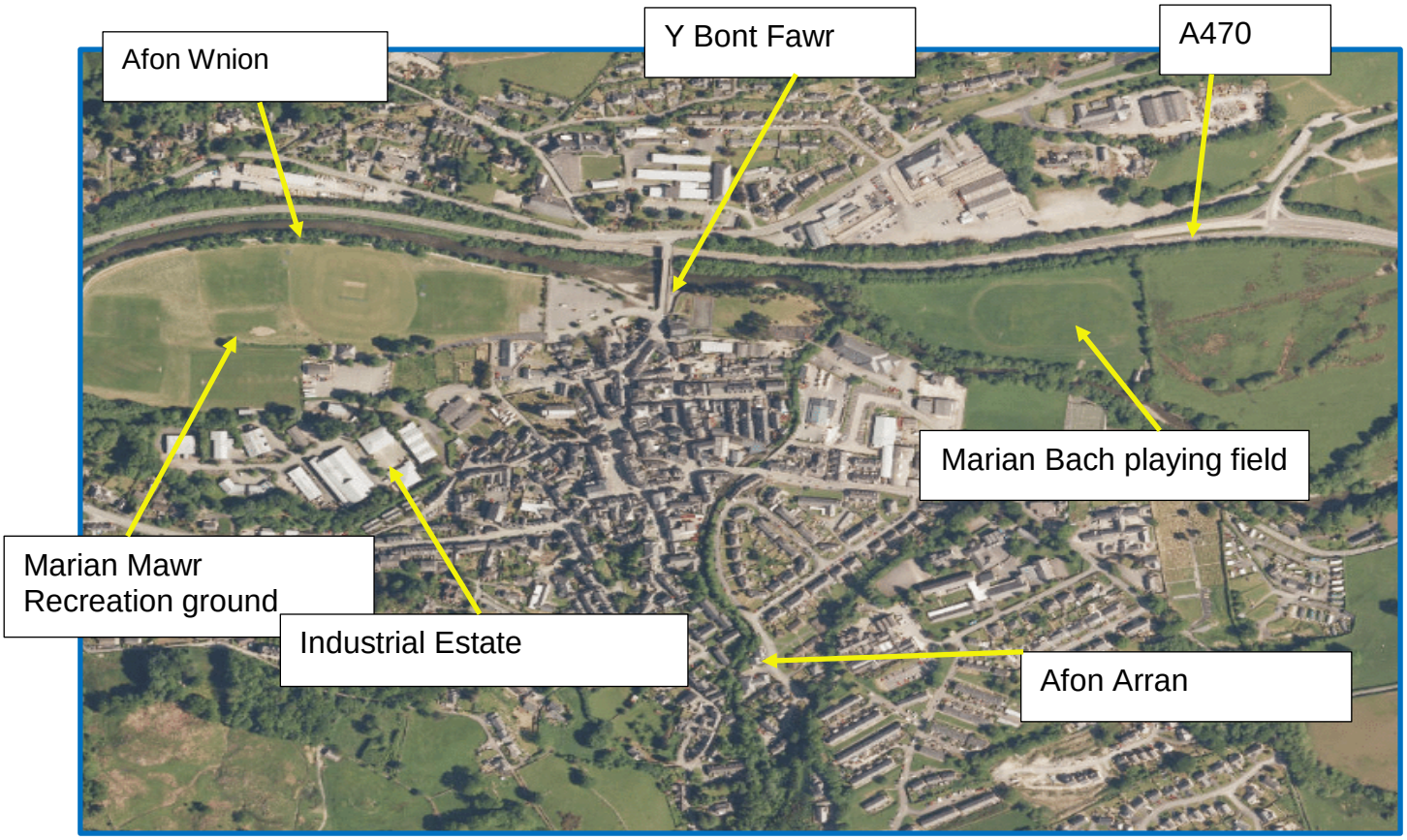

Fig. 6 – Aerial photo of Dolgellau

The mortar walls were not designed to act as formal flood defences. When inspected, they were found to be in need of repair following the result of storm damage and vegetation growth. The condition of the walls meant that their remaining service life, taking account of ongoing future repairs was estimated to be around 20 years.

Annual flood risk management practices in the town included the installation of temporary defences (sand bags used at Bont Fawr) during flood events.

With the walls in need of repair and hydrological modelling indicating that the town would be susceptible to flooding should the area be subjected to a major rainfall event, it was considered necessary to re-examine flood defences for Dolgellau. A proposal for a major new scheme was developed by the then Environment Agency Wales and reached a consultation stage in 2010.

Considerations for the new Flood Defence Scheme

The Afon Wnion

The Afon Wnion is an important river for salmon and sea-trout and is designated under the Freshwater Fish Directive. Spawning gravels are present on the Afon Wnion in the Dolgellau area. Sea trout and salmon migrate along the rivers between March and October and the spawning season runs from approximately October to January. The Afon Wnion is also a well-established area for angling. Dolgellau Angling Association and the Prince Albert Anglers Society are the main angling clubs, and the members fish the river throughout the season. There is a hatchery downstream of the study area, where fish are reared before being released into the river to boost numbers

Fig 7 – The Afon Wnion, an important spawning ground for salmon and sea-trout

The Afon Arran

The Afon Arran presents a significant flood risk to the town. The left-bank upstream of Pont yr Arran has a 2% annual probability of overtopping. Flooding at this location provides a path for flows into the centre of town. At current flow rates this could lead to flooding of around 0.3 metres in depth in inhabited parts of the town centre. Factoring in potential climate change this rises to above 0.5 metres in many parts of the town. The right-bank can also be overtopped and adds to the flooding in the Arran Road area.

Dolgellau's development was due to the woollen industry, which flourished in the 18th and 19th centuries. The mills ran using water from the Afon Arran. There are a number of old weirs along the river in Dolgellau which are associated with the historic woollen industry.

Fig 8, left - Pandy Mill on the Afon Arran, near Dolgellau

Bont Fawr Bridge; one of the three access routes into Dolgellau

The bridge at Bont Fawr is constructed with seven arches across the Wnion, and is approximately 60m wide.

The channel widens significantly through Bont Fawr bridge and is nearly three times the channel width upstream. The wider channel means that the flow is shallower and more spread out.

Fig 9 – View of deposition occurring at Bont Fawr bridge

The velocity of flow has been recorded as 2 m/s upstream of the bridge, slowing to 0.9 m/s at the bridge itself. The lower velocity causes gravel to settle out. Gravel build-up is worst around the three lowest arches on the left hand side of the bridge. The four remaining arches are relatively free of deposition. The clearance of gravel from within the river channel and the bridge arches at the Bont Fawr were last undertaken in 2008.

Designations

There are no designated sites of international or national conservation importance in the study area but the Mawddach Estuary Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC) is situated downstream.

Flood Risk Modelling

Flood risk assessment combines '*the **probability** and the **potential** consequences of flooding from all sources – including from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems, and from reservoirs, canals and lakes and other artificial sources*.' UK Government Planning Practice Guidance.[1]

The catchment

The land upstream of Dolgellau is predominantly farmland and is frequently flooded by the Wnion. Modelling and hydrology indicate that the old walls and embankments along the Afon Wnion would have a 5% annual probability of being overtopped. The town centre was deemed to have a 2% annual probability risk of flooding.

Modelling showed that changes in tidal levels in the Mawddach Estuary can also affect water levels along the Afon Wnion. Raising water levels by 1 metre downstream increases water levels in the Marian Mawr recreation ground by approximately 200mm and results in increased flooding at the Industrial Estate.

In the town

When flooding occurs, the sports grounds on both banks flood first, along with the Marian Mawr and the rear yard of the Fire Station situated to the north west of the town due to floodwater spilling over adjacent embankments.

Fig. 10 below, Flooding to the rear of Dolgellau Fire Station, November 2009.

199 residential properties and 142 commercial businesses within the town presently have a 0.67% annual chance of flooding in any given year. It was estimated that the frequency of overtopping would increase with the rise in river flows due to climate change.

Fig 11 - Y Bont Fawr, November 2015

The rivers

There is an existing stone retaining wall on the left bank of the Afon Wnion between the Afon Arran tributary and the Bont Fawr bridge (150m in length). This reduces the flood risk for most of the town to a 4% annual probability.

This stone wall extends from Bont Fawr bridge on the left bank along the northern boundary of the main car park (a length of 110m). The hydraulic modelling estimated that the downstream section of the wall (Marian Mawr Recreation Ground) has a 5% annual probability of overtopping.

At the north western corner of the car park, the wall changes to an earth embankment and extends along the northern boundary of the Marian Mawr floodplain. At the footbridge over the Afon Wnion, there is an 80m gap between the end of this earth embankment and the higher ground to the south. Prior to flood alleviation work, this area had a 50% annual probability of flooding. When flow rates are high, flood water from the Afon Wnion overtops the embankments, resulting in the intentional flooding of the Marian Mawr.

Fig 12 - View of the Bont Fawr carpark and Marian Mawr recreation ground from the Bont Fawr, 2011© Graham Hall

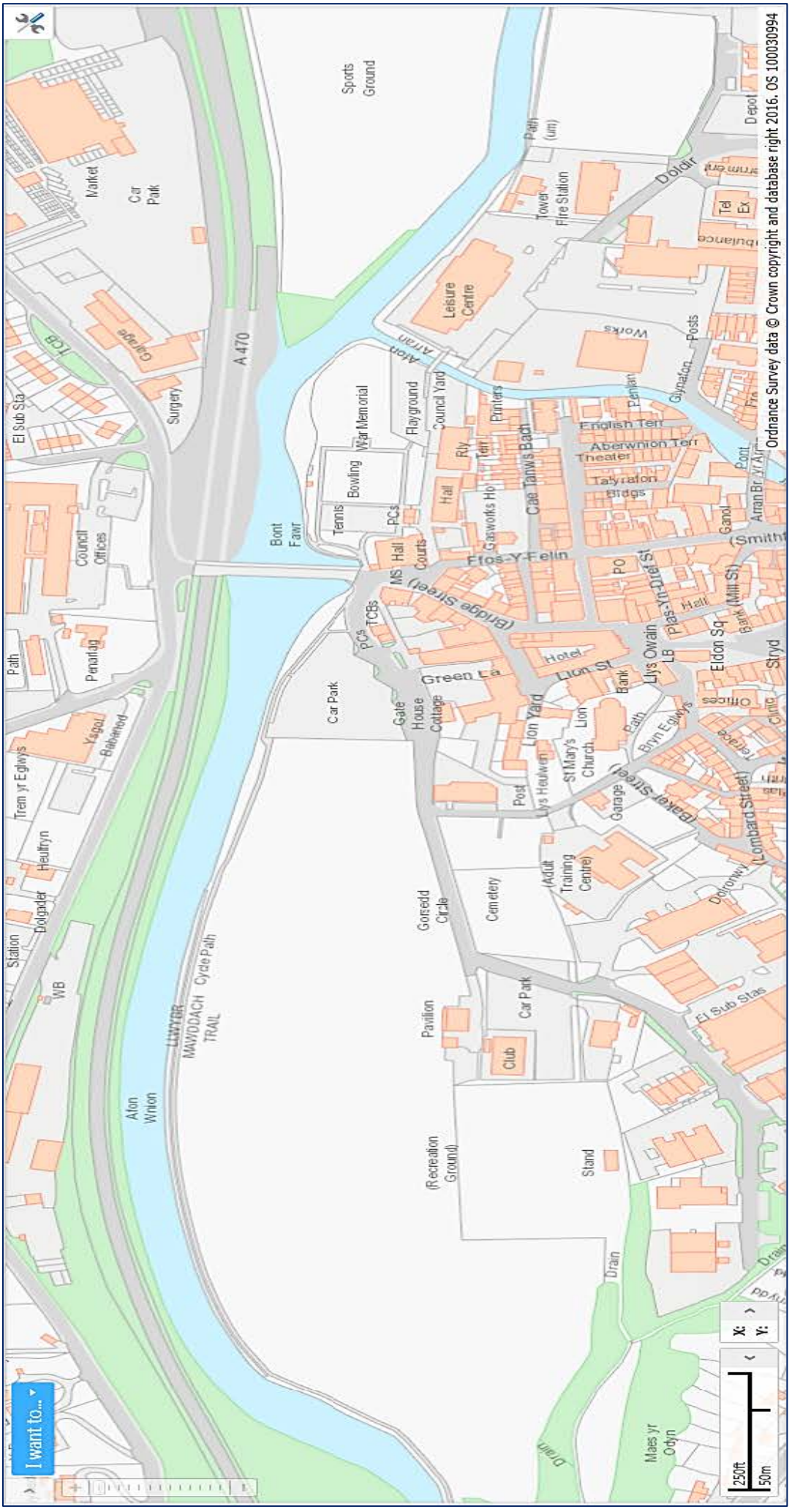

Fig 13, Street map of Dolgellau

The impacts of climate change in accordance with the latest guidance have been analysed. Flows are predicted to increase progressively and correspondingly therefore the numbers of properties at risk will increase in the future.

The increases in volume of flow, compared to the present-day, are predicted to be 15% by the 2020s, 20% by the 2050s, and 30% by the 2080s. These large increases in flow would see the river overtop upstream of Pont yr Arran and run through to the town centre.

Options considered for the Dolgellau Flood Risk Management Scheme

The following options were considered as part of the Dolgellau Flood Risk Management Scheme.

Option 1: Do Minimum – assumed to represent the existing situation, with 'Patch & Repair' of flood defences to slightly prolong their effectiveness to withstand flood water as well as ongoing maintenance works and existing flood warning measures.

Option 2: Raise existing defences – increase the height of the existing walls so as to provide an increased Standard of Protection (SoP) against floods.

Option 3: Construct new defences set back from the river – provide an increased Standard of Protection by constructing new flood defences set back from the river, in line with 'Making Space for Water'.

Option 4: Construct new channels or diversion routes – appraise options that would allow floodwater to be diverted from the Afon Wnion and Afon Arran to other water courses.

Option 5: Improve conveyance – increase the channel capacity by means of either increasing the flow area of the river or increasing flow velocities through:

a) Dredging;
b) Widening the river channel;
c) Narrowing the river channel.

Option 6: Floodplain storage – Deliberately flood land in the uplands of the catchment to reduce the flow and water levels through Dolgellau.

TASK

What would you do if you worked for us? Study the facts and the options and decide on the benefits of each scheme and the constraints of each scheme.

Place them in order of merit and explain why you chose your first option over the other options.

Consider who you would need to consult and involve?

References

1 - UK Government Planning Practice Guidance

http://planningguidance.communities.gov.uk/blog/guidance/flood-risk-and-coastal-change/planning-and-flood-risk/what-is-flood-risk/

Bibliography

1. Environment Agency Wales, Project Appraisal Report, Dolgellau Flood Risk Management Scheme, October 2012

2. NRW, Dolgellau FRMS Project Review Note

3. NRW, Dolgellau FRMS Environmental Report, April 2014

4. Black & Veatch, Dolgellau Flood Risk Management Scheme Flood Consequence Assessment Report, April 2014

This document will be reviewed on an annual basis.

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