

St Asaph Flood Risk Management Scheme

Flood Consequence Assessment



August 2016

ST ASAPH FLOOD RISK MANAGEMENT SCHEME FLOOD CONSEQUENCE ASSESSMENT

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ST ASAPH FLOOD RISK MANAGEMENT SCHEME FLOOD CONSEQUENCE ASSESSMENT

1. INTRODUCTION & DATA COLLECTION

1.1 Introduction

This report details the Flood Consequence Assessment (FCA) that has been undertaken for Natural Resource Wales' proposed flood risk management works at St Asaph in north-Wales (refer to Figure 1.1). The works are to provide new and improve existing flood defences to protect St Asaph from flooding from the Afon Elwy.

Figure 1.1 – Location Plan



The FCA has been completed following *Planning Policy Wales - Technical Advice Note 15: Development and Flood Risk* (TAN15)¹. In producing the FCA, reference was also made to the following documents:

- Review of FCA modelling good practice and managing potential detriment effects from FRM schemes; NRW, November 2014; and
- TAN 15: Development and Flood Risk; NRW Letter to Chief Planning Officers, 4th March 2015.

¹ *Planning Policy Wales - Technical Advice Note 15: Development and Flood Risk (2004)*

The FCA has been prepared to demonstrate, so far as is reasonably practicable, that the proposed scheme is acceptable under the criteria laid out in TAN15. The structure of report is as follows:

- **Section 2** focuses on the existing flood risk to St Asaph from all sources of flooding;
- **Section 3** provides details of flood consequence from the proposed development. As the proposed development is a flood risk management scheme, there is no consequence of flooding to the development itself, so the focus of this report is flood consequences for existing development in and around St Asaph.
- A summary is provided in **Section 4**.

1.2 Data Collection

Topographic Survey

Table 1.1 outlines the key topographic survey data used to produce this FCA.

Table 1.1 – Topographic Survey Data

Reference	Survey Title	Surveyor & Date	Details
1.1A	St Asaph FRMS Threshold Survey	Zetica, February 2015	Threshold survey of properties potentially at risk for a 1 in 1000 annual chance flood
1.1B	St Asaph FRMS Topographic Survey	Zetica, November 2014	Topographic survey of the flood defences through St Asaph and immediately adjacent floodplain
1.1C	St Asaph Flood Risk Area Threshold Survey	Infomap, August 2014	Threshold survey of properties through St Asaph (survey commissioned by NRW)
1.1D	St Asaph FRMS Topographic Survey	Central Surveys Ltd, March 2016	Additional topographic survey including Fountains Garage

Hydrology & Hydraulic Modelling

An existing ISIS/Tuflow model of the Afon Elwy through St Asaph was first developed by JBA during 2011². During November 2012, extensive flooding occurred in St Asaph which prompted a review of the work. The updated findings were reported in [the] *St Asaph Flood Map Update*³ and included:

- New design flows for the city which were re-calculated using the methods given in the Flood Estimation Handbook to account for the November 2012 flood; and
- Re-calibration of the ISIS/Tuflow model against November 2012 flood.

The new hydrological analysis suggested the November 2012 flood had between a 1 in 100 and 1 in 200 annual chance of occurring in any given year. The updated Afon Elwy model was calibrated against and gave a close match in terms of predicted flood level and extent to the November 2012 flood. Given the magnitude of the November 2012 flood, a good degree of confidence can be attached to flood levels predicted by the model.

² *Afon Elwy Flood Risk Mapping Study, JBA, 2011*

³ *St Asaph Flood Map Update – Final Report, JBA, May 2014*

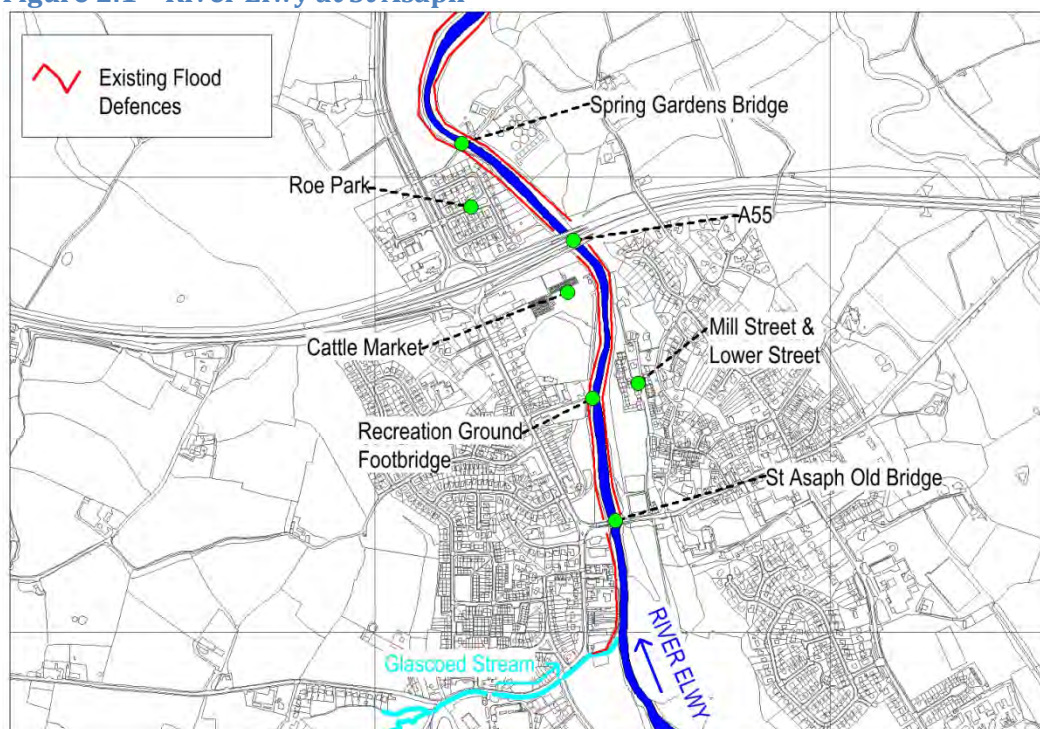
The 2014 Afon Elwy ISIS/Tuflow model has been used to provide flood levels and extents for the existing situation and with the proposed St Asaph Flood Risk Management Scheme (FRMS). The model was updated by B&V for this FCA to include the recent improvement works undertaken to the defences within the Roe Park area of St Asaph (refer to Section 2.1 of this report). No further amendments were made by B&V to either the model inflows or its in-channel/floodplain hydraulics.

2. EXISTING FLOOD RISK

2.1 Fluvial

The main river flowing through St Asaph is the Afon Elwy; (Figure 2.1). The Elwy is a medium sized river with a catchment area of around 250km² when it reaches St Asaph. Its head waters lie to the south-west from where it flows towards St Asaph. The river flows northwards through the middle of the city and then continues downstream to meet the Clwyd. There is also a small tributary of the Elwy known as the Glascoed Stream, which discharges into the Elwy on the left-bank. It runs adjacent to Glascoed Road at the southern end of the city, draining an area of 3km².

Figure 2.1 – River Elwy at St Asaph



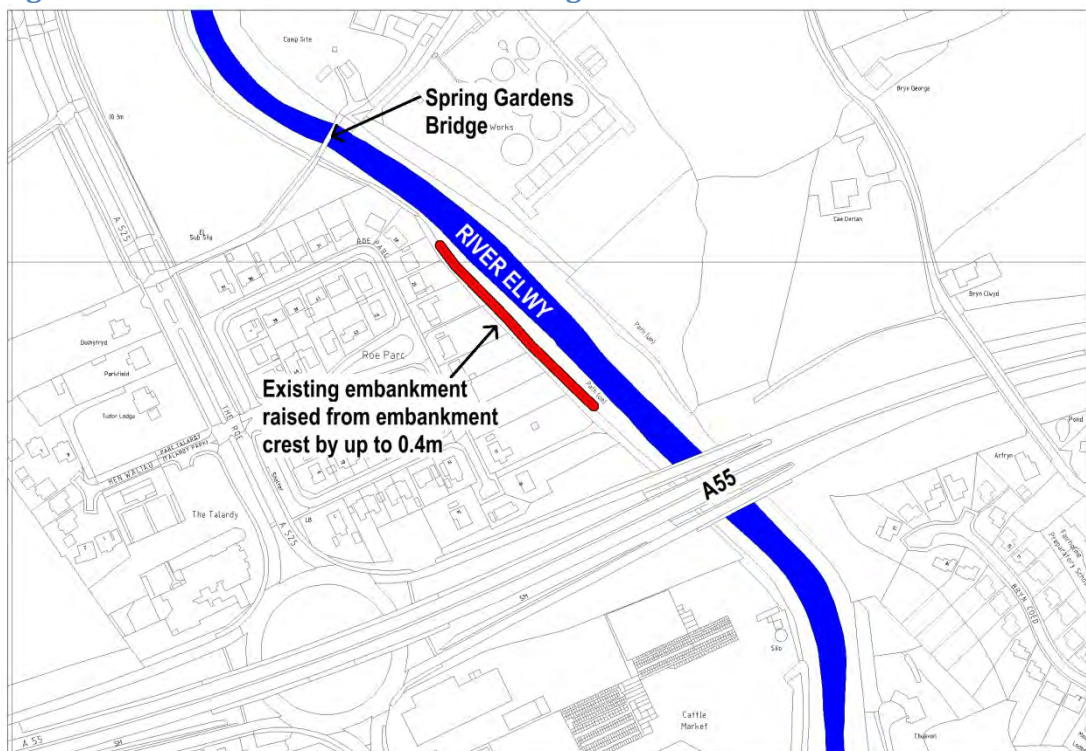
Historically, the evidence of flooding in St Asaph is limited, although there are entries in the Chronology of British Hydrological Events that indicate likely flooding in the vicinity of the city in 1871, 1882, 1896 and 1913. The existing flood defences were first constructed during the 1960s and raised again in the 1970s. The defences withstood all flood events until 27th November 2012, when around 320 properties and 70 caravans were flooded as a result of the flood embankments through the town being overtopped. This event is estimated to have been between a 1 in 100 and 1 in 200 annual probability flood. An aerial photograph showing the extent of flooding during the event is presented in Figure 2.2.

Figure 2.2 – Flooding in St Asaph, November 2012



During the November 2012 flood, flows overtopped the defences first at Roe Park where the existing defences were relatively low. Following the event, the embankment in the Roe Park area of the city was raised to provide the same standard of protection as the defences around the sewage works on the opposing bank of the river; refer to Figure 2.3.

Figure 2.3 – Roe Park Embankment Raising Works



Note – Black & Veatch updated the Afon Elwy model to include the Roe Park improvement works

The Afon Elwy ISIS/Tuflow Model (2014) provides more information on the existing flood risk through St Asaph. Drawing 122366-60001 (Appendix A) shows flood outlines for the 1 in 25, 1 in 50, 1 in 75, 1 in 100 and 1 in 200 annual chance floods. This shows the following:

- At the 1 in 25 annual chance event there is out-of-channel flow occurring upstream of the Old Bridge (A525), with possible flooding of the pavilion on the football ground, but is mainly contained in-bank.
- At the 1 in 50 annual chance event the existing defences are overtopped downstream of the A55 resulting in flooding of Roe Parc on the left-bank and Spring Gardens on the right-bank. NRW are however able to deploy demountable defences in this area to prevent overtopping here for the 1 in 50 annual chance flood.
- By the 1 in 75 annual chance event there is flooding on the left-bank upstream of the Old Bridge (A525) and downstream of it along Mill Street. Further downstream there is a risk of flooding to a number of isolated properties along the A525 including Plas Coch, Dol Afon, Blairmore Nurseries and Glyn Derw Farm.
- The 1 in 100 annual probability flood shows extensive flooding of the city on the left-bank side between Old Bridge (A525) and the A55. This becomes more extensive for the 1 in 200 annual probability flood. During a 1 in 200 annual chance flood, inundation of some 400 properties and businesses would be predicted occur within the city from flows overtopping the defences.

If an allowance is made for uncertainty (i.e. freeboard); the 2014 Afon Elwy ISIS/Tuflow model shows that the existing defences in St Asaph provide around a 1 in 50 annual chance standard of flood protection. This assumes existing demountable defences are deployed near Spring Gardens Bridge on top of the existing defences.

2.2 Flooding from the Tide

The Afon Elwy discharges to the Clywd 1.8km downstream of the city and the ground levels fall from around 10m OD to between 6-7m OD. The Clywd is tidally influenced and can give rise to tidal flooding at the confluence with the River Elwy. St Asaph is too far upstream for there to be a tidal influence on flood levels in the city.

2.3 Surface Water and Groundwater Flooding

Surface and groundwater flooding of St Asaph could arise from:

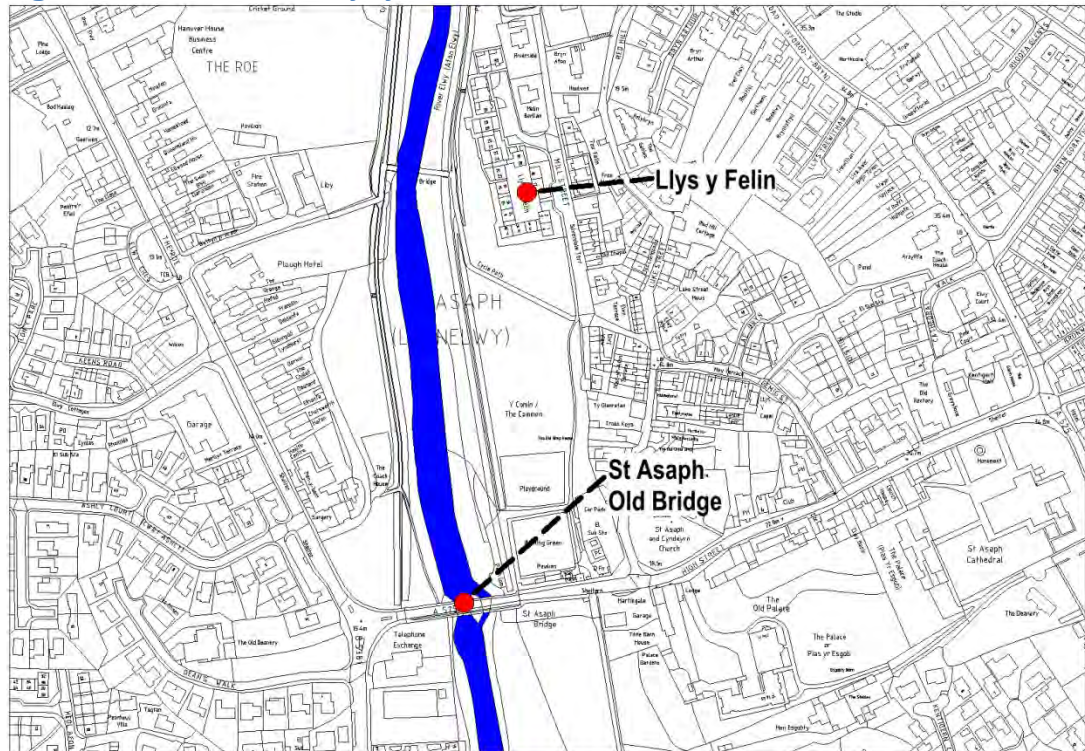
- **surface water flooding** as a result of heavy rainfall before it enters watercourse or drainage system;
- **sewer flooding** caused by intensive rainfall resulting in sewer capacity being exceeded with flooding occurring via manholes; and
- **groundwater flooding** which may occur where prolonged periods of rainfall result in a high water table and the emergence of groundwater.

There is a record of Llys y Felin sheltered housing having flooded in November 2000 as a result of overland flow from a surcharging combined sewer⁴. The site is located

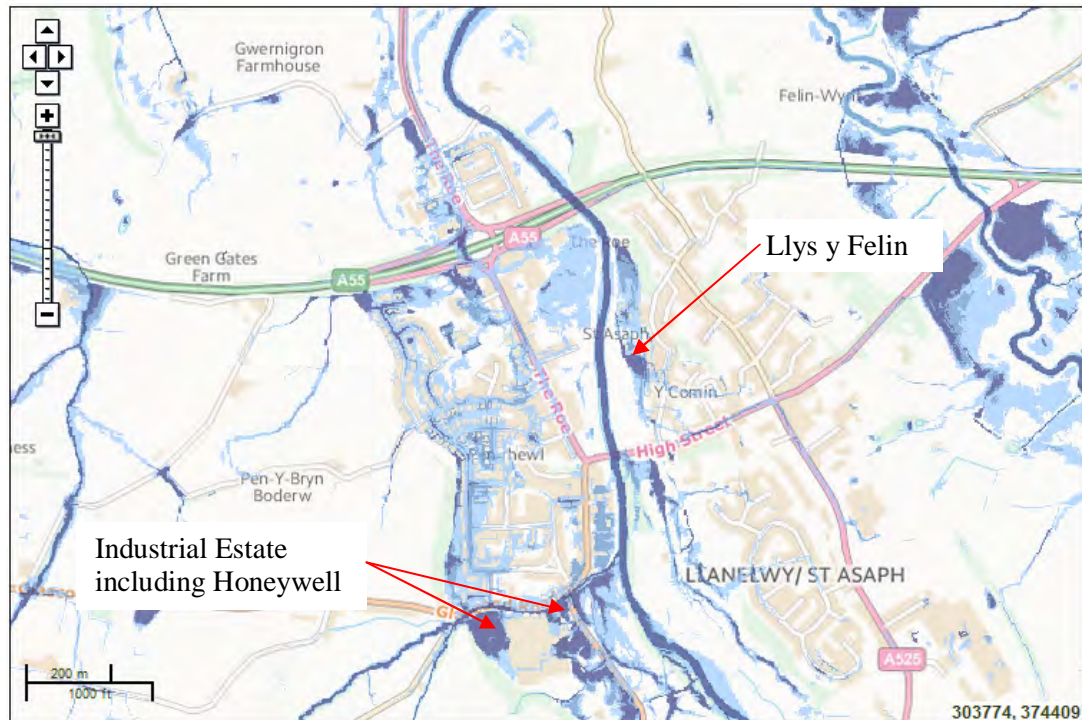
⁴ St Asaph Flood Map Update – Final Report, JBA, May 2014

on the right-bank side, near the footbridge midway between the Old Bridge and the A55 bridge crossing; refer to Figure 2.4.

Figure 2.4 - Location of Llys y Felin



The NRW surface water flood maps (Figure 2.5) also show this area of St Asaph to be at medium to high risk of surface water flooding (i.e. greater than 1 in 100 annual chance of flooding). The other notable area with a medium to high risk of flooding is within the Industrial Estate containing Honeywell to the south of the city.

Figure 2.5 – Extract from the NRW Surface Water Flood Map for St Asaph

Customers in Wales - From 1 April 2013 Natural Resources Wales (NRW) will take over the responsibilities of the Environment Agency in Wales.
 © Environment Agency copyright and database rights 2015. © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380.
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St Asaph sits on a Secondary 'A' Aquifer (capable of supporting water supplies locally and an important component of river baseflow). Susceptibility to groundwater flooding maps shows St Asaph to be at reasonable risk of groundwater emergence⁵; however, Denbighshire County Council reports no significant issues with groundwater flooding.

2.4 Reservoir and Canal Flooding

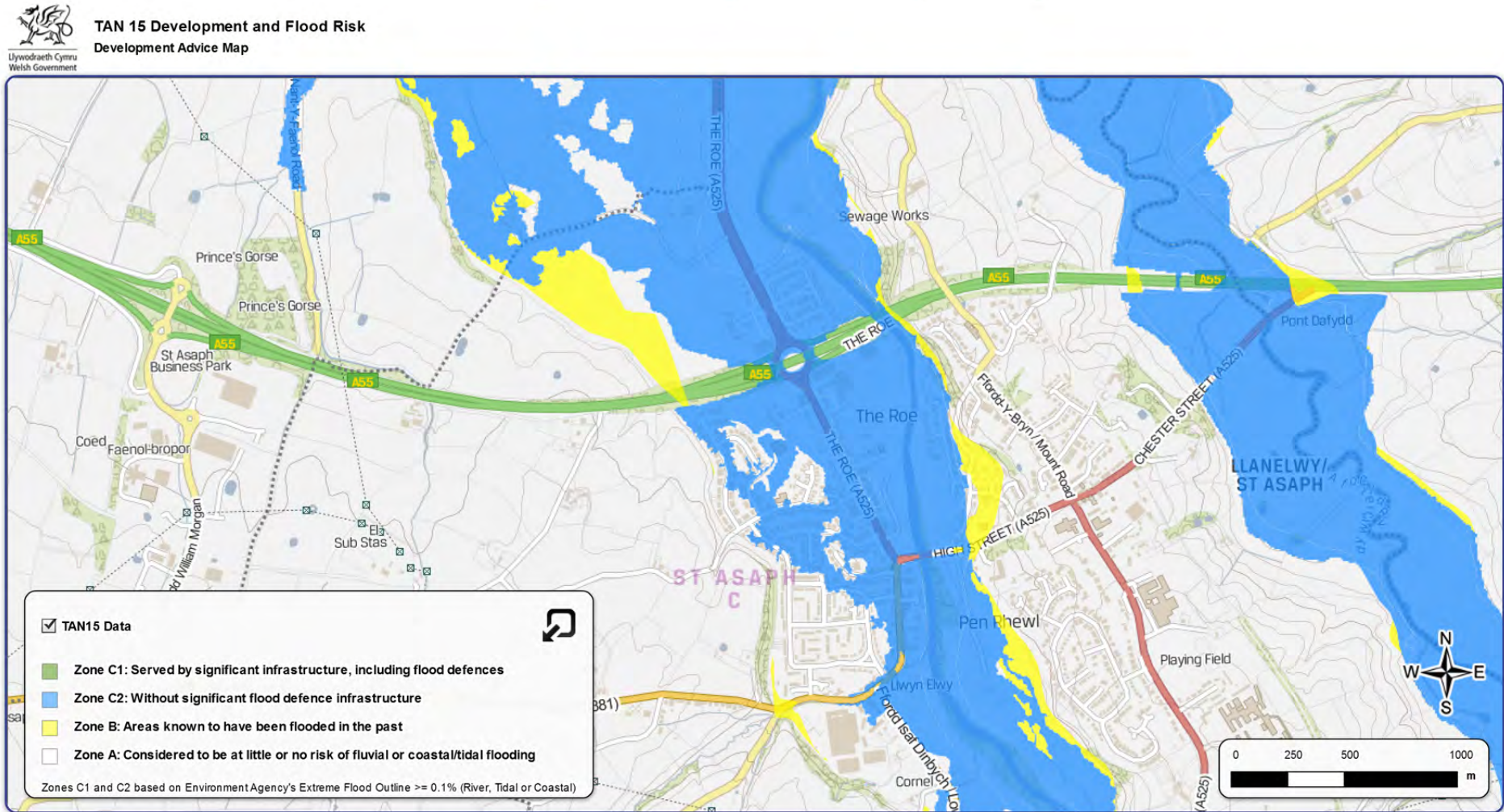
Reservoir and canals can present a flood risk as a result of dam or embankment failure. These risks are very low as a result of regular maintenance and inspection. All large reservoirs must be inspected regularly and supervised by the Reservoir Panel Engineers under the 1975 Reservoirs Act. Reservoir inundation flood maps on the Environment Agency website show a worst case scenario and indicate that St Asaph is at risk of flooding resulting from a failure of either Llyn Aled or Llyn Aled Isaf. These two reservoirs lie some 30km upstream of St Asaph. There are no canals in this area and therefore no risk of flooding from a canal embankment failure.

2.5 Flood Zones

Development Advice Maps are published to supplement TAN15 and its guidance on development. The majority of the areas of St Asaph shown to be at flood risk are contained in Zone C2 (refer to Figure 2.2). This denotes a risk of flooding up to and including the 1 in 1000 annual probability flood and that the area is without significant flood defence infrastructure. There are also areas of Zone B2 on the right-bank side, indicating evidence of flooding in the past based on sedimentary deposits. Those areas upstream and downstream of the city at flood risk are also contained in Zone C2.

⁵ Denbighshire County Council Strategic Flood Consequence Assessment, JBA, March 2007

Figure 2.6 – Development Advice Map for St Asaph



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Developed by Cartographics, Welsh Government

3. ST ASAPH FLOOD RISK MANAGEMENT SCHEME (FRMS)

3.1 Option Assessment

The proposed development outlined in this FCA is the St Asaph FRMS. The design for the scheme was developed following long and short list assessments of potential options to determine the most technically, economic and environmentally viable scheme for the city. A summary of both phases of the assessment is provided below.

Long List Assessment


A long list of options to reduce flood risk to St Asaph was formed in discussion with NRW. The list, together with a brief description of each option is presented in Table 3.1.

Table 3.1 – Options Long List

Option Reference	Description
L.1	<ul style="list-style-type: none"> Existing defences are raised and/or replaced
L.2	<ul style="list-style-type: none"> Existing defences are raised and/or replaced Spring Gardens Bridge is removed and replaced with a new bridge that does not impede in-channel flows
L.3	<ul style="list-style-type: none"> Existing defences are raised and/or replaced; Left-bank defences between Spring Gardens Bridge and Dol Afon are set-back to lower tail water levels at the bridge.
L.4	<ul style="list-style-type: none"> Existing defences are raised and/or replaced; Left-bank defences between Spring Gardens Bridge and Dol Afon are set-back to lower tail water levels at the bridge Spring Gardens Bridge is removed and replaced with a new bridge that does not impede in-channel flows
L.5	<ul style="list-style-type: none"> All in-channel and bankside vegetation is removed along the Elwy from St Asaph to its confluence with the River Clwyd to improve channel conveyance
L.6	<ul style="list-style-type: none"> Upstream storage together with improvements to the flood defence through the city where required.

The long listed options were assessed for their technical, environmental and economic feasibility to manage flood risk in St Asaph and to develop a short list of options to be subject to a more detailed appraisal. A summary of the long list option assessment is presented in Table 3.2.

Table 3.2 –Long List Assessment

Long List Option Reference	Description	Appraisal			Taken Forward
		Technical	Environmental	Economic	
L.1	• Raise existing defences	✓✓	U	✓	NO
L.2	• Raise existing defences • Replace Spring Gardens Bridge	✓✓	✓	✓	YES
L.3	• Raise existing defences • Set-back downstream defence	✓✓	U	✗	NO
L.4	• Raise existing defences • Set-back downstream defence • Replace Spring Gardens Bridge	✓✓	U	✗	NO
L.5	• Clear all channel vegetation to improve conveyance	✗	✗✗	✗	NO
L.6	• Upstream storage	✓	✗✗	✗✗	NO
✓✓		Technically / Economically / Environmentally Feasible			
✓					
U		Neutral / no impact			
✗					
✗✗		Not Technically Feasible / Too Expensive / Significant Adverse Environmental Impact			

It was agreed assessment of the Do Nothing (DN) and Do Minimum (DM) options was not required at the long list stage as it was accepted they should be on the short list

Option L.2, which is to raise the existing defences and replace Spring Gardens Bridge was selected as the preferred option. This gave an acceptable reduction in flood risk and, replacing Spring Gardens Bridge lowered required height of the defences upstream giving economic and environmental benefits compared to Option L.1.

Other options which were discounted included upstream storage (L.6), which would be prohibitively expensive and gave rise to unacceptable environmental impacts. Downstream storage (L.3 / L.4 - defence set-back) was also discounted as it did not deliver a sufficient reduction in flood levels through St Asaph. Improved channel conveyance (L.5) was discounted as it did not provide a sufficient reduction in flood risk and was also economically and environmentally unacceptable.

Short List Assessment

The option short list assessment was undertaken to find preferred economic standard of protection for the St Asaph FRMS. The assessment found that raising the defences to provide a present day 1 in 200 annual chance standard of flood protection to be the preferred option. This standard reduces to a 1 in 100 annual chance in the 2020s, due to climate change.

The assessment is described in full in [the] *St Asaph FRMS Economics Benefits Report*, GBV, 2015.

Scheme Benefits

The preferred option will provide a 1 in 200 annual chance standard of flood protection to 414 properties including 293 residential properties and 121 businesses. The total Present Value (PV) benefits from the scheme are approximately £35million with an average cost benefit ratio of 3.9:1.

3.2 Information on the Development

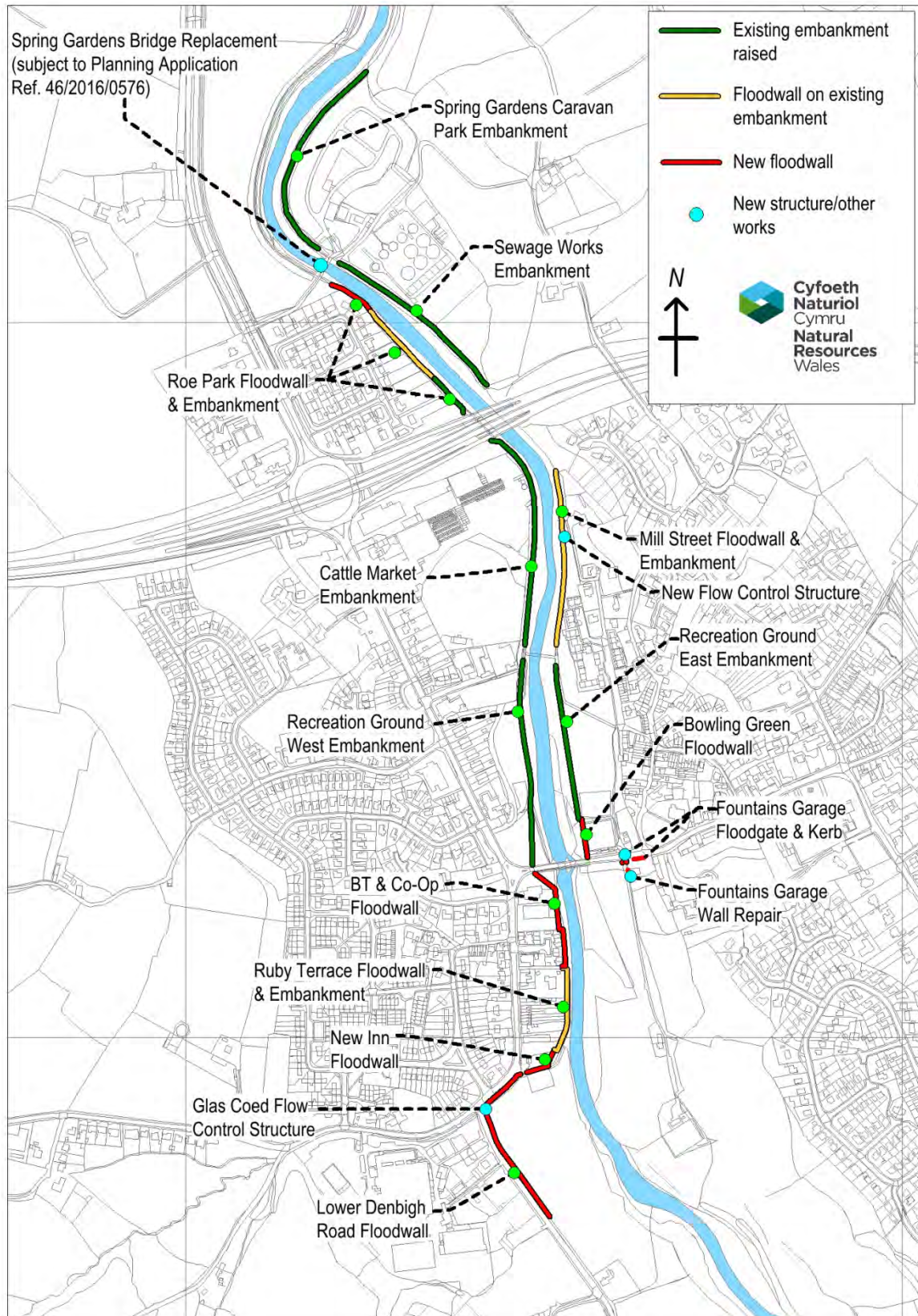
St Asaph is currently at risk of flooding from the Afon Elwy. The proposed flood risk management scheme is to provide protection against a minimum of a fluvial flood event with a 1 in 200 annual chance. Flood defence levels for the scheme have been determined using the 2014 Afon Elwy ISIS/Tuflow model. The scheme is described below and outlined in Figure 3.1. Appendix B contains General Arrangement drawings of the proposed flood defence works and a table of flood defence levels.

Scheme Description

The St Asaph FRMS extends along both banks of the Afon Elwy through St Asaph from Lower Denbigh Road to Spring Gardens Caravan Park. Existing defences are raised/new defences built to provide a 1 in 200 annual chance standard of flood protection. This includes a 300mm freeboard allowance.

Climate change is predicted to reduce the standard of protection provided by the scheme to a 1 in 100 annual chance standard during the 2020s. The defences are designed so they can be raised again in the future for climate change to maintain a 1 in 100 annual chance standard throughout their design life (100-years).

Figure 3.1 – Overview of St Asaph FRMS



Left Bank Works

Works along the left bank of the Elwy comprise:

- A new floodwall along Lower Denbigh Road to just downstream of the New Inn Pub up to 1.5m in height (320m length). The floodwall provides a 1 in 1000 annual chance standard to minimise flood detriment impacts arising from the scheme. A new flow control structure is provided where the new floodwall crosses the Glascoed tributary.
- A new floodwall up to 1m in height is constructed along riverward crest of the existing flood embankment through the gardens of Ruby Terrace (170m length). A 0.6m high floodgate is required to maintain access along a footpath at the end of Ruby Terrace.
- The existing masonry wall through the Co-Op supermarket and BT sites is demolished and replaced with a new floodwall up to 1.2m in height (99m length). The wall is set-back across the BT site to improve views of St Asaph Old Bridge.
- The existing embankment between St Asaph Old Bridge and the A55 is raised by up to 0.6m and re-profiled (620m length). All raising works are undertaken on the landward side of the embankment to ensure no loss of channel capacity.
- The existing embankment is lowered and existing floodwall removed at Roe Park. A new floodwall is constructed on the property boundaries which is up to 1.8m in height (280m length). The floodwall includes a sheet-pile cut-off to minimise seepage beneath the new defence. NRW advise seepage beneath the existing defence has been observed during past flood events.
- Spring Gardens Bridge is removed and replaced with a new bridge with a higher soffit and wider span that does not result in a significant head loss. This will help lower water levels through St Asaph when the upstream defences are raised. The soffit level of the new bridge will be at or exceed the 1 in 100 annual chance flood level with a 30% allowance for increasing flows due to climate change.

Right Bank Works

Works along the right bank of the Elwy comprise:

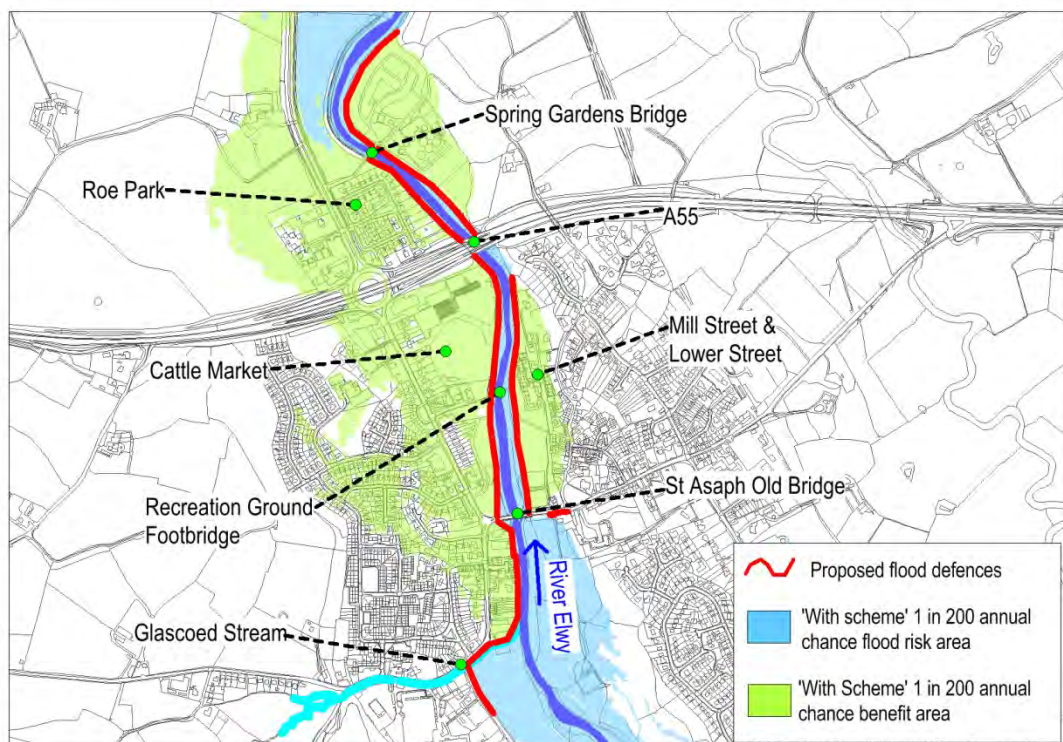
- A new floodgate is provided across the entrance to Roe Plas to prevent flows overtopping the High Street. Property level protection measures are provided to the Fountains Garage to ensure no increase in flood risk to this property. The boundary wall around the garage is also repaired where it has collapsed. This acts as an informal defence and limits overtopping into the garage site.
- The existing embankment is lowered, slightly set-back and a new 2m high floodwall provided on the boundary of the bowling green (96m length). Existing rip-rap is reinstated along the riverward face of the embankment downstream of St Asaph Old Bridge to prevent scour.
- The existing embankment from the bowling green to Pont Begard is raised by up to 0.6m and re-profiled (455m length). All raising works are undertaken on the landward side of the embankment to ensure no loss of channel capacity. Increasing the footprint of the embankment on the landward side is required,

particularly towards the downstream end of this section, to ensure it meets current design standards during flood conditions.

- A new flow control structure is provided through the embankment near to the A55. This is to allow flows which overtop the defences to be released back to the river when the flood event has passed on the Elwy. Presently, flows overtopping the defences are trapped on the landward side and need to be pumped out after a flood.
- The existing flood embankment past the sewage works is raised by up to 0.3m and re-profiled (270m length). All raising are undertaken on the landward side to ensure no loss in channel capacity. Welsh Water have confirmed that conifers currently growing at the toe of the embankment can be removed. The conifers shade the embankment and prevent grass from establishing on the embankment slopes. The embankment crest is also 'over-widened' to enable future raising works to be undertaken from the crest.
- The existing embankment which bounds Spring Gardens Caravan Park is raised by up to 0.1m. To prevent loss of land from the caravan park or narrowing of the river channel, all raising works are undertaken from the embankment crest.

Figure 3.2 shows the proposed St FRMS scheme will prevent flooding of St Asaph up to the 1 in 200 annual chance flood to the benefit of some 400 properties and businesses in the city. By containing larger floods in-bank than is currently the case however, it is inevitable that more flood water will be conveyed downstream at a faster rate and this could have an impact on thirds parties. Mitigation works are proposed to ensure no increase in flood risk to properties downstream of St Asaph; refer to section 3.6.

Figure 3.2 –St Asaph FRMS 1 in 200 Annual Chance Benefit Area



3.3 Justifying Location of Development

Section 6.2 of TAN15 states that “all new development should only be permitted within zones C1 and C2 if determined by the planning authority to be justified in that location”. Development is only justified if it can be demonstrated that:-

i. its location in Zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement; **or,**

ii. its location in Zone C is necessary to contribute to key employment objectives supported by the local authority, and other key partners, to sustain an existing settlement or region;

and,

iii. it concurs with the aims of PPW and meets the definition of previously developed land (PPW fig 2.1); and

iv. the potential consequences of a flooding event for the particular type of development have been considered and found to be acceptable.

The improvements of fluvial flood defences for St Asaph have been justified in a the Project Appraisal Report, which shows they deliver significant benefits over their 100-year design life. The consequences of flooding are considered and justified in the next section.

4. FLOOD CONSEQUENCE ASSESSMENT

Flooding of the proposed flood risk management works is necessary, planned for and justified as providing an economic benefit for the areas protected. However, by their nature flood defences can constrain flows and potentially increase flood depths for existing developments during low probability events. It is therefore necessary to carry out an assessment of flood consequences for the whole of St Asaph and its surrounds with the proposed flood risk management scheme in place and to compare this against existing (no scheme) flood consequences. Flood consequences from fluvial flooding have been assessed in detail using the Afon Elwy ISIS/Tuflow model.

4.1 Flood Extents

Drawings 122366-60002 and 122366-60003 (Appendix A) compare the flood outlines from the existing situation and with the proposed flood defence scheme for the 1 in 100 annual probability flood and climate change scenario (flows increased by 20%) respectively. These show that the flooding is contained by the proposed flood defences through St Asaph for both these events. Downstream of St Asaph flooding continues to occur, but to a lesser extent than under the existing situation. This is because presently, flows overtop the defences in the city continue on the floodplain to affect and properties downstream. Raising the defences in the city therefore provides a slight reduction in flood risk to some areas located downstream of the city.

Drawing 122366-60004 shows a comparison of flood outlines for the 1 in 1000 annual probability flood. The flood defences are now overtopped and as a consequence much of St Asaph is shown to be flooded. The flood outline is generally slightly reduced on the left-bank side through St Asaph with a significant reduction in the flooding of farmland downstream of the A55. There is an almost imperceptible increase in the flood outline through the industrial estate at the upstream end of the proposed defences on the left-bank side and a very slight increase in the flood outline along the right-bank side principally along Lower Street, Luke Street and Mill Street.

4.2 Flood Depths

Drawings 122366-60005 to 122366-60007 show the change in flood depth for the 1 in 100, 1 in 100 + climate change and 1 in 1000 annual probability floods respectively. The areas of blue indicate locations where flood depths have been reduced; orange and red indicate increased flood depths. Yellow indicates depth to have changed within a range of +/-20mm, which in terms of the modelling accuracy is generally not regarded as significant. The exact change in flood depth has been indicated at a number of locations on each plan.

Through the city of St Asaph, the 1 in 100 annual probability flood and climate change scenario are both contained by the flood defences and result in an increase in depth within the channel. The floodplain is inundated at the upstream end of the proposed scheme. This floods grazing land on the left-bank and playing fields on the right bank. For the 1 in 100 annual probability flood the increase in depth is a maximum of 0.05m, but with climate change, this increases to 0.36m. The threshold of the clubhouse associated with the sports ground in this area is above the flood level and so would not be internally flooded in either of these flood events as result of the scheme.

Downstream of St Asaph, the floodplain depths are generally reduced or unchanged. There is a notable reduction in flood depth in the 1 in 100 annual probability flood to Blairmore Nurseries where the flood depth is reduced by 0.20m. This is from

reduced flows overtopping the defences in St Asaph. Where there are increases in flood depth this occurs on open farm land and are less than 0.05m.

At the 1 in 1000 annual probability flood, the defences are overtopped and there is widespread flooding throughout St Asaph. Upstream of St Asaph the farmland and playing fields continue to show an increase in flood depth. The playing fields on the right-bank side show an increase of nearly half a metre in flood depth. Some of the industrial estate adjacent to the B5381, which is protected for smaller floods, shows a small increase in flood depth of 0.05m. The flood defence is not overtopped at this location because the proposed design level is set to the 1 in 1000 annual probability flood level, but it flows around the southern end of the defence into the industrial estate.

Further downstream and on the right-bank, the flooding now extends across the A525 and affects the housing around Lower Street and Mill Street. The proposed scheme has increased flood depths by as much as 0.53m in this area. In contrast, on the opposite bank, flood levels are reduced by as much as 0.37m. Downstream of the A55, flood depths in Roe Parc are reduced by 0.27m and in Spring Gardens by nearly one metre. Further downstream on the open farmland the flood depths area reduced by between 0.06 - 0.11m.

4.3 Flow Velocity

It is important to consider flood velocity. An increase in velocity in the flooded areas could increase the risk of someone being swept away by flood water. Although not prescriptive, A1.15 of TAN15 gives 0.30 m/s as the upper limit of velocity for which access and egress is generally acceptable.

Drawing 122366-60008 (Appendix A) shows the change in velocity of the flood water in the event of St Asaph being inundated by the 1 in 1000 annual probability flood. This indicates that throughout much of St Asaph and downstream of it flood velocities on the floodplain are reduced or show only a very small increase (as indicated by the dark and light blue shading). The dark blue indicates large areas of St Asaph in which the velocity has been reduced.

The most notable residential area where this is not the case is on the right-bank side in the area of Mill Street where velocities are increased by more than 0.3 m/s. However, as indicated on the plan, the velocity is already well in excess of the recommended upper limit of 0.3m/s under the existing conditions. There is also a large increase in an already high velocity where the flood water flows over the A525 by Lower Street.

Within the industrial estate, there are areas where the velocity is significantly increased by the proposed scheme. Closer inspection of the velocity data shows that the existing velocities across the site range from near standing water up to 0.5 m/s. The impact of the scheme is similarly wide ranging resulting in areas where the velocity is increased significantly and others where there is a reduction in velocity, all within close proximity of each other.

4.4 Onset of Flooding

Upstream of St Asaph

The onset of flooding within the playing fields and open farmland upstream of St Asaph is unchanged by the scheme. Presently these areas flood during a 1 in 25 annual chance flood, which is less than the standard provided by the existing defences.

St Asaph

The onset of flooding through the city centre is prevented up to a minimum of the 1 in 200 annual probability flood compared to the current onset of flooding of a 1 in 50 annual probability flood. Within the city itself, a comparison of the simulation for the 1 in 1000 annual probability flood shows that the proposed scheme delays the onset of the first properties being flooded by 1.5 – 2 hours, giving greater opportunity to warn and evacuate people in the event of such an extreme flood occurring.

Downstream of St Asaph

The onset of flooding downstream of the city is also unaffected. Presently, flooding of agricultural land on the left bank downstream of the city comes first from flows overtopping the flood defences within St Asaph during a flood exceeding a 1 in 50 annual chance. Existing defences downstream are also overtopped locally during a flood exceeding a 1 in 50 annual chance. Improving the flood defences in St Asaph, will provide a slight benefit to the onset of flooding downstream.

5. FLOOD RISK DETRIMENT & MITIGATION

There are two key flood consequences from the proposed scheme which require further investigation; these are:

- An increased risk of flooding to some parts of St Asaph for events exceeding a 1 in 200 annual chance and particularly for the 1 in 1000 annual chance flood; and
- An increased risk of flooding to a small number of properties downstream of St Asaph due to additional flows being passed through the city.

Although some these of areas benefit greatly from the proposed scheme, the detriment caused by flows overtopping the proposed defences or being passed downstream needs to be addressed. This is because Section A.1.12 of TAN15 states: '*No flooding elsewhere*', which is applied up to and including the 0.1% (1 in 1000) annual chance event.

The sections below consider the flood risk impacts of the scheme on St Asaph and areas downstream in detail, together with the mitigation measures proposed. An increased risk of flooding to agricultural land upstream of the city does not require further investigation as there is **no** change on the onset of flooding

5.1 St Asaph Benefit, Detriment & Mitigation

St Asaph Scheme Benefit

The standard of protection provided by the scheme is a minimum of the present day 1 in 200 annual chance flood. The flood outlines shown in Drawings 122366-60002 and 122366-60003 clearly demonstrate that St Asaph is protected from flooding at the 1 in 100 annual probability flood and climate change scenario. This provides significant benefit to a community where parts are at currently risk for the 1 in 50 annual probability flood with widespread flooding occurring in a 1 in 100 annual probability flood.

St Asaph 1 in 1000 Annual Chance Detriment

There is an increased risk of flooding to parts of St Asaph when the new defences are overtopped. These impacts are most pronounced for a 1 in 1000 annual chance flood, which gives rise to an increase in flood depth, outline and velocity in a number of locations. The most notable location is on the right-bank in the area of the Mill Street and Lower Street.

Although the city benefits greatly from the proposed scheme by a reduction in flood risk, the detriment caused in the event of a 1 in 1000 annual chance flood needs to be considered. As noted, TAN15 states: '*No flooding elsewhere*', which is applied up to and including the 0.1% (1 in 1000) annual chance event.

NRW's internal guidance advises that where an increase in flood risk cannot be avoided, a scheme should deliver '*benefits to society, economy and environment that significantly outweigh detrimental effects of increased flooding*'.

The proposed scheme will provide a 1 in 200 annual chance standard of flood protection to 414 properties including 293 residential properties and 121 businesses. The total Present Value (PV) benefits from the scheme are approximately £35million with an average cost benefit ratio of 3.9:1. Environmental enhancements

are also provided which will benefit the wider community including footpath improvements and amenity planting.

In addition, the proposed scheme has sought to:

- Manage the consequences of flooding down to an acceptable level; and
- Investigate all possible mitigation measures to ensure the development is safe as possible.

To fully mitigate the effects of detriment during a 1 in 1000 annual chance flood in St Asaph would require raising all the defences in the city to contain a 1 in 1000 annual chance flood. This is too expensive and would give rise to unacceptable environmental impacts in the city. It would also be likely to further increase flood risk downstream.

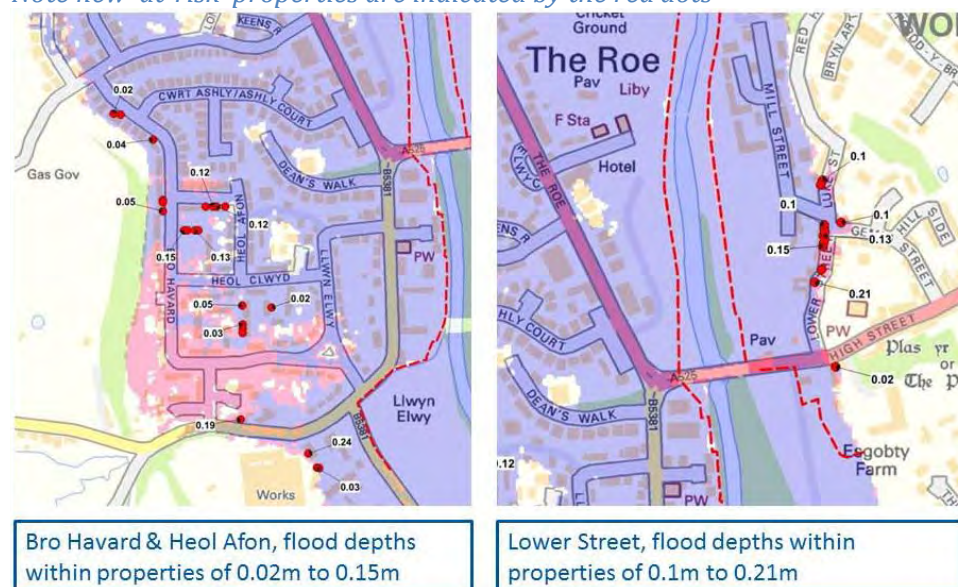
A thorough investigation was carried out to establish whether there was a viable option that would minimise the detriment in St Asaph. Following consultation with Denbighshire County Council, the focus of the investigation was on preventing new properties from flooding in a 1 in 1000 annual chance flood (i.e. properties that under existing conditions are not flooded by the 1 in 1000 annual chance flood, but would do so as a result of the proposed scheme). The work is reported in *St Asaph Flood Detriment Impacts*⁶, which is appended to this FCA in Appendix C and summarised below.

St Asaph 1 in 1000 Annual Chance Detriment Mitigation

The original proposal for the St Asaph FRMS comprised providing a 1 in 200 annual chance scheme throughout the city. This was shown to result in 44 new properties to be at risk for the 1 in 1000 annual chance flood; refer to Figure 5.1. Whilst the scheme had still delivered a significant overall reduction in flood risk to St Asaph, Denbighshire County Council advised the high number of new properties at risk for 1 in 1000 annual chance flood might not be acceptable.

Figure 5.1 –St Asaph FRMS - Original Scheme New Properties at Risk

Note new 'at-risk' properties are indicated by the red dots



⁶ *St Asaph Flood Detriment Impacts, GBV, April 2015*

The *St Asaph Flood Detriment Impacts* considered 16no. options to reduce the number of new properties at risk for a 1 in 1000 annual chance flood as a consequence of the scheme. The proposed flood defence scheme presented in this FCA results in 19 new properties for the 1 in 1000 annual chance flood⁷, 25 fewer than the original proposal. This was achieved by raising a section of defence on Lower Denbigh Road to provide a 1 in 1000-year standard of protection to minimise the numbers of new properties on the left bank at risk; refer to Figure 5.2.

Figure 5.2 – St Asaph FRMS City Mitigation

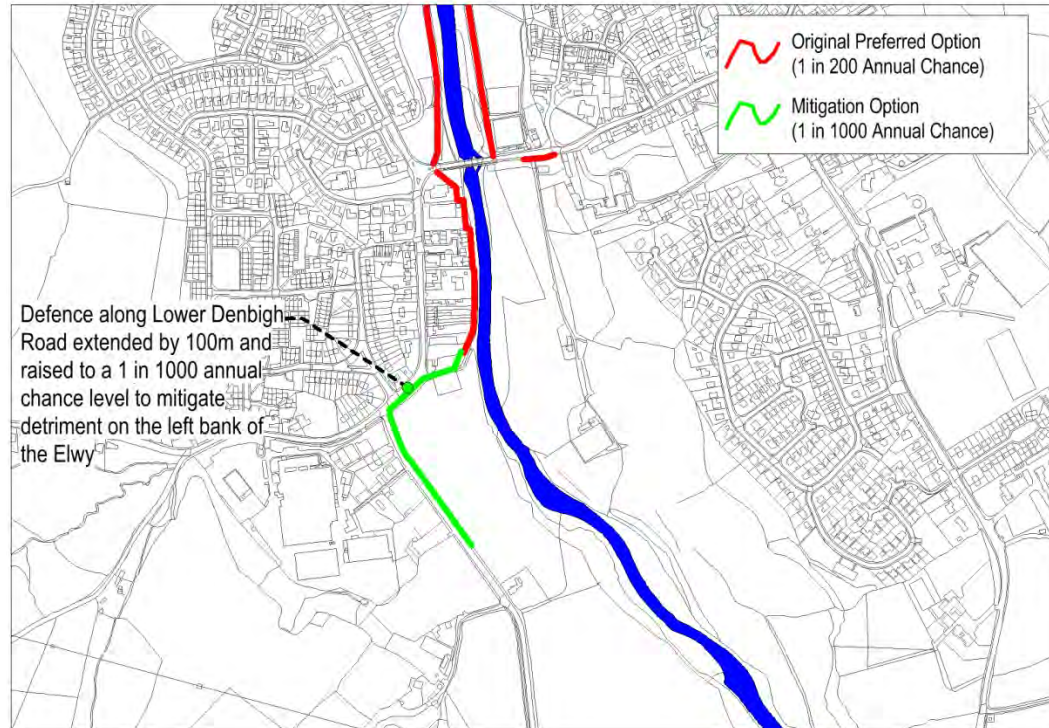


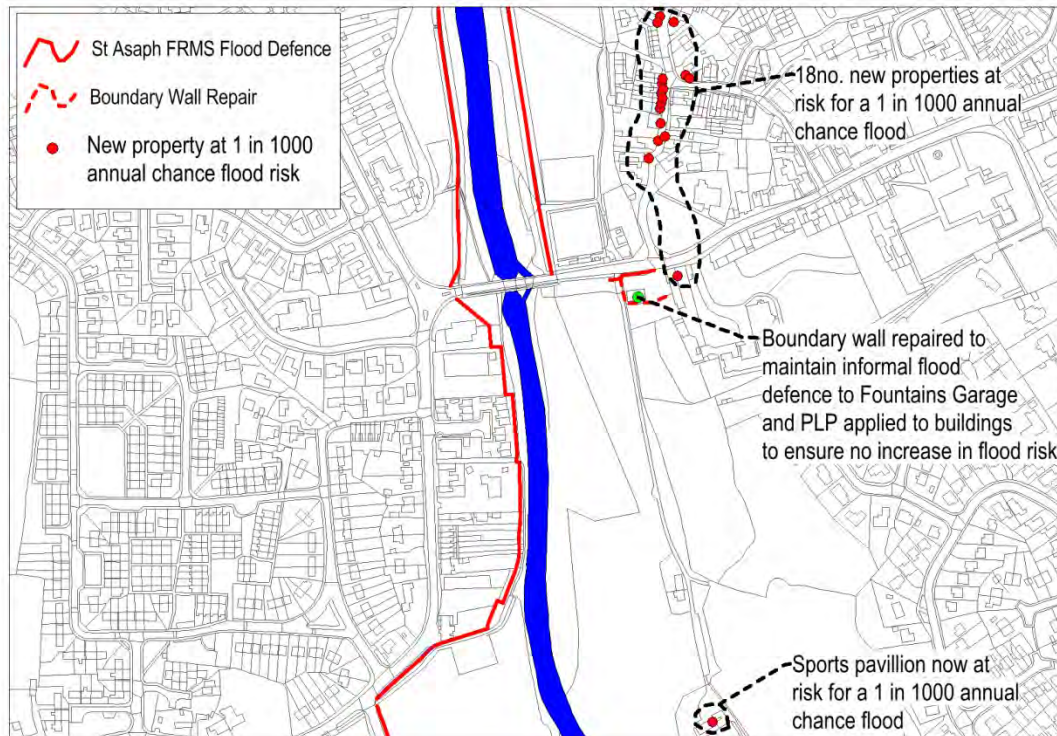
Figure 5.3 shows the 19 new properties at risk for a 1 in 1000 annual chance flood as a consequence of the scheme⁸. It was not possible to achieve a further reduction in the numbers of new properties at risk from flooding or reduce flood depths on the right bank any further as any measures would:

- Result in an increased risk of flooding of the A525 at St Asaph Old Bridge. This is an important route for evacuation during a flood so an increased risk of flooding would not be acceptable.
- Require a reduction in the allowance for future climate change on the proposed defences. This would mean a much larger number of properties being at a high risk of flooding in the future due to climate change.

⁷ This is referred to as Option 2.4 in *St Asaph Flood Detriment Impacts*, GBV, April 2015

⁸ There are reports some of the 'new' properties at risk from flooding as a consequence of the scheme may have been subject to historic flooding. It is understood this is likely to have been flooding to basements from the Elwy or from surface water due to extreme rainfall rather flooding from water overtopping the main property threshold. This does discredit the model, which has been calibrated and validated, but it does show that modelling has its limitations and the complexity which arises when properties can flood from multiple sources

Figure 5.3 –St Asaph FRMS City Mitigation



St Asaph 1 in 1000 Annual Chance Overall Impact

The overall impacts of the proposed scheme on flood risk for a 1 in 1000 annual chance flood in St Asaph are presented in Drawings 122366-60009 and 122366-60010 (Appendix A). Drawing 122366-60009 compares the existing and with scheme flood depths for individual properties throughout the flooded areas of St Asaph for the 1 in 1000 annual probability flood. Drawing 122366-60010 simplifies the information by categorising properties based on whether they benefit from the scheme (reduction in flood depth); are at detriment from the scheme (flooded to an increased depth or flooded because of the scheme) or unaffected. The results are summarised in Table 5.1

Table 5.1 – Number of Properties at Benefit & Detriment

Benefit/Detriment	No. of Properties Affected
Detriment through increase of flood depth	64
Detriment through flooding resulting from scheme	19
Total Detriment	83
Benefit through reduction of flood depth	262

The key points to draw from these results are:

- There are many more properties that benefit from the scheme than suffer from any form of detriment (by around 3 to 1).
- Nearly all properties on the left-bank benefit from the proposed scheme (with mitigation) as flood depths are reduced up to a maximum of 0.40m; the exception to this is the area of the Honeywell industrial estate where the flood depth at some buildings is increased by up to 0.05m. No residential properties on the left-bank side suffer detriment and no new properties flood as a result of the scheme.

- The greatest depth of flooding to property is found on the right-bank to the housing around Lower Street and Mill Street. Here, the scheme increases the depth of flooding by 0.5m to 1.5m. Given the already severe flood risk in this area, this is unlikely to change significantly flood damages or risk to life. This area also includes 17 of the 19 of properties caused to flood in the 1 in 1000 annual chance flood by the scheme.

As noted, it was not possible to achieve a further reduction in the numbers of new properties at risk from flooding or reduce flood depths on the right bank any further as any measures would:

- Result in an increased risk of flooding of the A525 at St Asaph Old Bridge. This is an important route for evacuation during a flood so an increased risk of flooding would not be acceptable.
- Require a reduction in the allowance for future climate change on the proposed defences. This would mean a much larger number of properties being at a high risk of flooding in the future due to climate change.

The scheme includes a new gravity outfall in the Mill Street area to allow the area to drain more quickly in the event of flooding. Presently, pumps need to be deployed to draw-down flood water trapped on the landward side of these defences. The scheme also delays the onset of flooding by up to 2-hours for the 1 in 1000 annual chance flood which will provide more time for the Mill Street area to be evacuated.

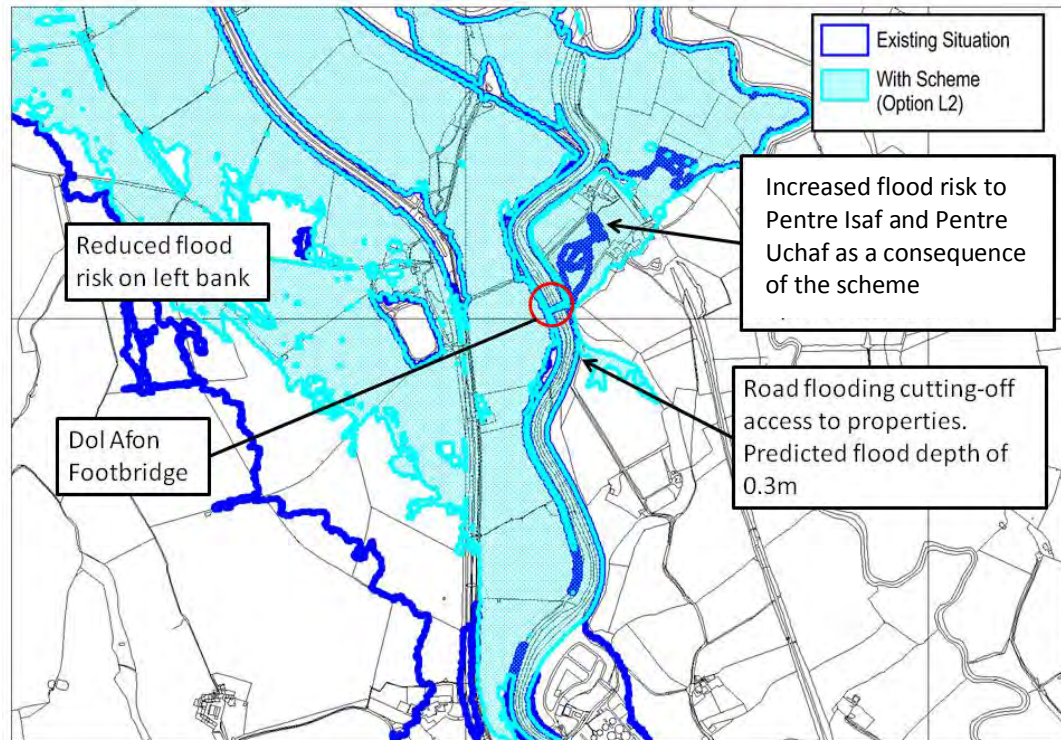
NRW have also advised Denbighshire County Council, that relocation of the council housing at Llys y Felin should be considered. This is due to the potential for them to be subject to severe flood depths, both presently and with the proposed scheme.

5.2 Downstream Detriment & Mitigation

River Elwy – Right Bank

Raising the defences through St Asaph raises in-channel flood levels downstream. The downstream impacts of the scheme were first assessed in *St Asaph Downstream Storage Assessment*⁹. An extract from this paper is presented as Figure 5.4 below. This shows that for a 1 in 200 annual chance flood, without mitigation, increased flood depths could occur affecting two properties known as ‘Pentre-Isaf’ and ‘Pentre Uchaf’.

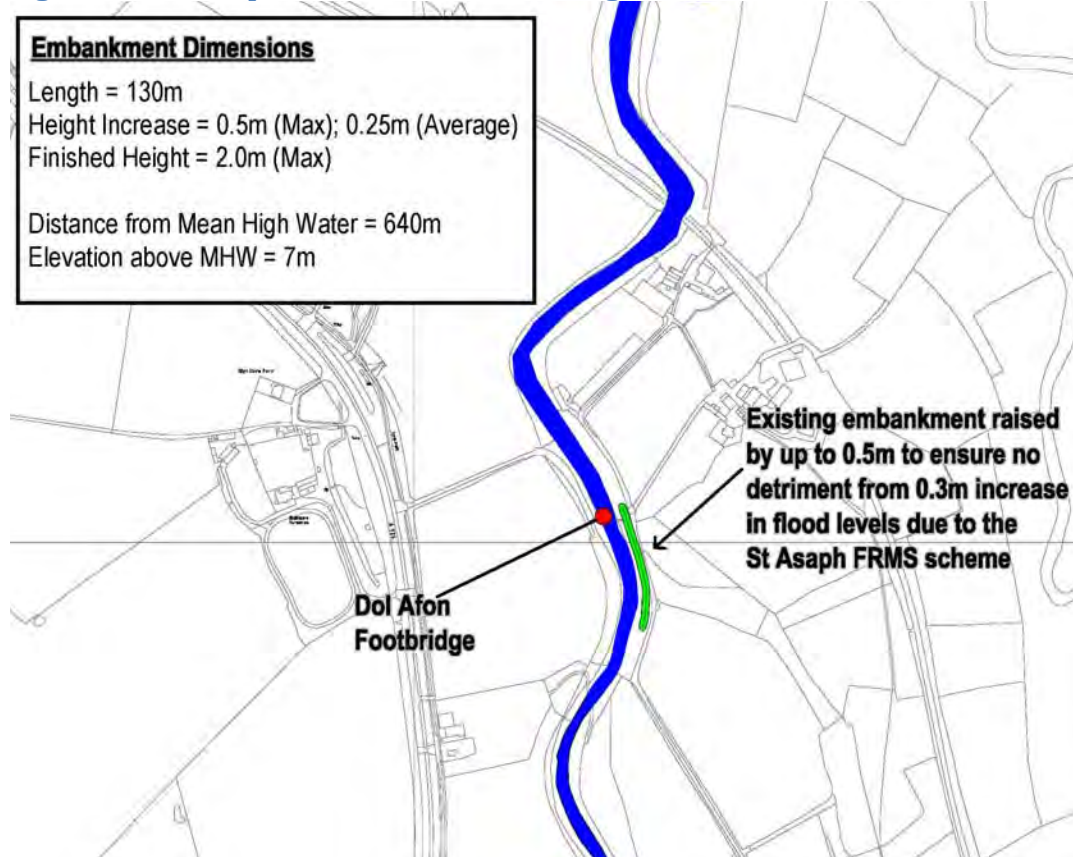
Figure 5.4 – St Asaph FRMS Scheme Impacts at Pentre Isaf and Pentre Uchaf



Raising the flood defences through St Asaph, increases peak water levels against the existing defences protecting Pentre Isaf and Pentre Uchaf by up to 0.3m. This significantly increases the rate of overtopping, resulting in flood depths in excess of 2m through the properties for a 1 in 200 annual chance flood.

The St Asaph FRMS therefore includes works to raise the defence at Pentre Isaf and Pentre Uchaf to ensure no detriment; refer to Figure 5.5. To comply with TAN15, these works are applied to also ensure no detriment from the scheme to either property for the 1 in 1000 annual probability flood; refer to Drawing 122366-60004.

⁹ *St Asaph Downstream Assessment, GBV, October 2014*

Figure 5.5 –St Asaph FRMS Downstream Mitigation

River Elwy – Left Bank

Downstream locations on the left bank the Elwy subject to an increase in flood depths are agricultural land; refer to Drawing 122366-60007. Here the floodplain is much wider and flood depths are increased by less than 20mm. Furthermore, there is no change to the onset or duration of flooding as the first flows to inundate these areas come from flows overtopping the defences upstream in St Asaph (Roe Park). These defences are raised by the St Asaph FRMS. The St Asaph FRMS therefore does not impact use of this farmland meaning no mitigation is required.

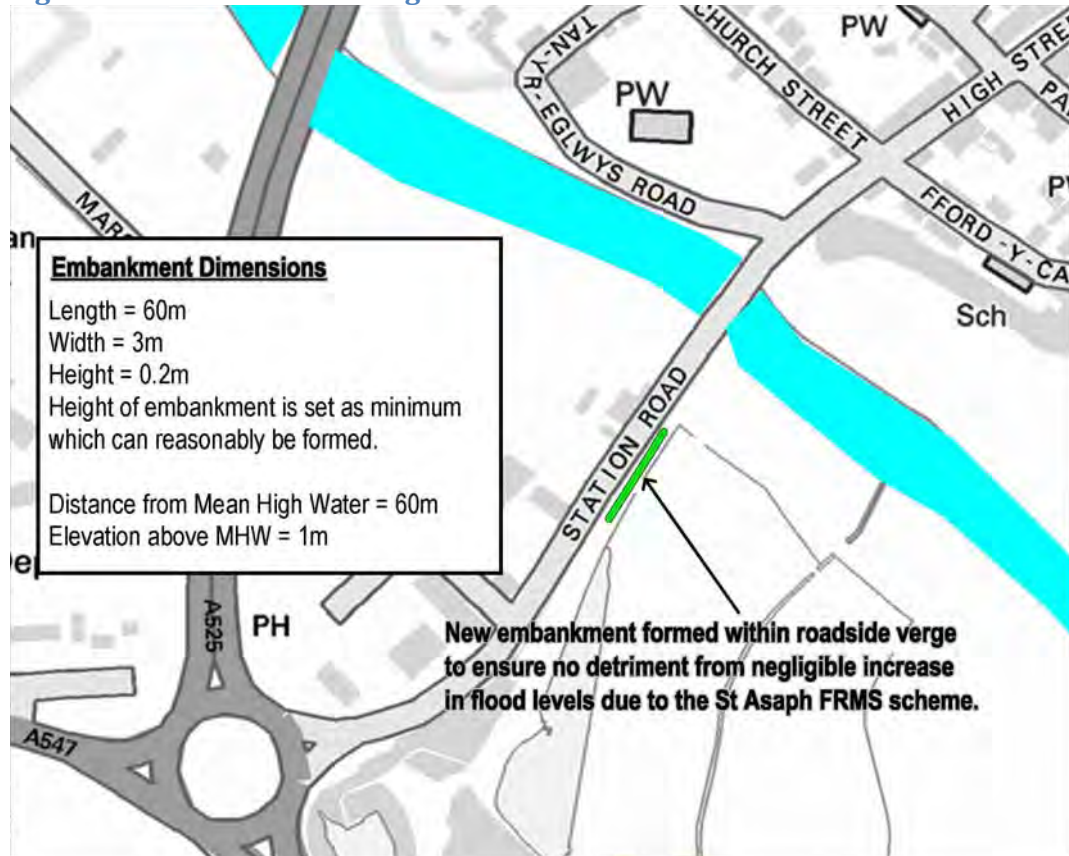
River Clwyd

The nature of the scheme is that flood waters are funnelled down the Elwy instead of spreading across the floodplain and being attenuated. As a result a higher peak flow may reach the Clwyd, which in turn could result in detriment along the Clwyd valley. An assessment using the Tidal Clwyd Model has been carried out; the results are presented in Appendix D.

The findings of the analysis indicated that peak flood levels to the west of Station Road, on the left-bank side in Rhuddlan could potentially increase by 20-30mm as a result of the scheme. This would potentially affect several properties, however because most sit in a hollow, flood depths are already in excess of 1m.

To compensate for minor detriment affecting the properties immediately downstream of Station Road, a new embankment is formed along the road some 0.2m in height; refer to Figure 5.6. These works are applied to ensure no detriment from the scheme to either property for the 1 in 1000 annual probability flood.

Figure 5.6 – Station Road Mitigation

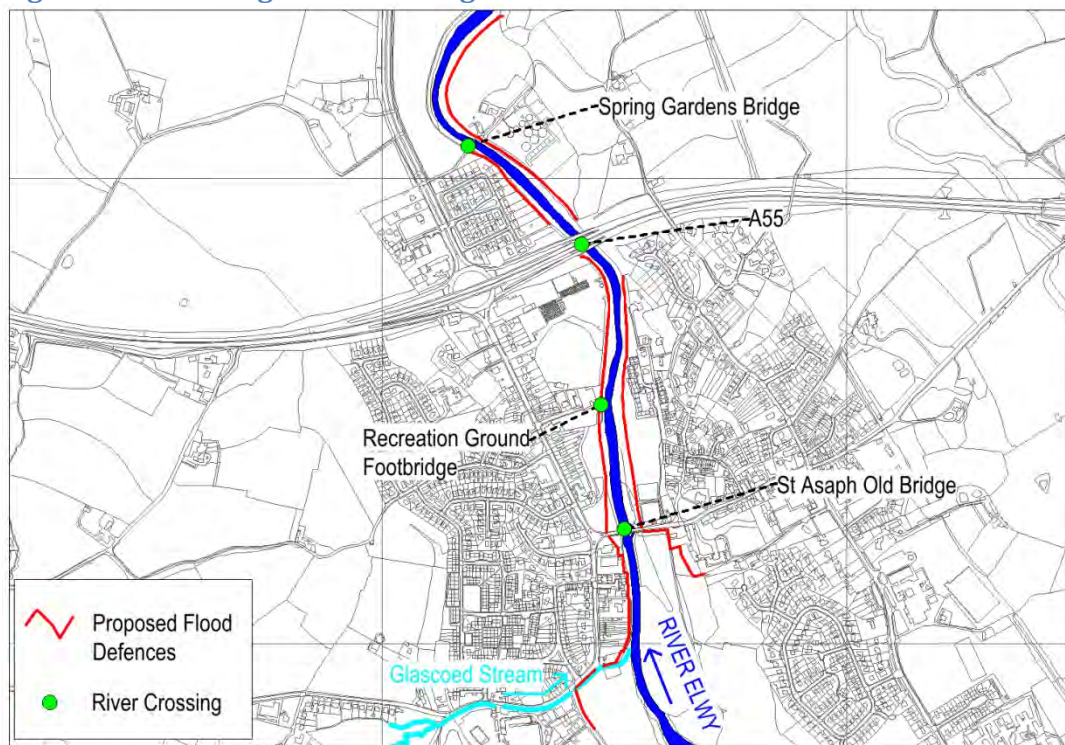


6. ADDITIONAL CONSIDERATIONS

6.1 Blockages

It is a requirement of TAN15 that the likelihood of blockages at structures and their impact are considered. Figure 6.1 shows there 4no. structures which cross the River Elwy in St Asaph.

Figure 6.1 – Existing River Crossings



Blockage of either the A55 crossing and Recreation Ground Footbridge is very unlikely due to their size. Blockage of St Asaph Old Bridge is also viewed as unlikely due to the size of the main arches, which should allow passage of debris. The proposed scheme also sets-back the defences at the outer arches, which will improve the efficiency with which flows are able to pass through the bridge. NRW have also reported no previous issue with blockage of any of these structures.

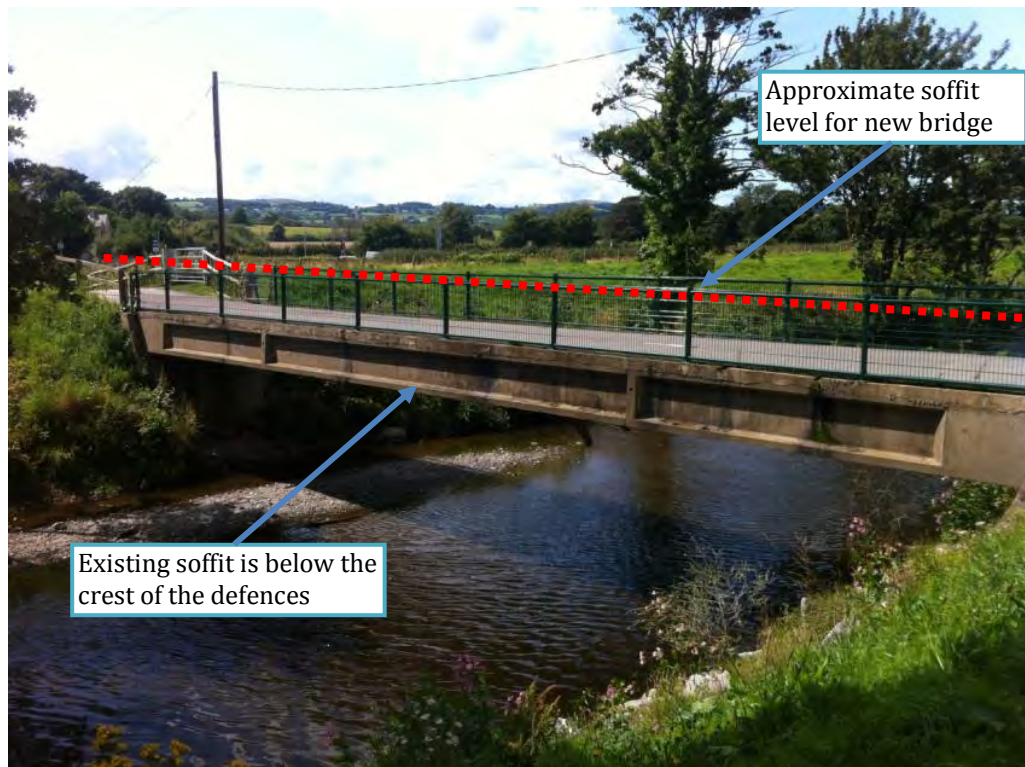
Spring Gardens Bridge, which is located downstream of St Asaph is prone to debris accumulation. The bridge (Figure 6.2) sits very low in the channel and, during the 2012, was seen to trap debris, particularly in its railings. There was also a notable afflux across the bridge during November 2012, although this was not the direct cause of flooding upstream.

Denbighshire County Council have approved a planning application (Ref. 46/2016/0576) to replace Spring Gardens Bridge with a new crossing which has a higher and wider span. Figure 6.2 indicates the approximate soffit level for the new bridge; it will be located approximately 2m downstream from the existing crossing.

The new bridge is designed to allow for St Asaph FRMS flood defence works upstream. The minimum soffit for the new crossing is designed to the 1 in 100 annual chance level with a 30% allowance for increasing flows due to climate change. The soffit of the bridge will therefore be higher than the crest of the defences

upstream. Flows will therefore overtop the defences first before being 'backed-up' against the bridge soffit.

Figure 6.2 – Spring Gardens Bridge



6.2 Other Sources of Flooding

Glascoed Stream

The Glascoed Stream passes beneath the proposed defences on Lower Denbigh Road (Figure 6.3). Backing-up of the Glascoed Stream by the Elwy beneath Lower Denbigh Road could lead to property flooding. A new flap valve is to be installed across the Glascoed Stream to prevent Ely flows backing-up along the water course.

To minimise the likelihood of property flooding from tide-locking of the Glascoed Stream by the Elwy, a dry riser will also be installed to allow over-pumping of the stream. It should be noted that the very steep gradient of the stream means that there is a low probability of tide-locking by the River Elwy. Inspection of the available topographic survey suggests free discharge on the Glascoed Stream will continue to occur up to and including the 1 in 100 annual chance flood.

Surface Water

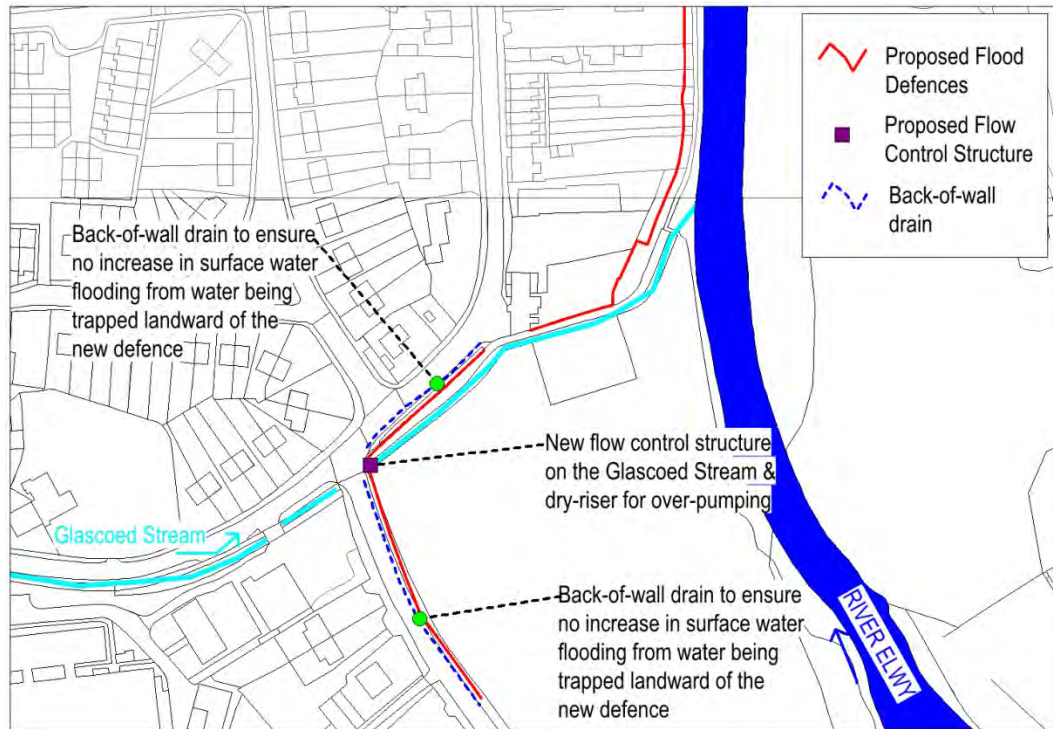
The works largely comprise raising existing defences on their existing alignment. In these locations, there will be no change to the risk of surface water flooding as the defences can already act to intercept surface water. Existing surface water flood depths will also be significantly less than the crest level of the existing defences.

There is the potential for an increase in surface water flooding along Lower Denbigh Road from construction of the new defence. A back-of-wall drain will be provided as part of the work to intercept any surface water which is trapped landward of the

defence (Figure 6.3). Design of the drain will be confirmed at a later stage of the project and in agreement with the highway authority.

As noted previously, a new gravity outfall is also to be provided in the Mill Street area to drain flows which overtop the defences.

Figure 6.3 – Surface Water Flooding Mitigation



7. CONCLUSIONS

St Asaph is located in north Wales on banks of the Afon Elwy. In 2012 the Elwy burst its banks, overtopping the existing flood defences and flooded large areas of the city. A flood defence scheme for the provision of defences with a minimum of a present day 1 in 200 annual chance standard of protection has been proposed. These defences comprise improvements to existing embankments and the construction of new floodwalls.

Flood defence works are compatible with flooding and therefore there are no consequences to the development. This flood consequence assessment is therefore focussed on existing development and has been assessed for the 1 in 100 annual probability flood, 1 in 100 annual probability plus climate change and 1 in 1000 annual probability flood.

Modelling of the flood defence scheme shows the overall benefit that the scheme provides in reducing flood risk at the 1 in 100 annual probability flood and climate change scenario. Although farmland and recreational areas are still at a risk of flooding, in both these flood scenarios residential and commercial property throughout St Asaph is protected from flooding.

At the 1 in 1000 annual probability flood, the defences are overtopped and large areas of St Asaph are flooded. The majority of properties on the left-bank side benefit from the scheme during this flood event as flood depths are reduced. The exception to this is around the Honeywell industrial estate, where some buildings show a small increase in flood depth of up to 0.05m (note there are no new properties risk on the industrial estate). On the right-bank side, the narrower and more constrained floodplain results in increased flood depths for 64 properties, mainly around Mill Street and Lower Street, but many of these are already flooded to depths in excess of 1m without the scheme in place. The increase in flood depth would be likely to make little difference to damage caused or to the existing risk to life. There are also 19 new properties, mainly in the same area, that are flooded as a result of the scheme.

Overall, the number of properties that benefit from the scheme in a 1 in 1000 annual probability flood outnumbers those that suffer detriment by around 3 to 1. A further benefit of the flood defences is that they increase the time that residents would have to evacuate their homes in the event of such an extreme flood event occurring. The benefits of the scheme therefore far outweigh the detriment that is caused and the scheme has been justified through economic analysis.

Mitigation is designed into the scheme to limit detriment in the 1 in 1000 annual probability flood. For St Asaph, this has comprised raising a section of defence at Lower Denbigh Road to a 1 in 1000 annual probability flood level. Flood defence improvement works are also proposed downstream to:

- Raise an embankment on the right bank of the Elwy to maintain protection to Pentre Isaf and Pentre-Uchaf; and
- Construct an embankment along Station Road (Rhuddlan), to compensate for potentially increasing flood levels on the Clwyd.

Overall, the flood consequences of the proposed scheme are considered to be compliant, so far as is reasonably practicable, with the requirements of TAN15 and its associated NRW internal guidance.

APPENDIX A – DRAWINGS

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APPENDIX B – SCHEME LAYOUT DRAWINGS

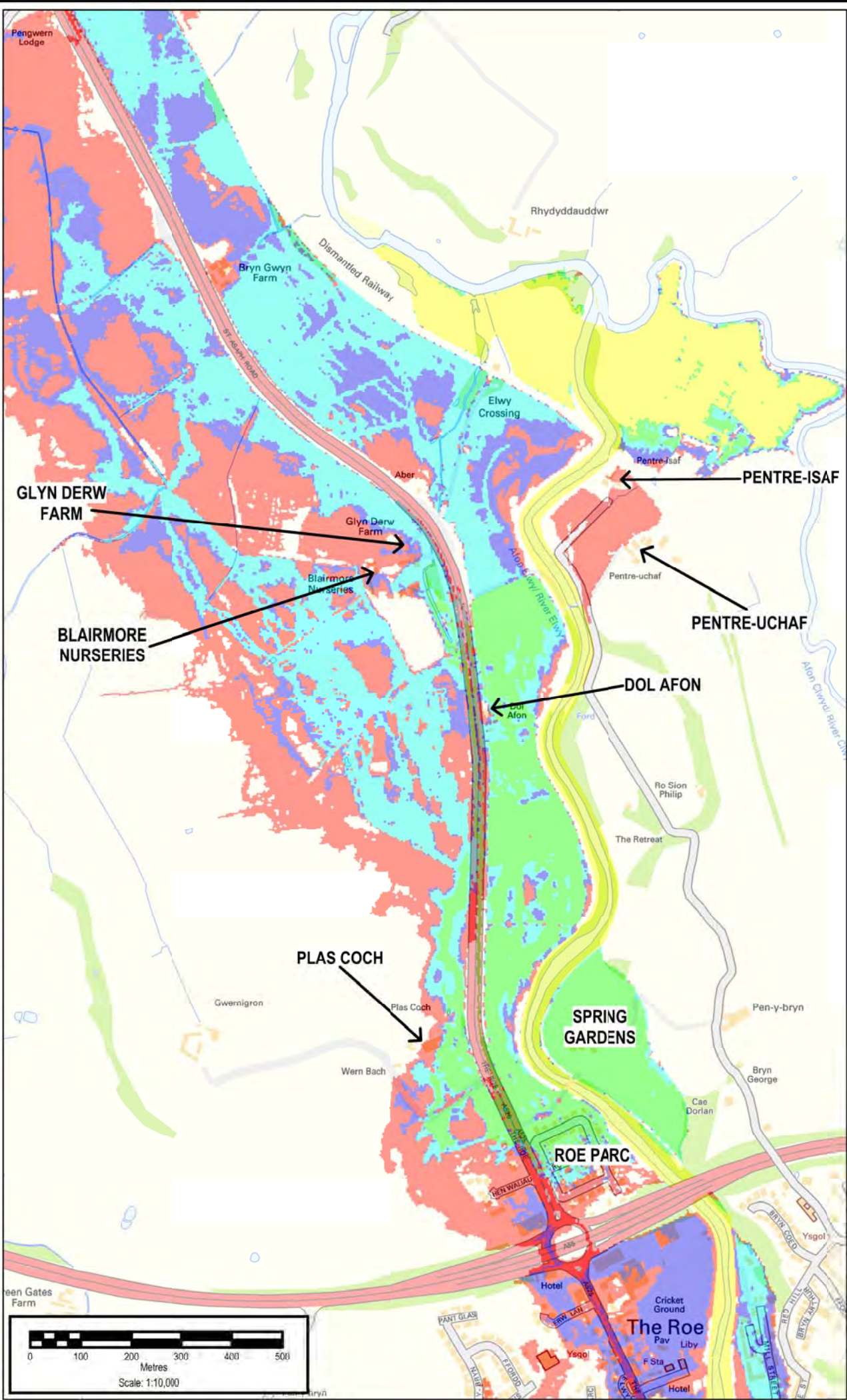
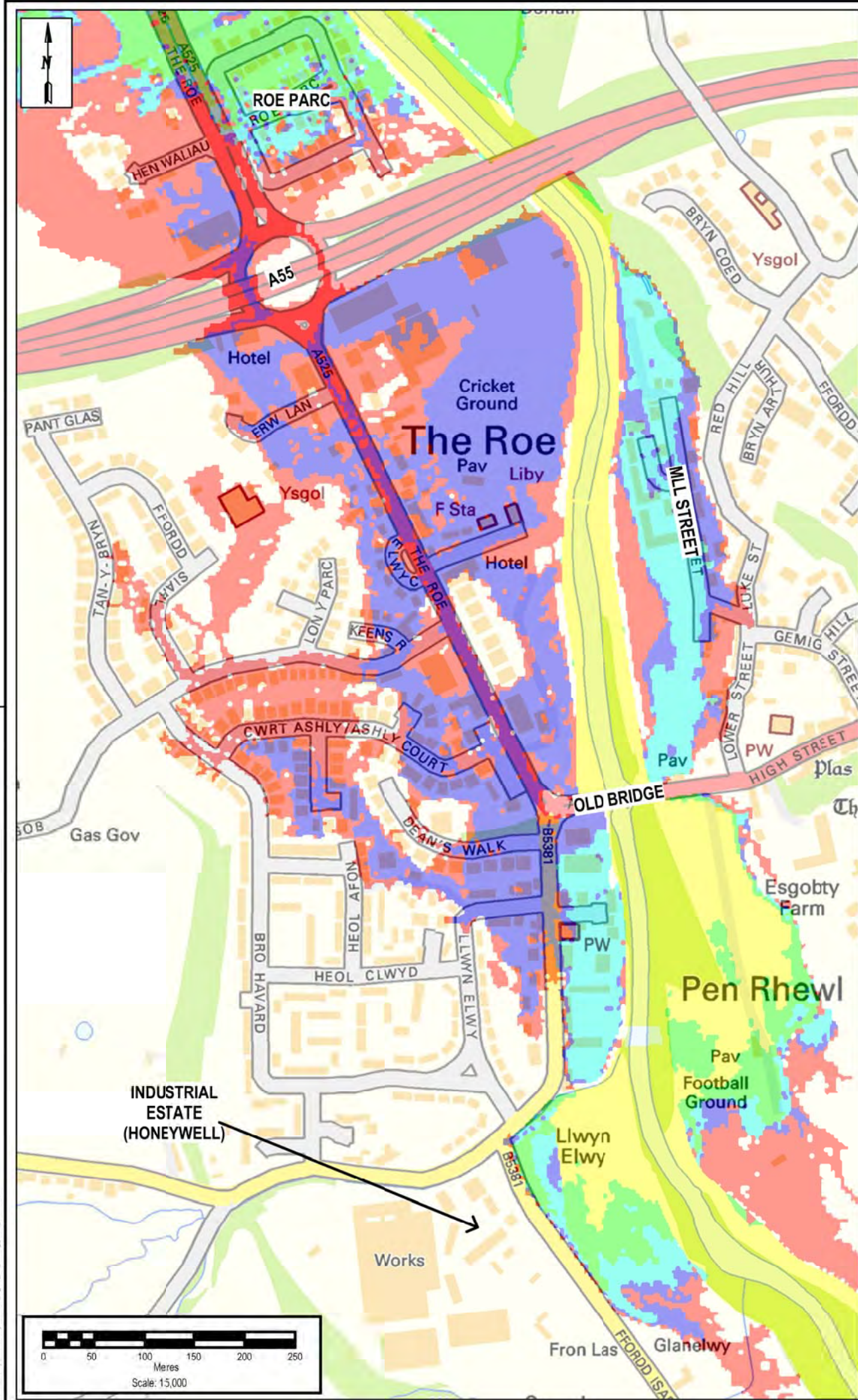
Omitted for file size, please refer to design drawings provided separately with the planning application

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APPENDIX C – ST ASAPH DETRIMENT ASSESSMENT

Annual Probability Flood Outlines

- 1 in 25
- 1 in 50
- 1 in 75
- 1 in 100
- 1 in 200



A	TSP	NSI	RAF	JUN.15	FCA ISSUE	
Rev	Drawn	Chkd.	Revd.	Apprd.	Date	Description
Designed by: TSP				Date: JUN.14		

Client

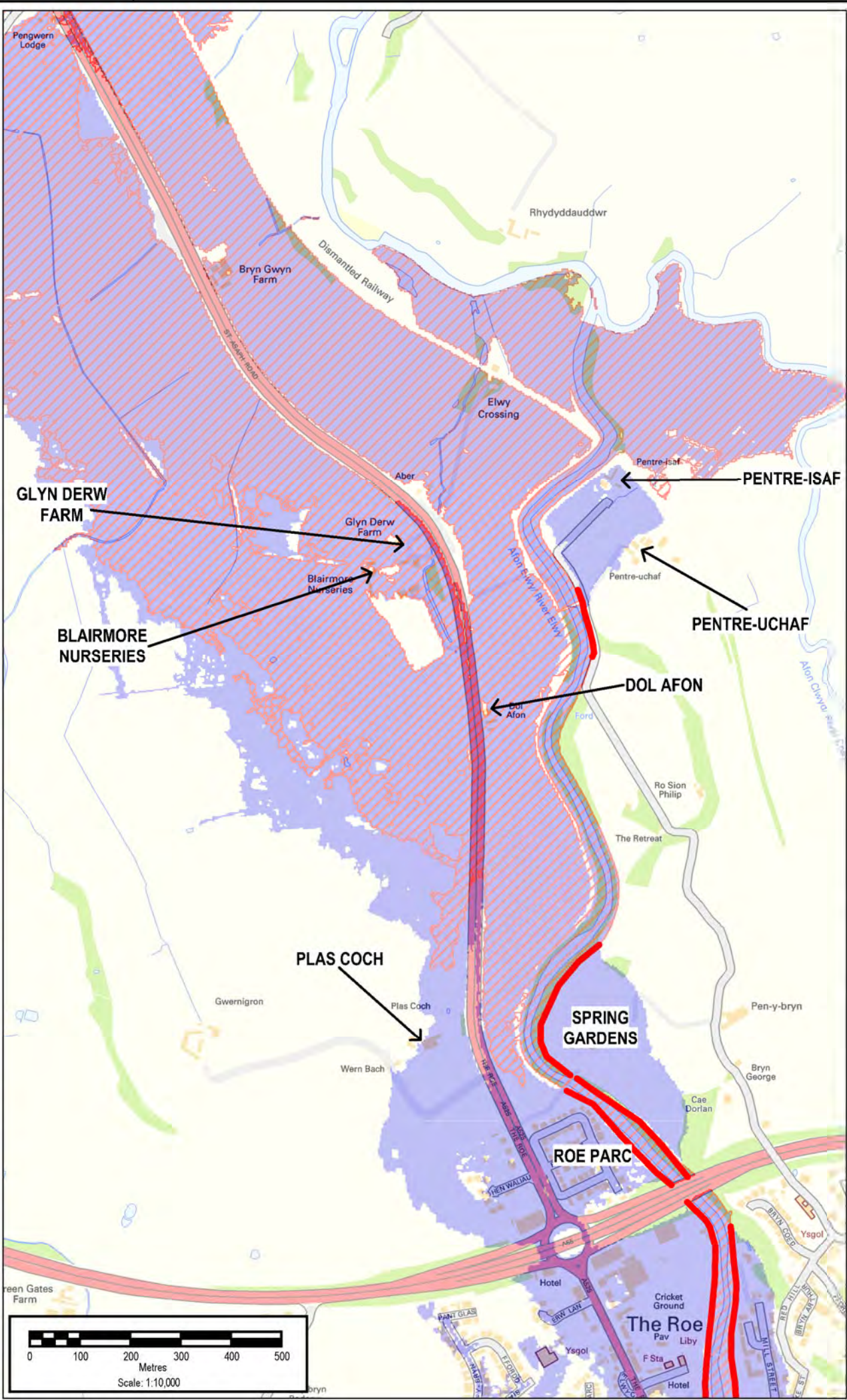
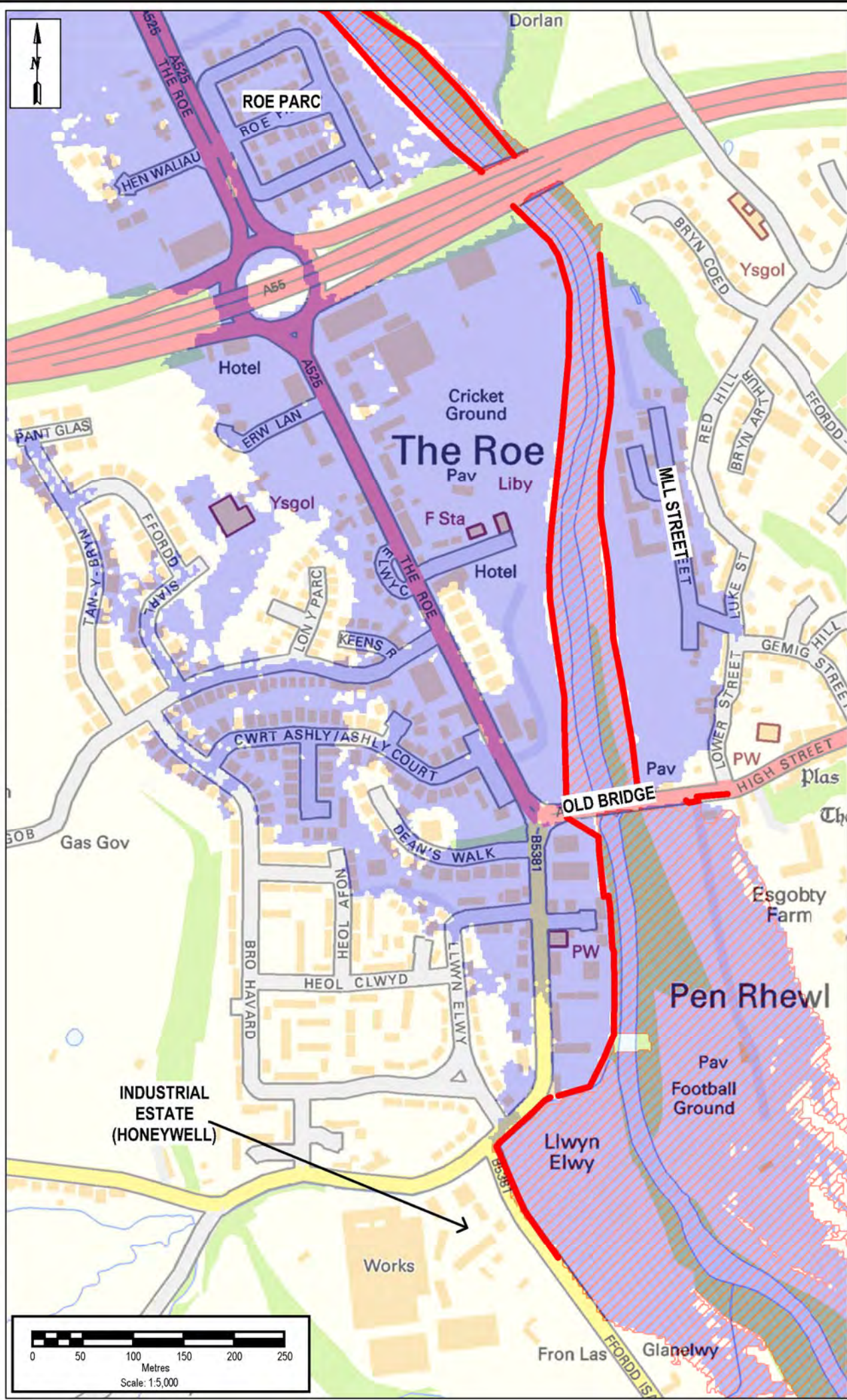
Client Drawing No. _____ Revision _____

GBV JV Limited
Registered Office
Cowley Business Park, Cowley, Oxford, OX4 2AL United Kingdom

ST ASAPH FRMS PAR

EXISTING SITUATION FLOOD OUTLINES

Drawing Scale: See scale bars Sheet size: A3
Drawing no: 122366-60001 Revision: A



- KEY**
- Existing Situation Flood Outline
 - With Scheme Flood Outline
 - Proposed Flood Defence Alignment

A	TSP	NSI	RAF	JUN 15	FCA ISSUE
Rev	Drawn	Chk	Rev'd	Appr'd	Date

Designed by _____ Date _____



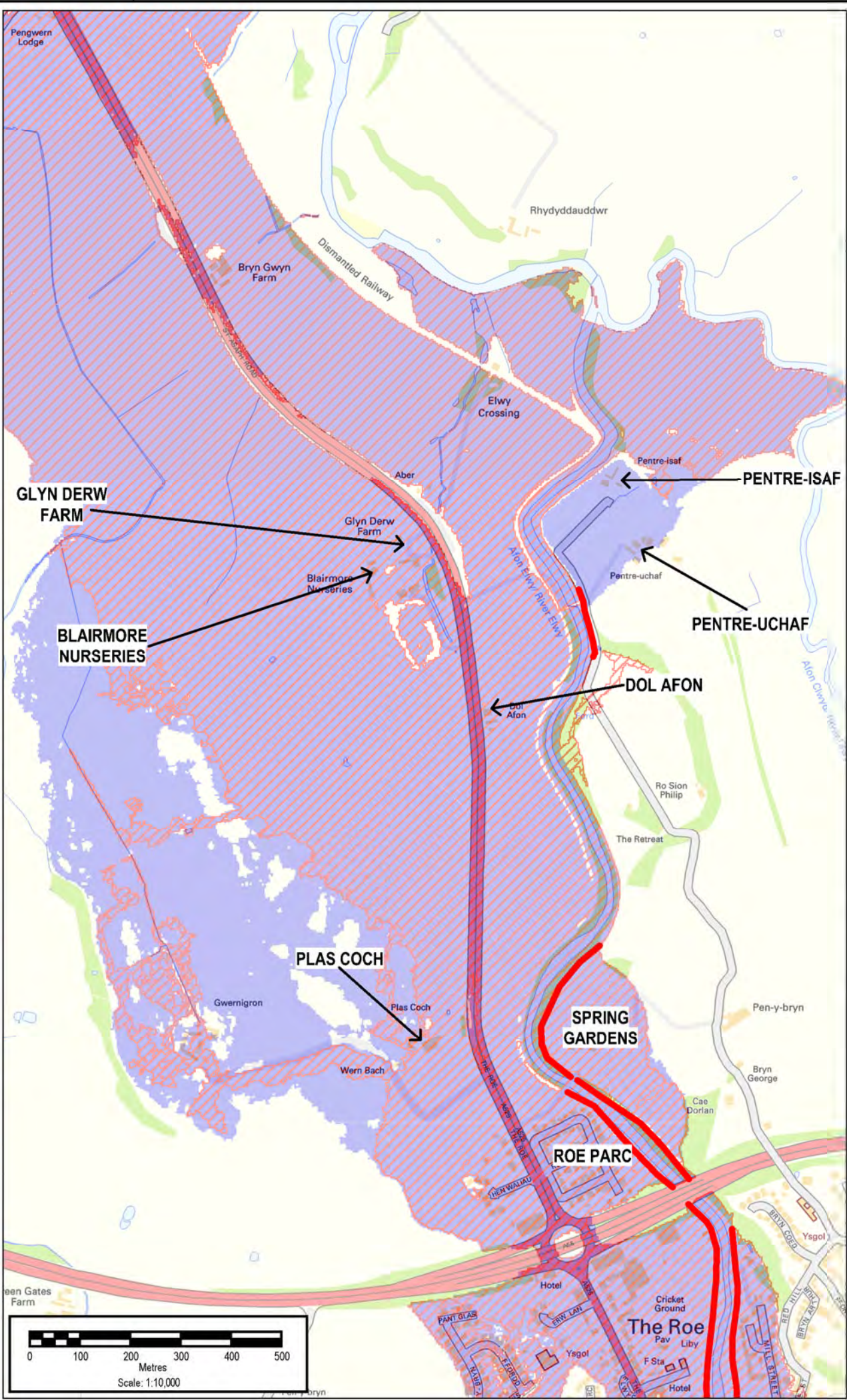
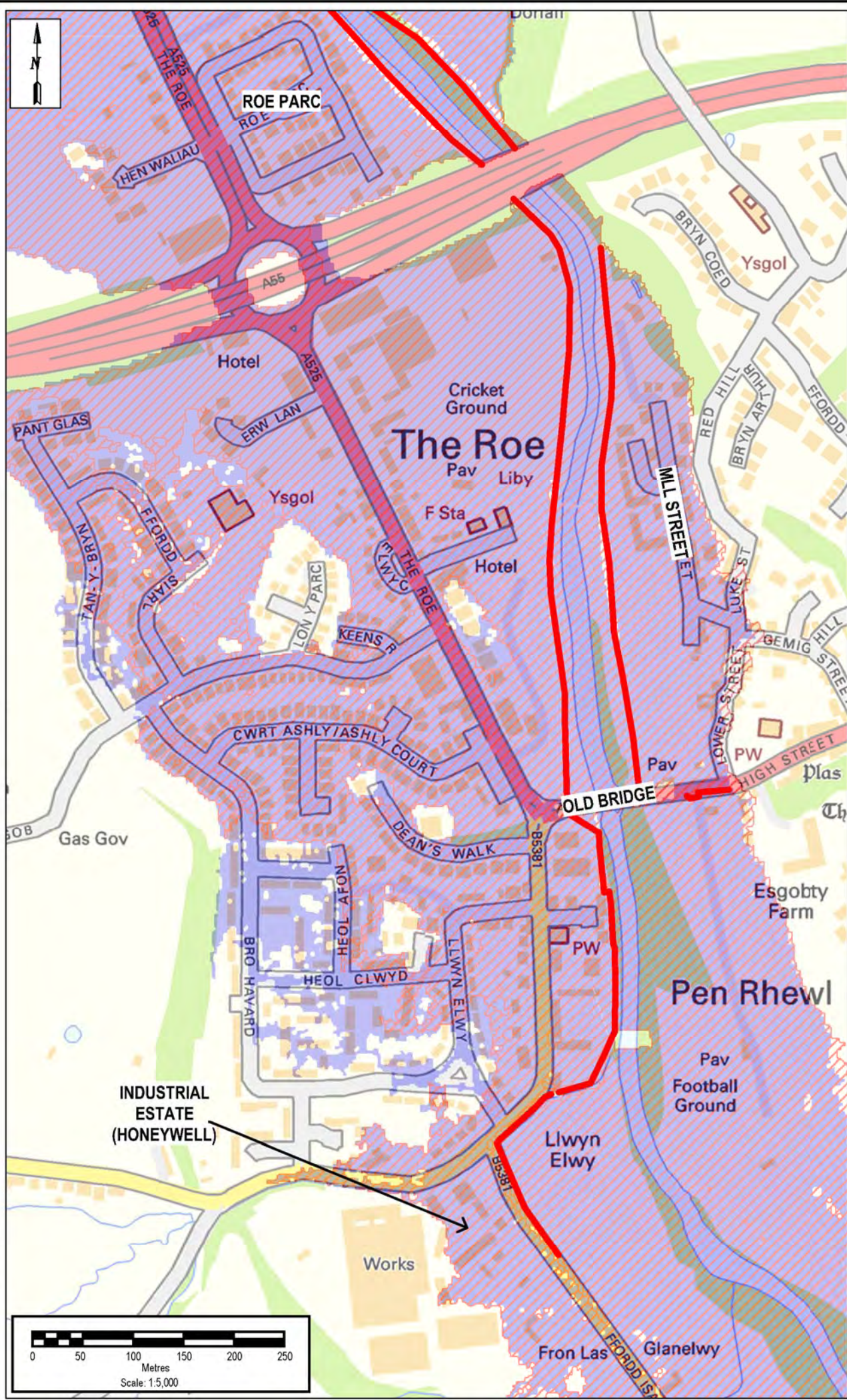
Chief Drawing Officer _____



ST ASAPH FRMS PAR

COMPARISON OF 1 IN 100 ANNUAL PROBABILITY WITH CLIMATE CHANGE FLOOD OUTLINES

Drawing Scale: See scale bars Sheet no: A3
 Drawing no: 122366-60003 Revision: A



-  Existing Situation Flood Outline
-  With Scheme Flood Outline
-  Proposed Flood Defence Alignment

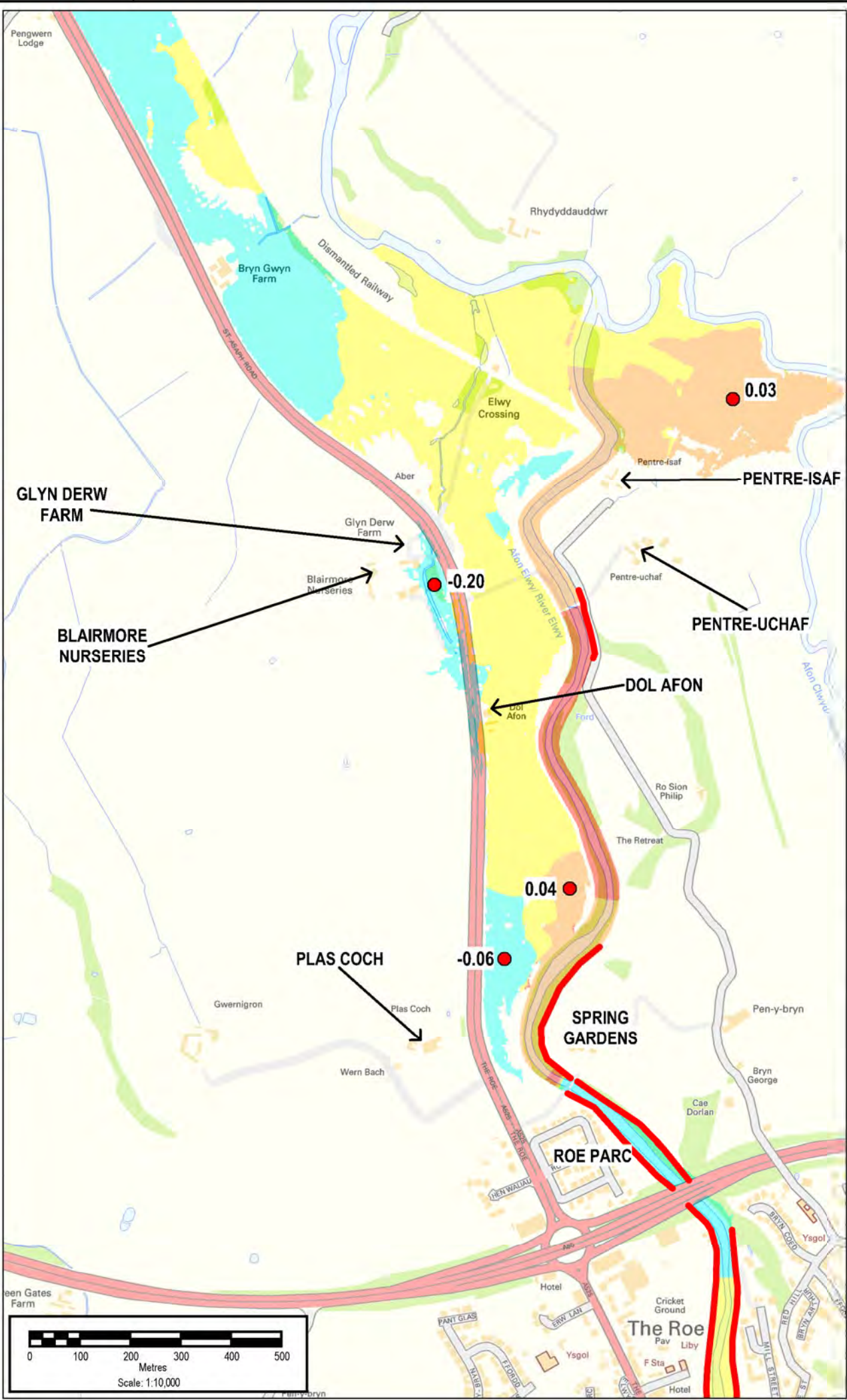
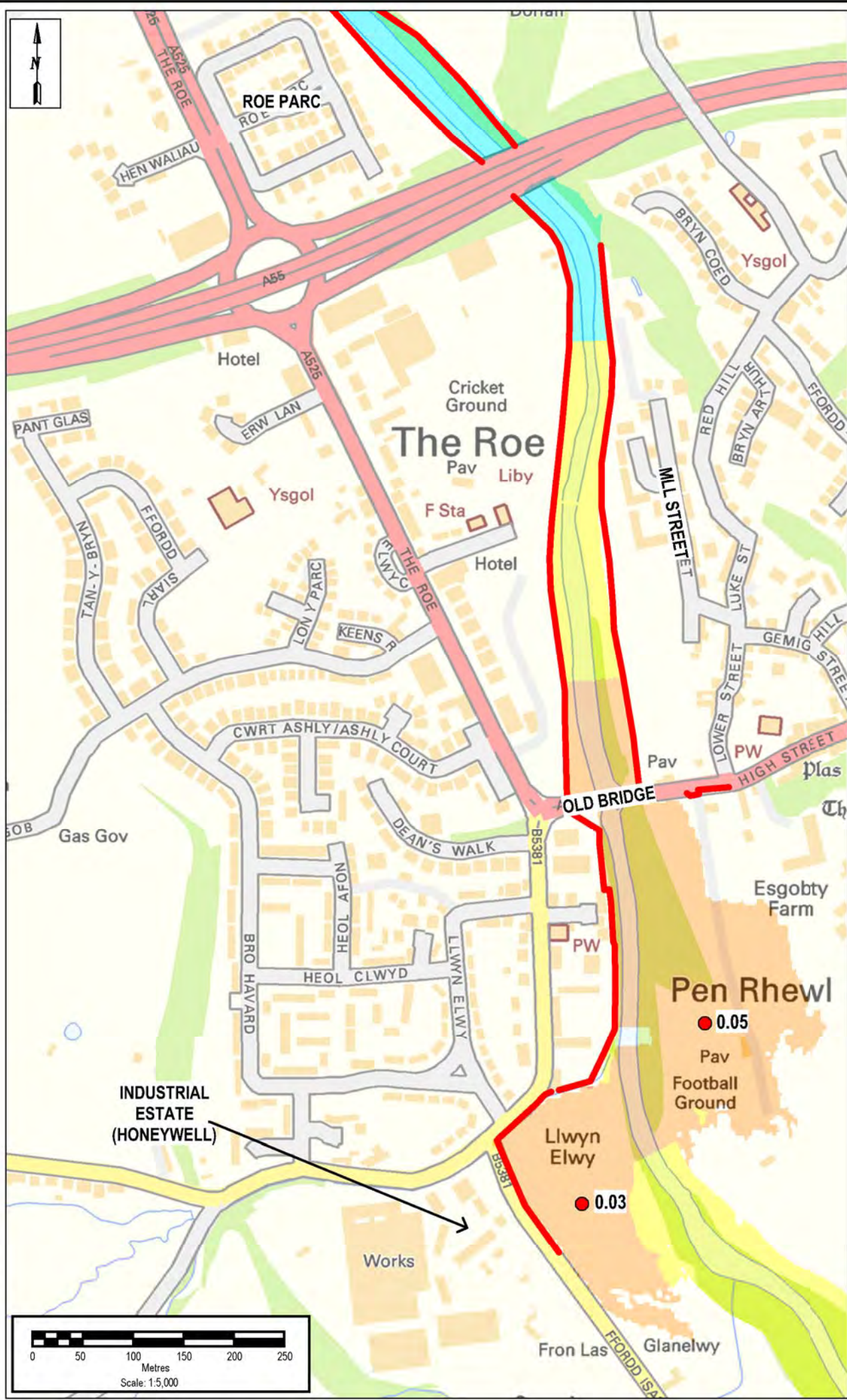
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Client Drawing No: _____ Revision: _____

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 Registered Office
 Cowley Business Park, Cowley, Lidsdale, Midlesex, UB8 3LL, United Kingdom

Project: **ST ASAPH FRMS PAR**
 Drawing title: **COMPARISON OF 1 IN 1000 ANNUAL PROBABILITY FLOOD OUTLINES**
 Drawing Scale: See scale bars Sheet size: A3
 Drawing no: 122366-60004 Revision: A



Change in Flood Depth (m)

- <-0.02
- 0.02 to 0.02
- 0.02 to 0.10
- >0.10

- Spot Change in Flood Depth (m)
- Proposed Flood Defences

A	TSP	NSI	RAF	JUN 15	FCA ISSUE
Rev	Drawn	Chk	Rev'd	Appr'd	Est'd

Designed by: _____ Date: _____



Chief Drawing No: _____ Revision: _____

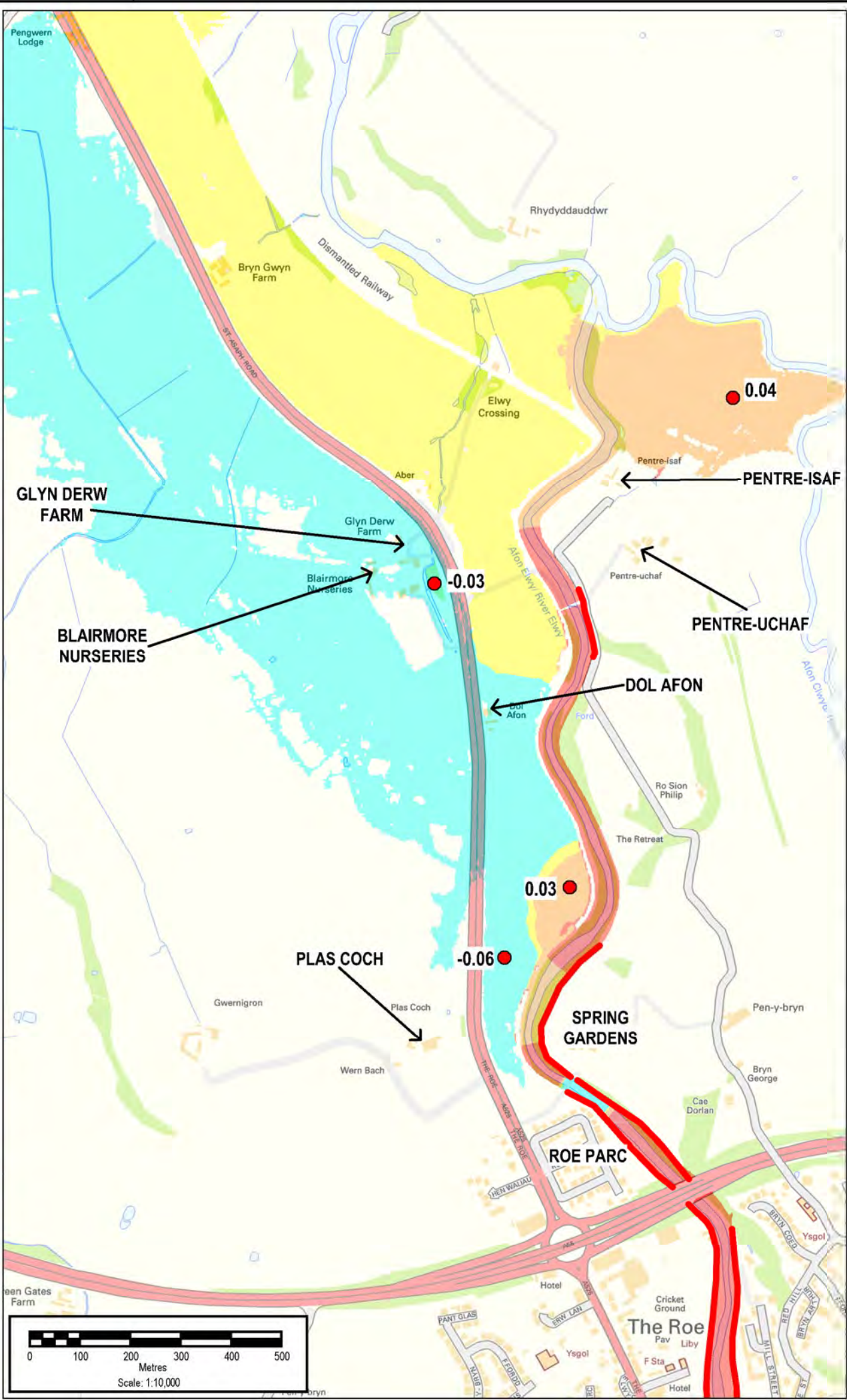
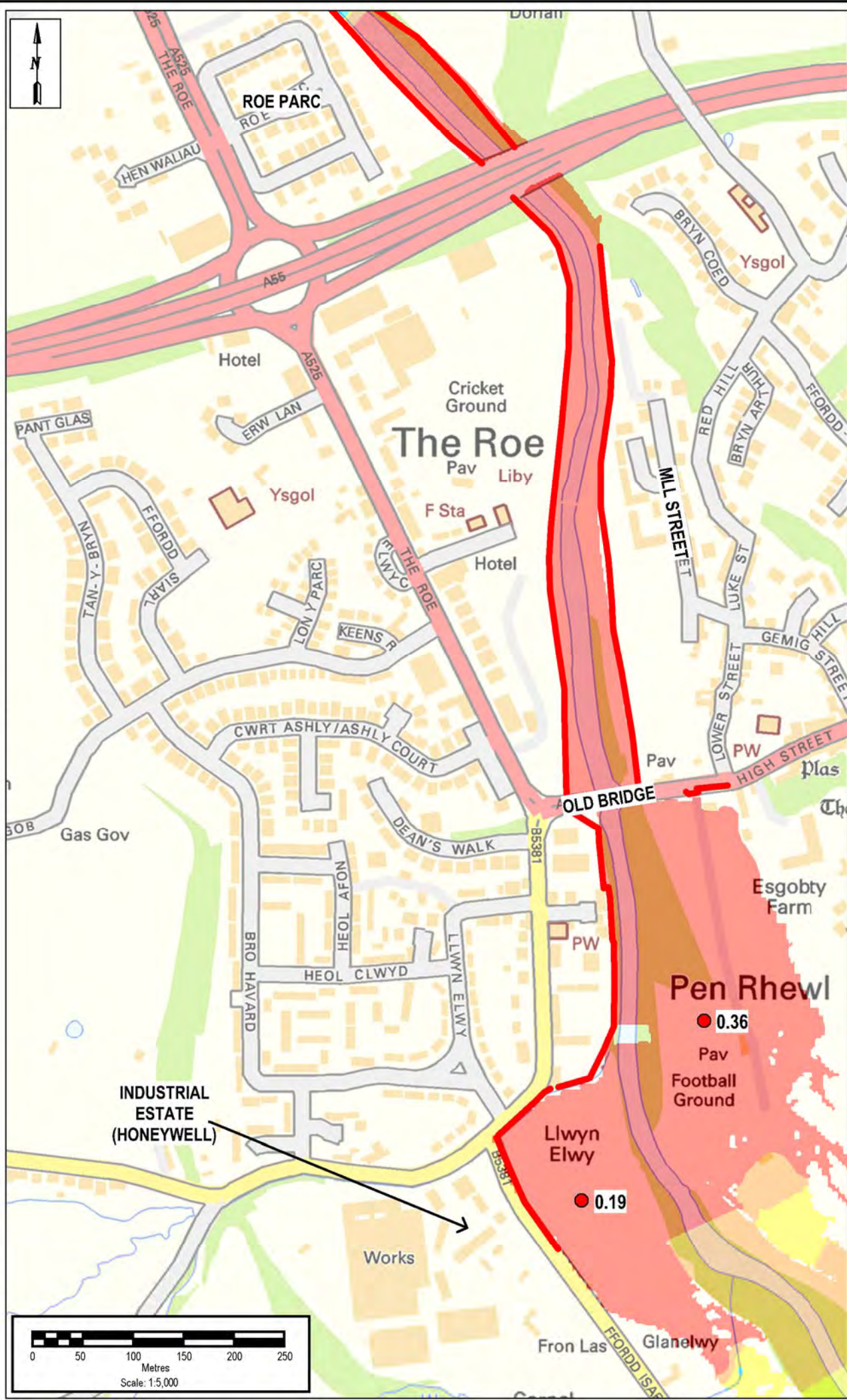


ST ASAPH FRMS PAR

**CHANGE IN FLOOD DEPTHS
1 IN 100 ANNUAL PROBABILITY**

Drawing Scale: See scale bars Sheet size: A3

Drawing No: 122366-60005 Revision: A



Change in Flood Depth (m)



- Spot Change in Flood Depth (m)
- Proposed Flood Defences

A	TSP	NSI	RAF	JUN 15	FCA ISSUE
Rev	Drawn	Chk	Rev'd	Appr'd	Date

Designed by: _____ Date: _____



Chief Drawing Officer: _____

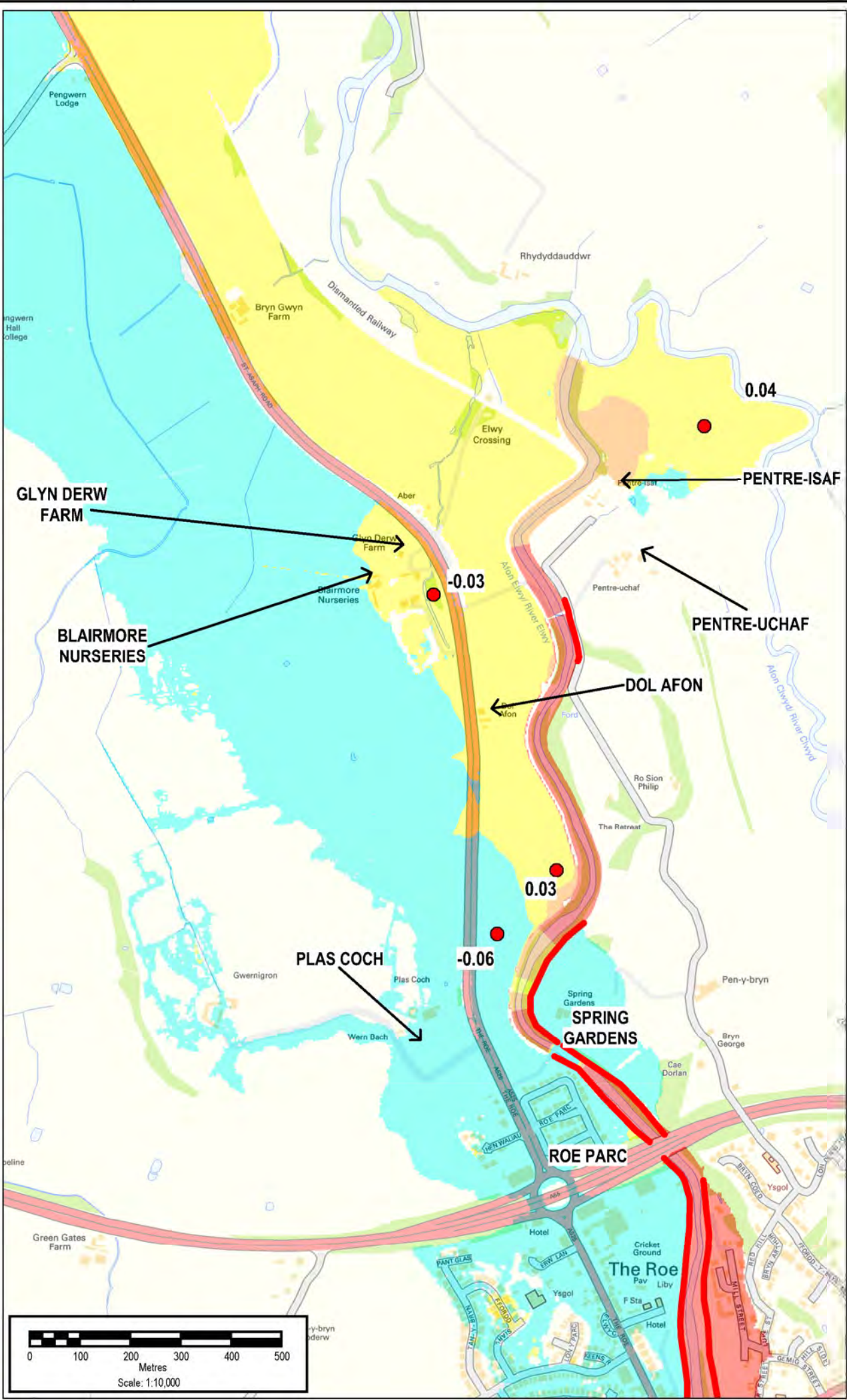
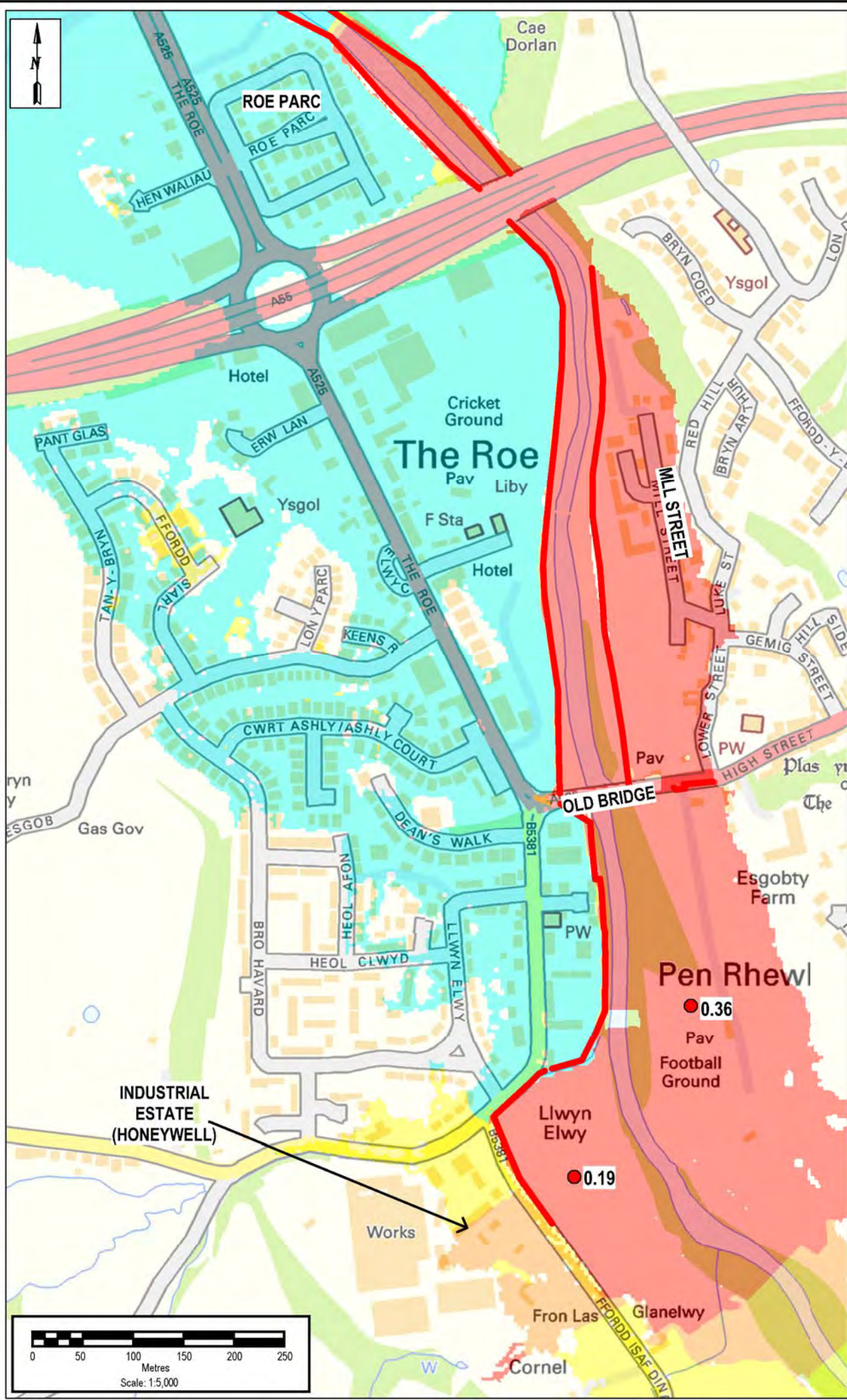


ST ASAPH FRMS PAR

CHANGE IN FLOOD DEPTHS
1 IN 100 ANNUAL PROBABILITY
+ CLIMATE CHANGE

Drawing Scale: See scale bars Sheet size: A3

Drawing no: 122366-60006 Revision: A



Change in Flood Depth (m)

- <math><-0.02</math>
- 0.02 to 0.02
- 0.02 to 0.10
- >0.10

- Spot Change in Flood Depth (m)
- Proposed Flood Defences

A	TSP	NSI	RAF	JUN 15	FCA ISSUE
Drawn	Checked	Reviewed	Approved	Dated	Disapproved

Designed by: _____ Date: _____

Client: 

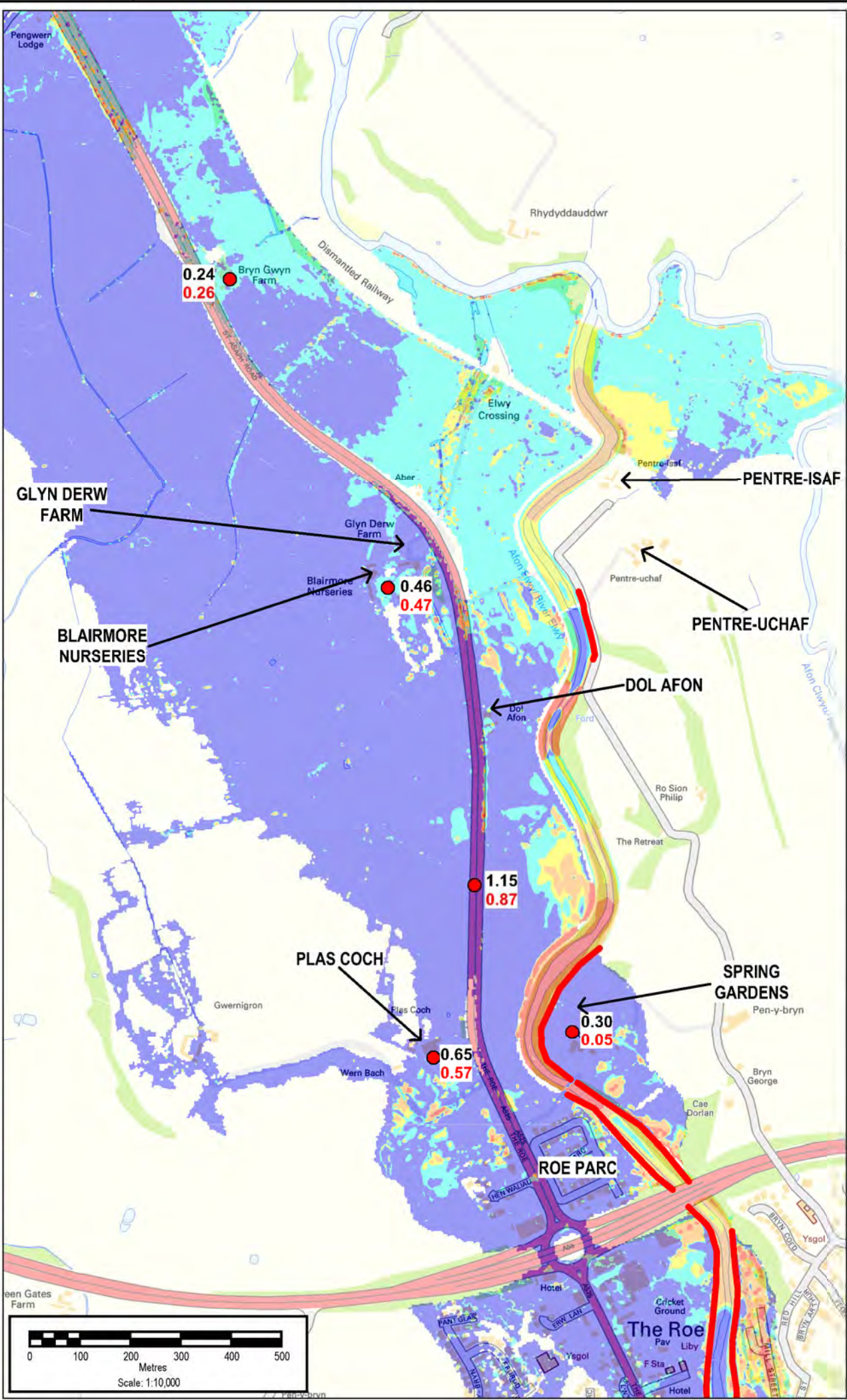
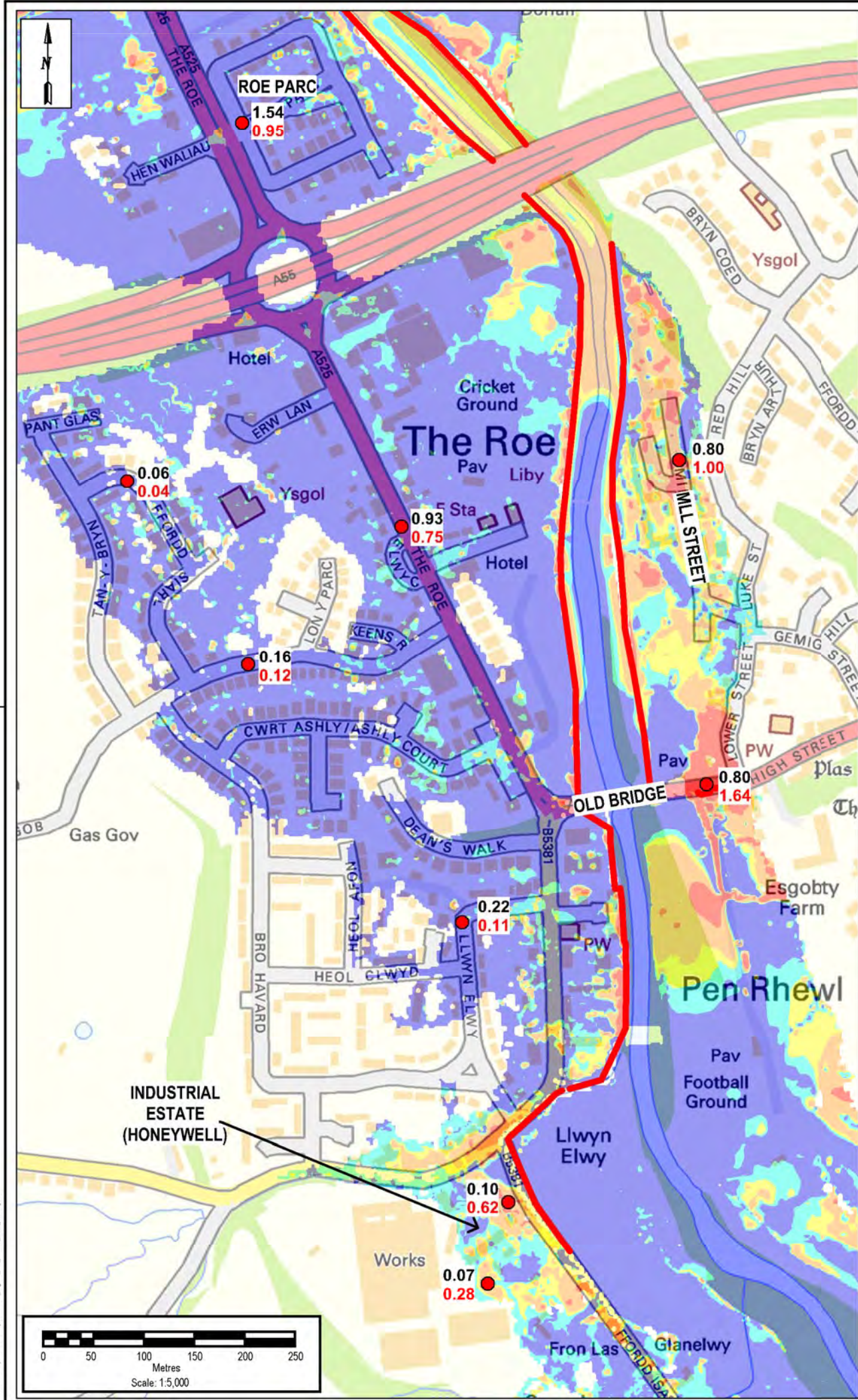
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Project: **ST ASAPH FRMS PAR**

Drawing title: **CHANGE IN FLOOD DEPTHS
 1 IN 100 ANNUAL PROBABILITY
 + CLIMATE CHANGE**

Drawing Scale: See scale bars Drawing size: A3
 Drawing no: 122366-60006 Revision: A



Spot Velocity

- 0.24 Existing
- 0.27 With Scheme

— Proposed Flood Defences

Change in Velocity (m/s)

- <0
- 0 to 0.05
- 0.05 to 0.10
- 0.10 to 0.30
- >0.30

A	TSP	NSI	RAF	JUN 15	FCA ISSUE
Rev	Drawn	Chk	Rev'd	Appr'd	Est'd

Designed by: _____ Date: _____

Client: **Cyfoeth Naturiol Cymru Natural Resources Wales**

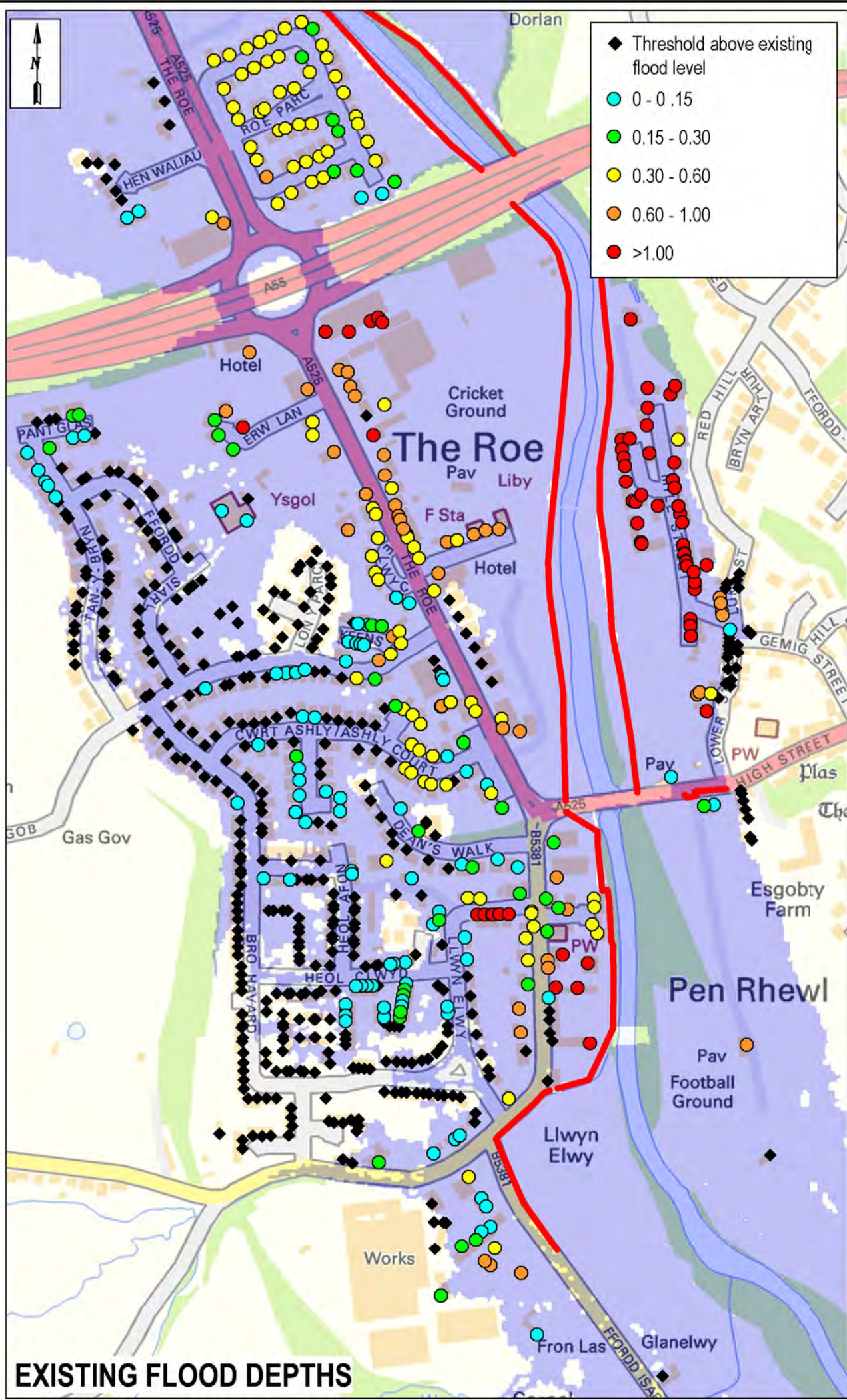
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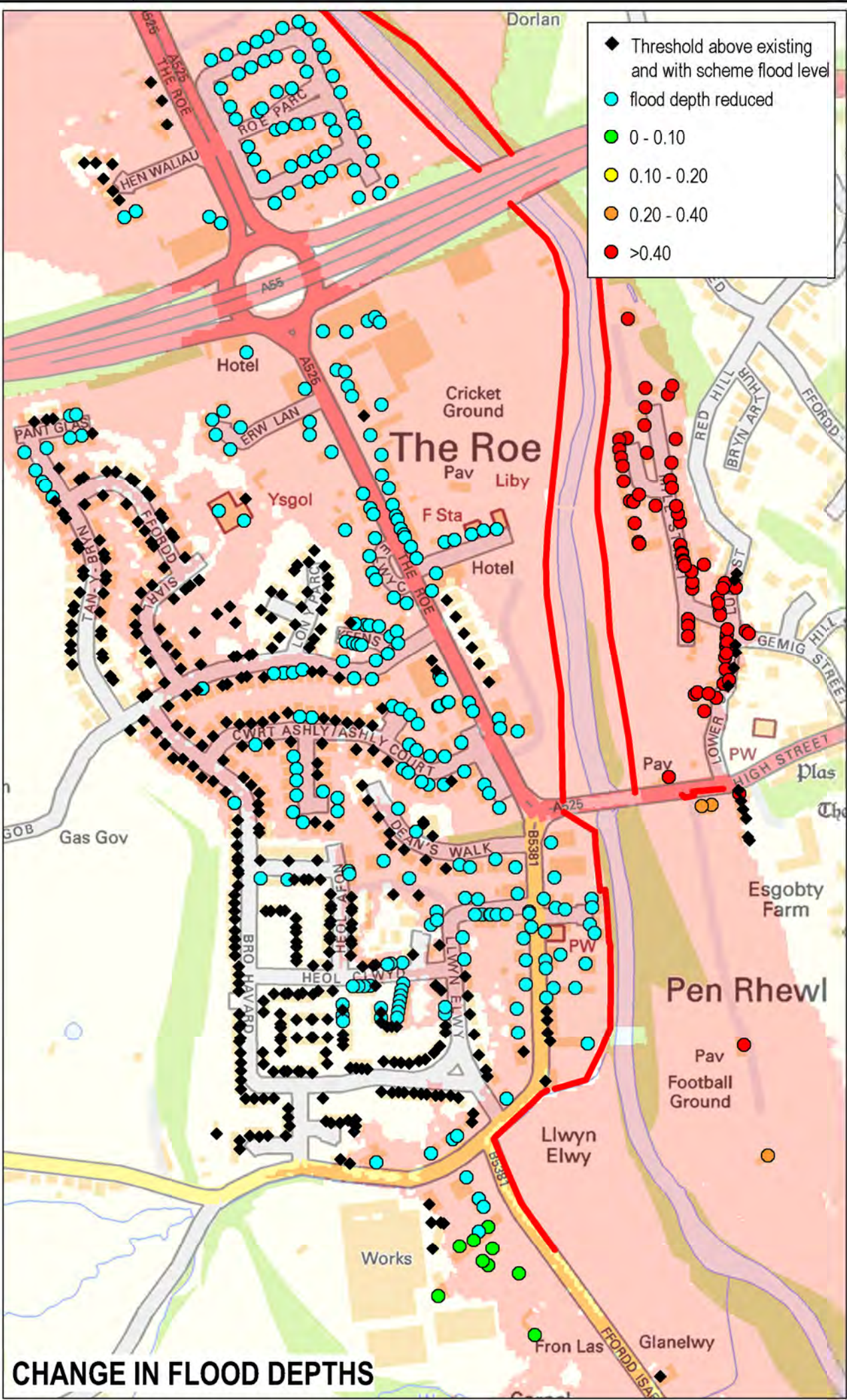
ST ASAPH FRMS PAR

Drawing title: **CHANGE IN FLOOD VELOCITY 1 IN 1000 ANNUAL PROBABILITY**

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Drawing no: 122366-60008 Revision: A



EXISTING FLOOD DEPTHS



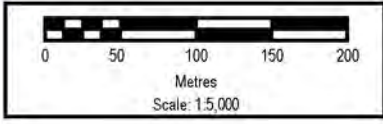
CHANGE IN FLOOD DEPTHS

- ◆ Threshold above existing flood level
- 0 - 0.15
- 0.15 - 0.30
- 0.30 - 0.60
- 0.60 - 1.00
- >1.00

- ◆ Threshold above existing and with scheme flood level
- flood depth reduced
- 0 - 0.10
- 0.10 - 0.20
- 0.20 - 0.40
- >0.40

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- Existing Situation Flood Outline
- With Scheme Flood Outline
- Proposed Flood Defence Alignment



A	TSP	NSI	RAF	JUN 15	FCA ISSUE
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Designed by: _____ Date: _____

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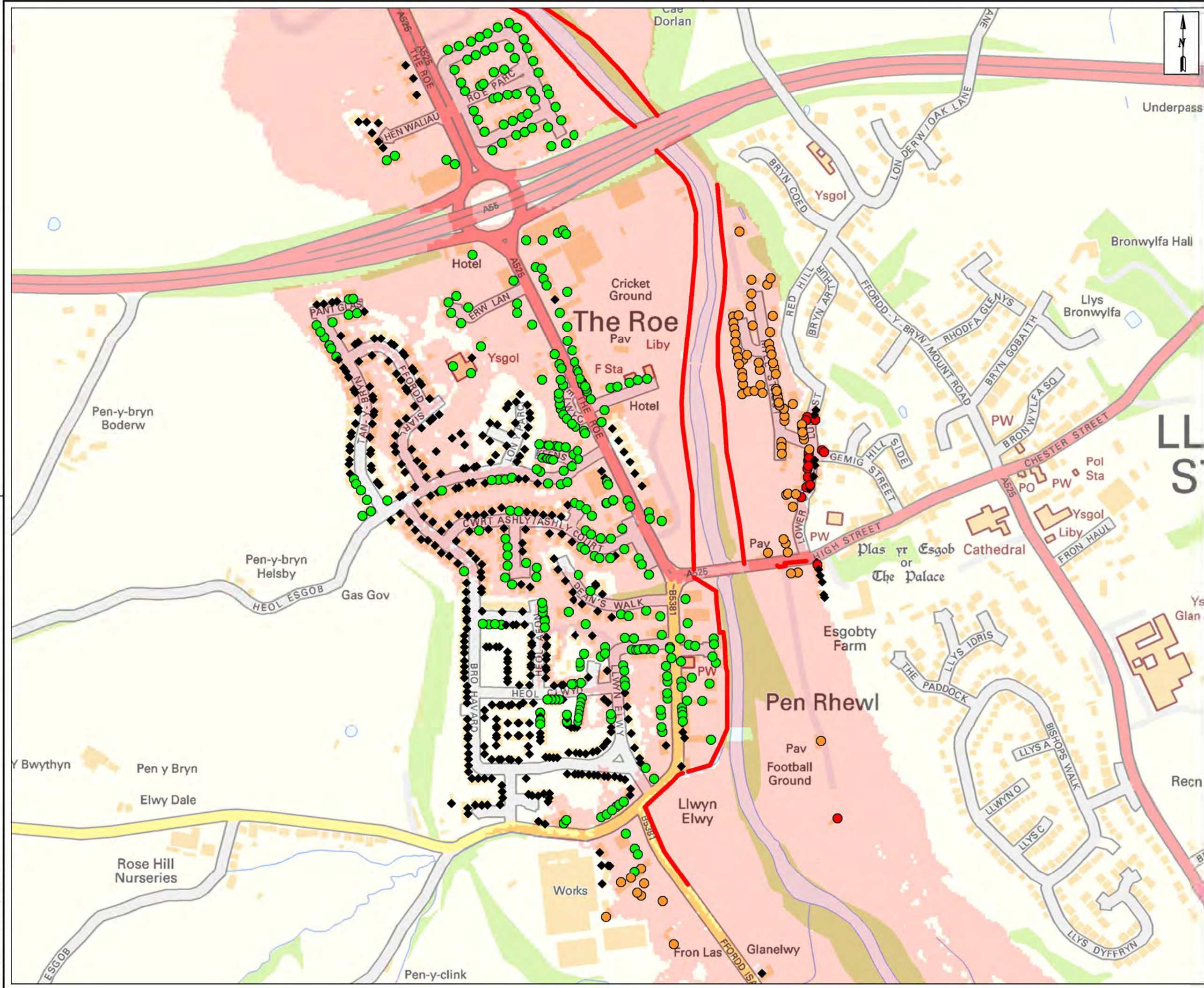
ST ASAPH FRMS PAR

1 IN 1000 ANNUAL PROBABILITY PROPERTY FLOOD DEPTHS

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Drawing No: 122365-60009 Revision: A

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Proposed Defence Alignment

With Scheme Flood Outline

Property Flood Condition

- ◆ Threshold above flood level (no change)
- Flood depth reduced (benefit)
- Flood depth increased (detriment)
- Flooded by scheme (detriment)

A	TSP	NSI	RAF	JUN 15	FCA ISSUE
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Designed by:	TSP				Date:
DEC 14					

Client: **Cyfoeth Naturiol Cymru Natural Resources Wales**

Client Drawing No: **gbv**
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 Gwilym Business Park, Cowley, Lichfield, Staffs, B66 2AL, United Kingdom

ST ASAPH FRMS PAR
 Drawing title:
1 IN 1000 ANNUAL PROBABILITY FLOOD PROPERTY AT BENEFIT & DETRIMENT

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St Asaph Flood Detriment Impacts

23 April 2015

Details of note preparation and issue:

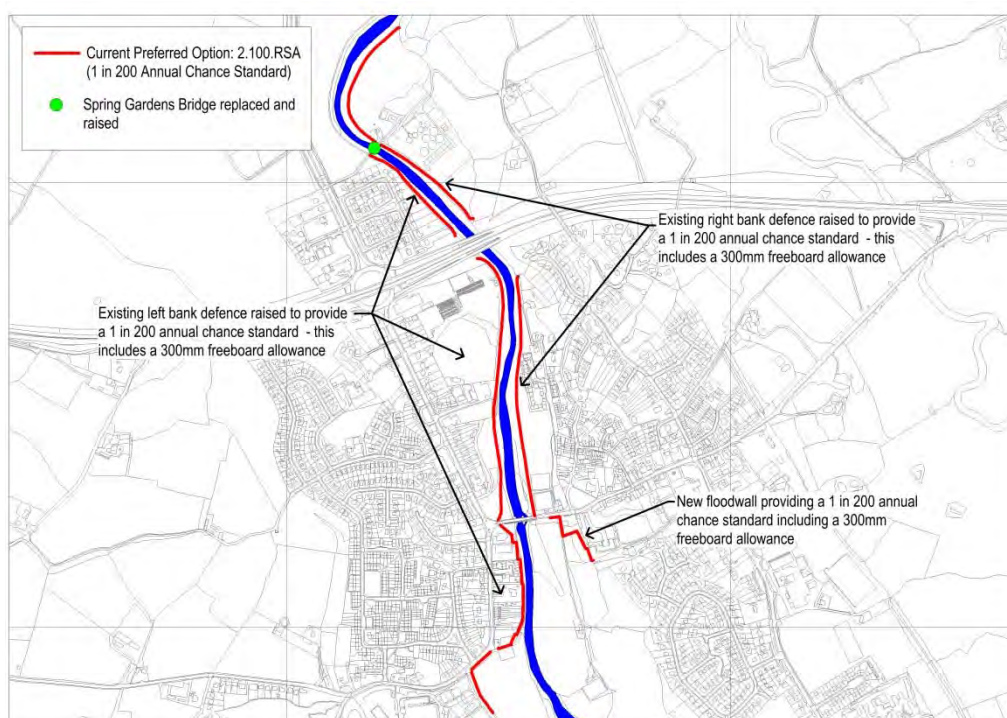
Revision	Prepared by:	Checked by:	Approved by:	Issue date	Issue status
A	N Stokes	R Flitter	R Flitter	21/04/2015	DRAFT
B	N Stokes	R Flitter	R Flitter	23/04/15	DRAFT V2

1. Introduction

1.1 Introduction & Project History

An economic assessment¹ undertaken in accordance with FCERM-AG found that the preferred economic option for St Asaph was to raise the existing and construct new defences to provide a 1 in 100 annual chance standard with a 15% allowance for future climate change and replace Spring Gardens Bridge; refer to Figure 1.1.

Figure 1.1 – St Asaph FRMS Preferred Option (2.100.RSA)



The option was selected as whilst satisfying the requirements laid out in FCERM-AG, it also provided a **present day** 1 in 200 annual chance standard of flood protection. This is a key objective for NRW as it exceeds the magnitude of the November 2012 flood². The option is

¹ St Asaph FRMS Economic Benefit Appraisal Report, GBV JV Ltd, February 2015

² The November 2012 flood was estimated to have been between a 1 in 100 and 1 in 200 annual chance flood.

referred to subsequently as '2.100.RSA' (the reference given to it in the economic assessment¹) or the 'preferred option'.

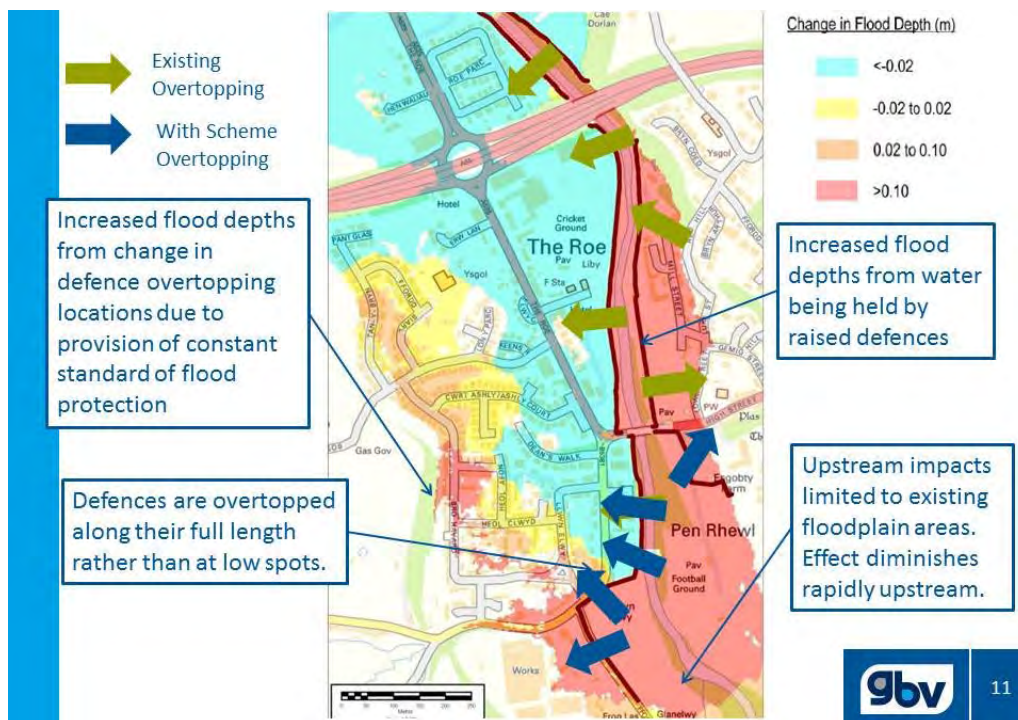
Raising the flood defences through St Asaph for option 2.100.RSA has the following consequences on flood risk:

- 293 properties and 130 businesses in St Asaph protected to the present day 1 in 200 annual chance standard;
- An increased risk of flooding downstream of the city to two properties near the Dol Afon Footbridge and adjacent to Station Road (Rhuddlan) during a 1 in 200 annual chance event;
- An increased risk of flooding through St Asaph during a 1 in 1000 annual chance flood, with 44 new properties at risk of flooding as a consequence of the scheme.

Improvements to the defences near the Dol Afon Footbridge and at Station Road are included as part of the preferred option to mitigate the impacts of raising the defences through St Asaph. These works ensure no net increase in flood risk at either location for either the 1 in 200 or 1 in 1000 annual chance floods.

Raising the defences through St Asaph increases the risk of flooding to some parts of the city when the new defences are overtopped. Figures 1.2 shows that raising the defences to provide the same standard of protection throughout the city, changes the locations where they are first overtopped.

Figure 1.2 – St Asaph Defences Overtopping Locations



The impacts of the preferred option on flood risk for a 1 in 1000 annual chance flood are:

- | | |
|--|---|
| ✓ 260 properties at reduced flood depth; | ✗ 160 properties at an increased flood depth; |
| ✓ 30 properties no longer at risk from flooding. | ✗ 44 new properties at risk from flooding. |

A paper outlining an approach to managing detriment on flood defence schemes has been prepared by NRW and reviewed by Welsh Government³. The paper states:

- FRM schemes should aim to meet the requirements Section A.1.12 of Technical Advice Note 15⁴ which states: *'No flooding elsewhere up to and including the 0.1% (1 in 1000) annual chance event'*;
- Where this cannot be achieved, all appropriate evidence must be provided for a fully informed decision to be made on the merits of a scheme. This must include:
 - Investigations to show the consequences of flooding are managed down to an acceptable level; and
 - Suitable mitigation has been investigated to ensure the proposed development is as safe as possible.

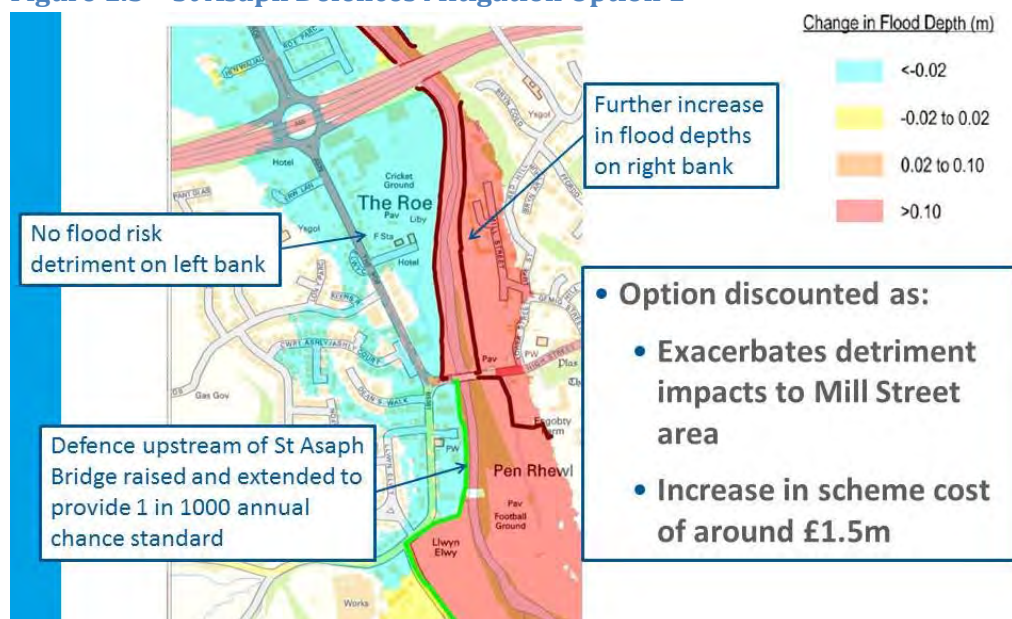
The following options were proposed to mitigate the impacts of the scheme on flood risk through St Asaph for the 1 in 1000 annual chance flood:

- **Option 1:** raising the defence on the left bank between Lower Denbigh Road and St Asaph Old Bridge to provide a 1 in 1000 annual chance standard of flood protection (Figure 1.3); and
- **Option 2:** raising all the existing and constructing new defences to provide a 1 in 1000 annual chance standard of protection.

³ Review of FCA modelling good practice and managing potential detriment effects from FRM schemes, NRW, March 2015

⁴ Add Tan ref.

Figure 1.3 – St Asaph Defences Mitigation Option 1



Option 1 was discounted as whilst it eliminated detriment problems on the left bank of the Elwy through St Asaph it increased flood depths on the right bank in the Mill Street area. Providing variable standards of protection to different parts of the city was also not preferred as it was unlikely to be acceptable to the local community.

Option 2 was discounted as a 1 in 1000 annual chance scheme would be too expensive to deliver and have unacceptable environmental impacts within the city.

No further mitigation options were considered to be practicable as these would require providing a lower standard of flood protection to parts of the city. This approach was not preferred as it would not meet NRW's objective of providing a present day 1 in 200 annual chance standard of flood protection to St Asaph. The proposed scheme was also considered to comply with the requirements of the NRW detriment paper as it would still deliver a net flood risk benefit to St Asaph for a 1 in 1000 annual chance flood.

1.2 Project Consultation

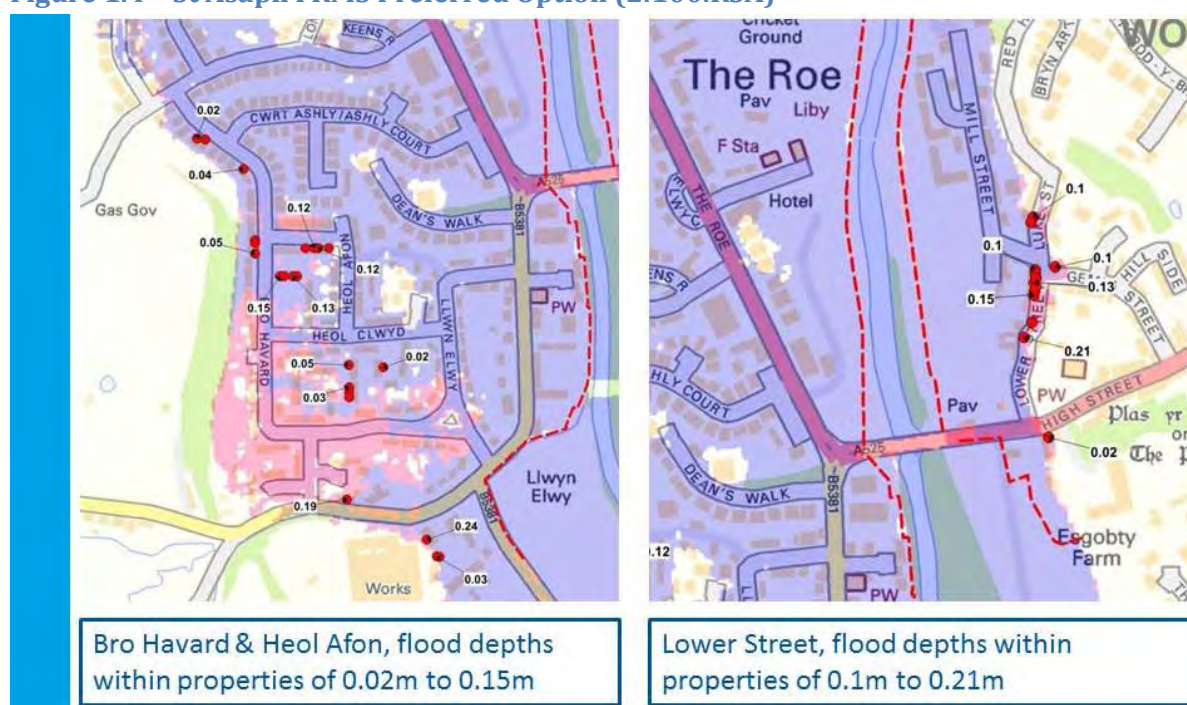
A meeting between NRW and Denbighshire County Council (DCC) was held on 25th March 2015 to discuss the flood risk detriment issues which had arisen as a consequence of the preferred option. The minutes from the meeting are provided in Appendix A; key points from the meeting are given below:

- Changing the onset of flooding will allow more time for warning and evacuation of vulnerable residents e.g. at Mill Street;
- From a planning perspective the main focus will be placed on **any new properties** being put at risk from flooding **rather than** an increase in flood depths incurred by properties already at risk;
- It would only take 4no. objections to a planning application for it to be brought to a planning committee. DCC expected there would be a sufficient lobby objecting to the detriment issues for the scheme to be taken to committee;

- The present focus has been on internal property flooding. As part of a planning application, an assessment of flood risk detriment to farmland and private gardens might also be required;

DCC noted that the requirements of TAN15 clearly state: 'no flooding elsewhere up to and including the 0.1% (1 in 1000) annual chance event'. Figure 1.4 shows the preferred option (2.100.RSA) will result in 44 new properties through St Asaph to be at risk from flooding during a 1 in 1000 annual chance event as a direct consequence of the scheme. DCC advised there would be no grounds to rule against objections received from these property owners to the proposed scheme given the requirements of TAN15. There would therefore be a risk of the current scheme would not receiving planning permission as it did not strictly meet the requirements of TAN15. Whilst the scheme was shown to be compliant with NRW's detriment paper, presently, this advice is not recognised as planning policy.

Figure 1.4 – St Asaph FRMS Preferred Option (2.100.RSA)



1.3 This Paper

Following the meeting with DCC, it was agreed further investigation of potential measures to mitigate flood risk detriment issues through St Asaph was required. Unlike the previous assessment, this was to include consideration of options which provided lower or variable standards of flood protection throughout the city.

This paper details the assessment of a further 14no. options to mitigate flood risk detriment issues in St Asaph. Further to the discussions with DCC, the options have focussed on **minimising the number of new properties** at risk from flooding during a 1 in 1000 annual chance flood rather than mitigating the impacts on properties already at risk from flooding. This is not discount the importance of the latter, but from a planning perspective, the greatest risk to the scheme not receiving permission to proceed is expected to come from objections received from those property owners who currently are not at risk from flooding.

The assessment has focussed on the 1 in 1000 annual chance flood as this event gives rise the largest number of new properties to be at risk from flooding with the preferred option in St Asaph.

2. Results

2.1 Alternative Economic Options

The *St Asaph Economics Benefit Assessment* report identified two further options, in addition to the preferred option, which were economically viable. Whilst neither was economically preferred, the two have been reassessed to see if they would give rise to a smaller increase in the number of new properties at risk from flooding for a 1 in 1000 annual chance flood compared to the preferred option. Should either option significantly reduce the new number of properties at risk, there could be strong grounds for their implementation under Stage 5 of the FCERM-AG option assessment criteria. The results of the assessment are presented in Table 2.1.

Table 2.1 – Alternative Economic Options Detriment Impacts

Option Reference	New Present Day Standard of Protection	No of New Properties at risk for 1 in 1000 Flood	Change in no. of New Properties from preferred option
2.100.RSA (Preferred Option)	1 in 200	44	-
2.100.FA	1 in 100	42	-2
2.200.RSA	1 in 380	38	-6

Options 2.100.FA and 2.200.RSA give rise to a slightly smaller number of new properties at risk during a 1 in 1000 annual chance flood as a consequence of the scheme. The largest reduction of 6no. properties is for Option 2.200.RSA, which requires construction of defences to provide a present day 1 in 380 annual chance standard. Option 2.100.FA only reduces the number of new properties at risk by 2no.

Whilst an improvement on the preferred option, it is suggested that neither option provides a sufficient reduction in the number of new properties at risk from flooding to warrant their selection. Option 2.200.RSA requires construction of relatively high defences through St Asaph, and there are concerns about whether these could be delivered given the limited space to raise the defences along the river. Option 2.100.FA provides a lower standard of flood protection than the preferred option (2.100.RSA) and only results in 2 fewer new properties as risk as a consequence of the scheme.

Option 2.100.RSA is therefore retained as the preferred option, with mitigation works considered to reduce the number of new properties at for a 1 in 1000 annual chance event as a consequence of the scheme. This assessment is described in Section 2.2.

2.2 Detriment Mitigation Options

The details and results of each of the detriment mitigation runs are discussed in the paragraphs below. A full summary of the results is presented in Appendix B. **In all cases**, the proposed 'detriment mitigation' option has been applied to the preferred option 2.100.RSA, as shown in Figure 1.1.

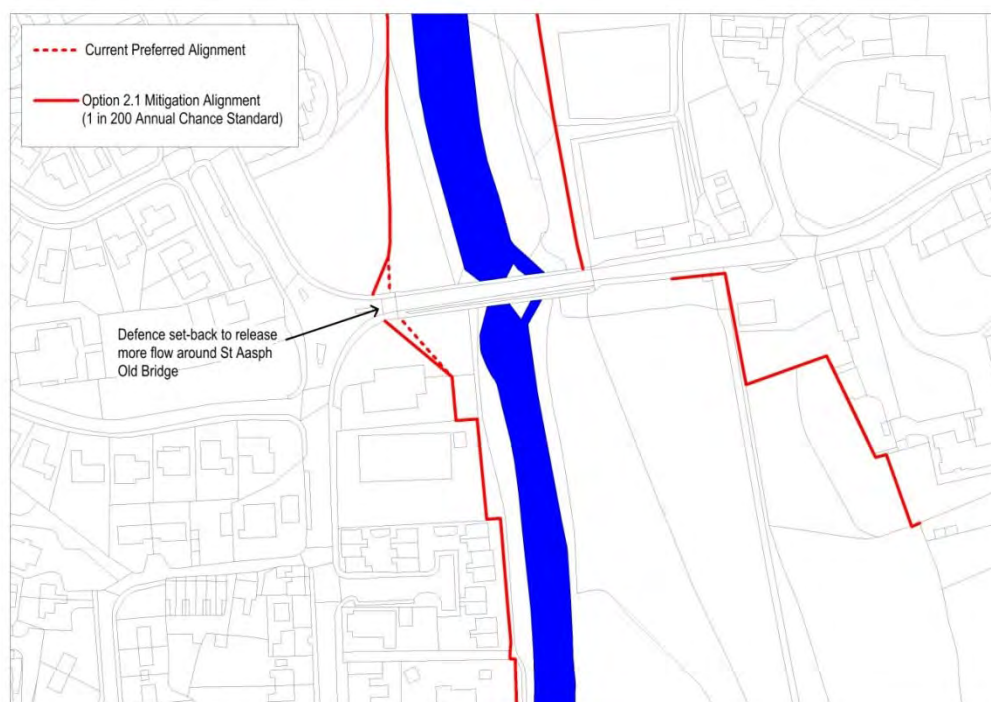
2.3 St Asaph Bridge Old Bridge Options

Option 2.1 – St Asaph Old Bridge A

Option Description

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard of protection to St Asaph; Spring Gardens Bridge replaced and raised.
Detriment Mitigation:	Defence tie-ins on left bank of St Asaph Old Bridge are set-back by a further 6m to increase the rate of flows bypassing the bridge for a 1 in 1000 annual chance event; refer to Figure 2.1.

Figure 2.1 – Option 2.1 St Asaph Bridge A



Results & Discussion

The proposal has little impact on flood levels upstream of St Asaph Old Bridge. The set-back is relatively narrow and allows only a small additional flow to bypass the bridge.

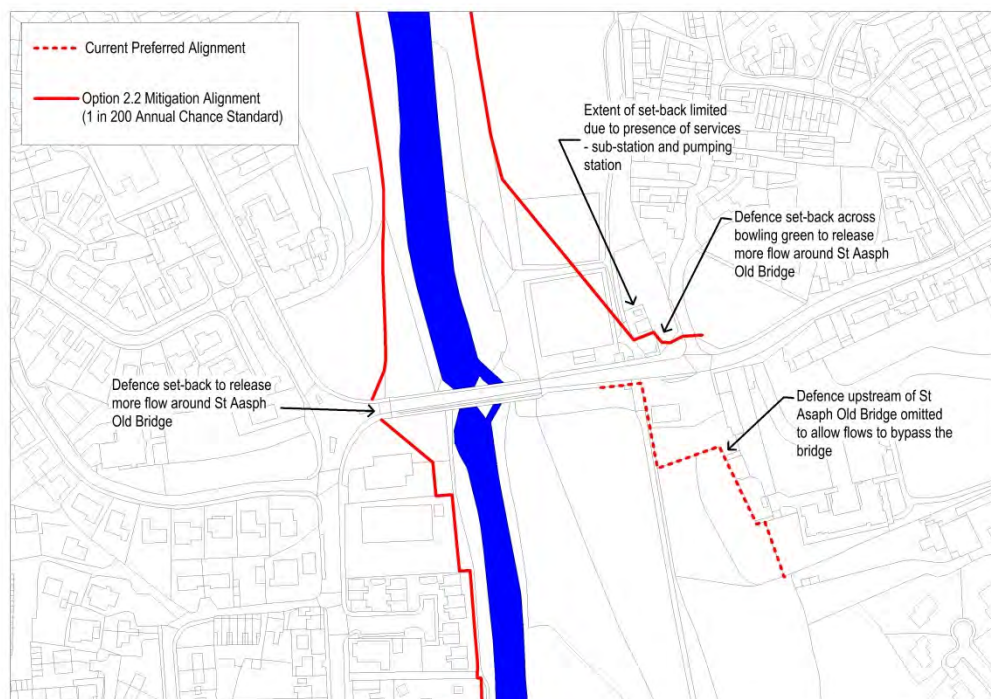
There is no change in the number of new properties at risk from flooding as a consequence of the scheme.

Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:	44 – no decrease from the current preferred option
Impact on scheme economics	None – no change in standard of flood protection and a negligible increase in construction costs
Recommended Option:	Yes – whilst it does not reduce the number of new properties at risk, setting back the defences where possible is good practice and will enhance views of St Asaph Old Bridge.

Option 2.2 – St Asaph Old Bridge B*Option Description*

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard of protection to St Asaph; Spring Gardens Bridge replaced and raised; No new defence on right bank upstream of St Asaph Old Bridge, increasing the risk of flooding to the 'Fountain Car Sales' garage for a 1 in 200 annual chance event (Figure 2.2).
Detriment Mitigation:	Defence tie-ins to St Asaph Old Bridge are set-back as follows to increase the rate of flows bypassing the bridge for a 1 in 1000 annual chance event: <ul style="list-style-type: none"> - Up to 6m on the left bank (as option 2.1) - Across the bowling green and play area on the right bank with both these facilities relocated; - No new defence upstream on the right bank upstream of St Asaph Old Bridge

Figure 2.2 – Option 2.2 St Asaph Bridge B

Results & Discussion

Allowing flows to bypass St Asaph Old Bridge on both banks gives rise to a slight reduction in the number of new properties at risk during a 1 in 1000 annual chance event as a consequence of the scheme. The overall effect is limited as the set-back on the right bank is still relatively close to the bridge to protect locally important statutory services.

There are **36 new properties** at risk from flooding during the 1 in 1000 annual chance flood. This is **8 fewer** than with the preferred option without any mitigation.

Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:	36 – 8 less than the current preferred option
Impact on scheme economics	The section of defence on the right bank is likely to be relatively costly to deliver. It is possible omitting it and setting the defence back across the bowling green would be cost neutral, despite the additional cost of having to replace facilities adversely affecting by this option
Recommended Option:	No – the benefits in terms of reducing the number of properties at risk is small.

2.4 Channel Roughness Sensitivity Option

Option 2.3 – Channel Roughness Sensitivity

Option Description

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard of protection to St Asaph; Spring Gardens Bridge replaced and raised;
Detriment Mitigation:	Channel roughness reduced to 0.15 on basis of more intensive maintenance regime

Results & Discussion

Reducing channel roughness lowers water levels by around 100mm with the proposed scheme for a 1 in 1000 annual chance flood. The effects are relatively limited as; for an event of this size, the actual size of the channel and structures that cross it limit conveyance more than hydraulic roughness.

It is also noted that channel maintenance is undertaken on a cyclical basis so it cannot be guaranteed optimum conditions would be prevalent at the time of flooding. During parts of the year, maintenance is also limited by other factors e.g. protected species.

There are **34 new properties** at risk from flooding during the 1 in 1000 annual chance flood as a consequence of the scheme. This is **10 fewer** than with the preferred option without any mitigation.

Recommendation

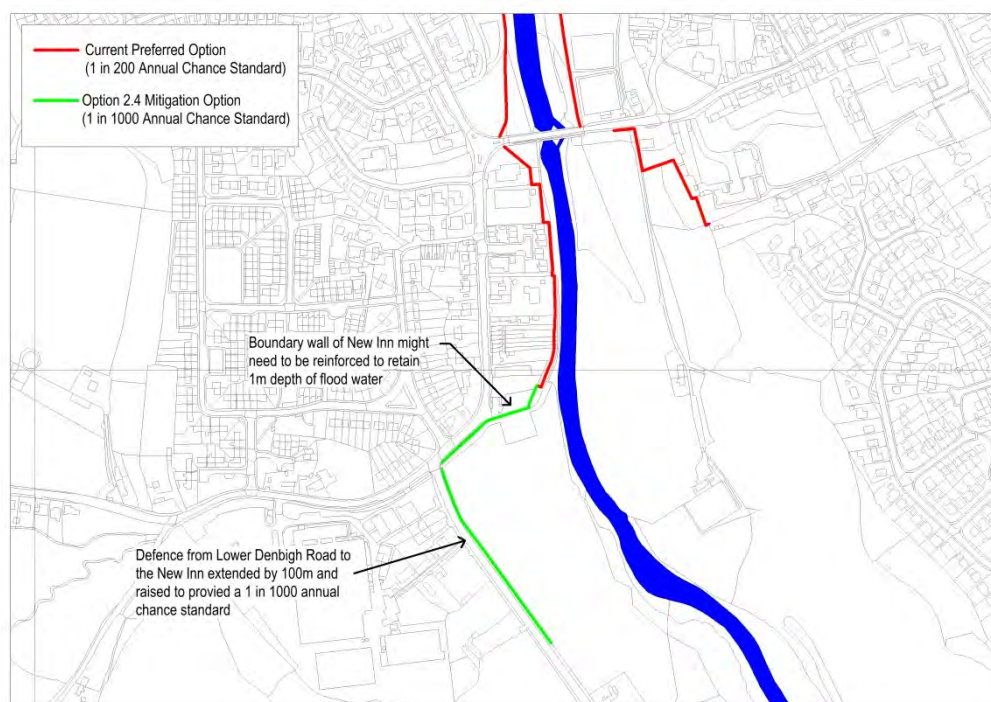
Number of new properties at risk for a 1 in 1000 annual chance flood:	34 – 10 less than the current preferred option
Impact on scheme economics	Increasing the annual spend on maintenance for the preferred option or decreasing the annual spend on maintenance for the do minimum option would be required and likely to make raising the defences look less favourable. It is hoped however that the preferred option would still remain economically viable.
Recommended Option:	No – the benefits in terms of reducing the number of properties at risk is small. Furthermore, maintenance works are undertaken on a cyclical basis and it cannot be guaranteed that optimum channel conditions could be maintained throughout the year.

2.5 New Inn Defence Option

Option 2.4 – New Inn Defence Option

Option Description

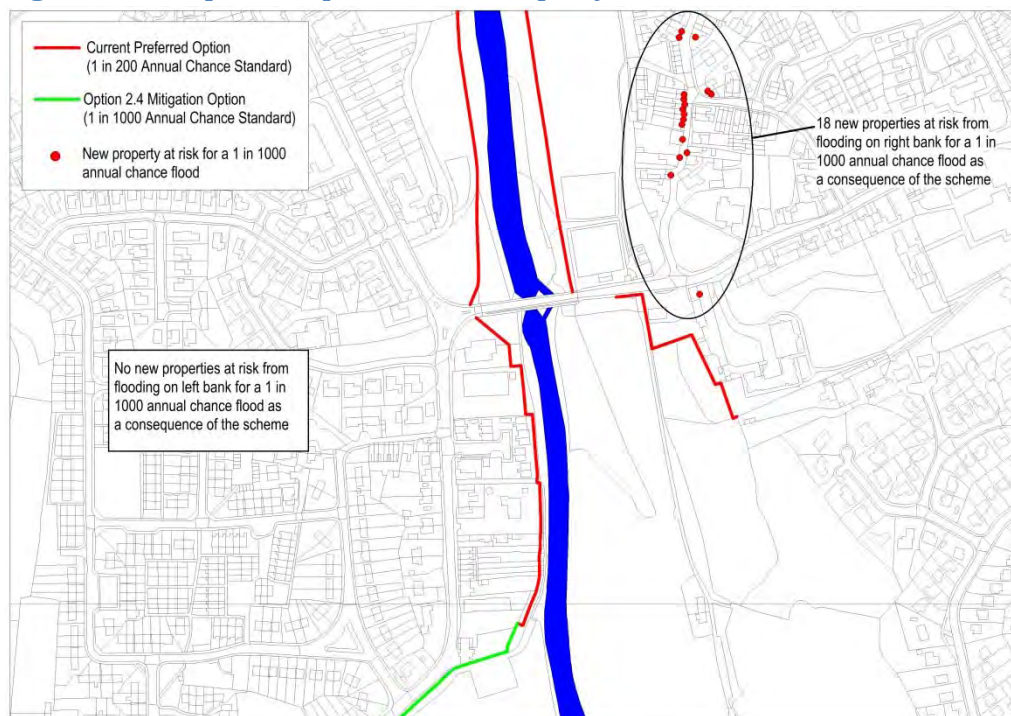
Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard of protection to St Asaph; Spring Gardens Bridge replaced and raised;
Detriment Mitigation:	The section of defence from Lower Denbigh Road to the New Inn is raised to provide a 1 in 1000 annual chance standard to encourage overtopping of the defences downstream, which more closely matches the existing situation; refer to Figure 2.3

Figure 2.3 – Option 2.4 New Inn Defence*Results & Discussion*

Raising the defence from Lower Denbigh Road to the New Inn significantly reduces the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme.

Figure 2.4 shows, **no new** properties at risk from flooding on the left bank of the Elwy for the 1 in 1000 annual chance flood. There are **17 new properties** at risk from flooding during the 1 in 1000 annual chance flood, all of which are located on the right bank of the Elwy. This is however **27 fewer** than for the preferred option without mitigation.

Figure 2.4 – Impact of Option 2.4 on Property Detriment



It should be noted that providing a 1 in 1000 annual chance defence for Lower Denbigh Road and the New Inn will be challenging to deliver. In particular, works are likely to be required to reinforce the wall of the New Inn pub so it is stable against a 1m head of flood water. For the current option, the wall is only required to retain a maximum 0.4m head of water

Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:	17 – 27 less than the current preferred option
Impact on scheme economics	This would increase scheme delivery costs but would not significantly increase scheme benefits.
Recommended Option:	Possible – the option does deliver a significant reduction in the number of new properties at risk from flooding. The following risks would need to be addressed however: <ul style="list-style-type: none"> - Technical challenges of providing a 1m high defence past the New Inn; - Impacts on economic assessment of the preferred option

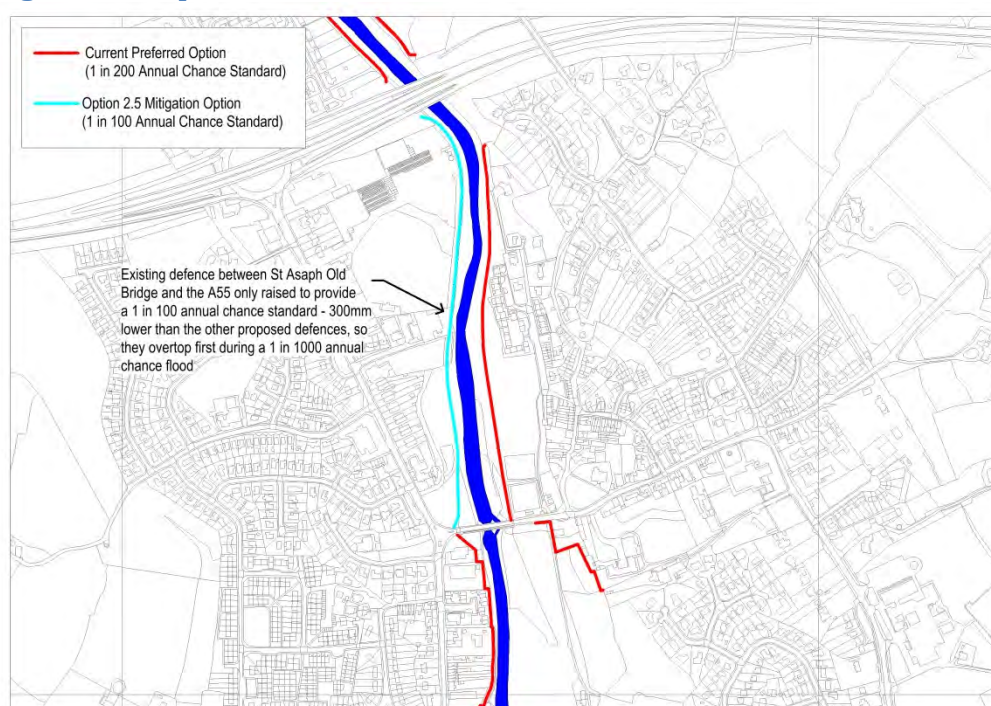
2.6 Lower Left Bank Defence Options

Option 2.5 – Lower Left Bank Defence A

Option Description

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard except for the defence on the left bank from St Asaph Old Bridge to the A55, which is raised to provide a 1 in 100 annual chance standard. Spring Gardens Bridge replaced and raised;
Detriment Mitigation:	The section of defence on the left bank from St Asaph Old Bridge to the A55 is only raised to provide a 1 in 100 annual chance standard, which is 300mm lower than the rest of the proposed defences. This is to encourage overtopping of the defences which more closely matches the existing situation; refer to Figure 2.5.

Figure 2.5 – Option 2.5 Lower Left Bank Defence A



Results & Discussion

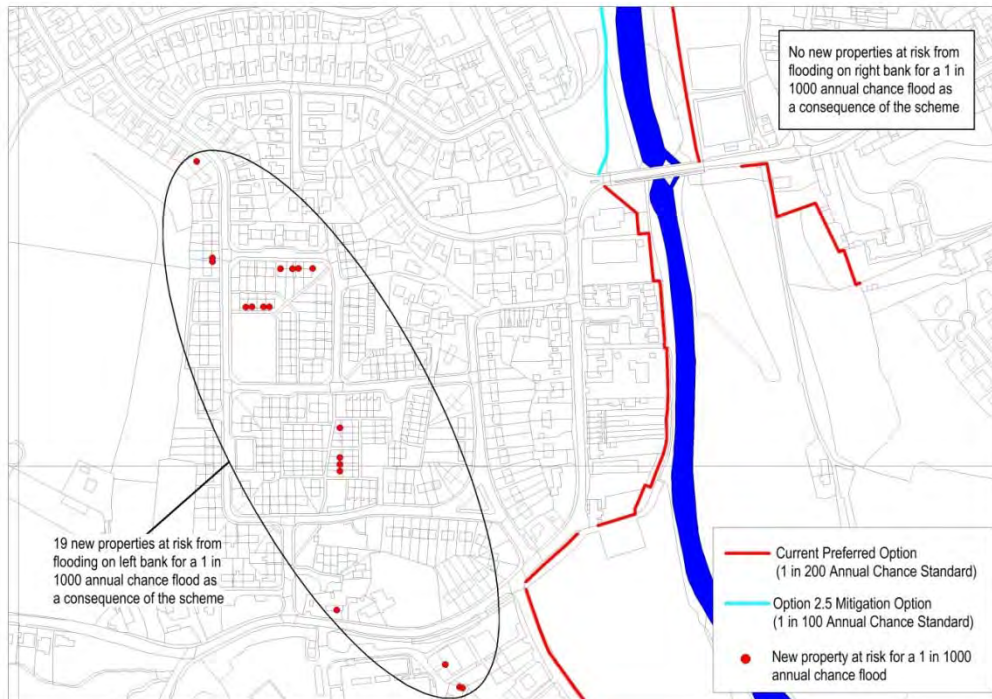
Lowering the proposed defences on the left bank between St Asaph Old Bridge and the A55 significantly reduces the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme. Figure 2.6 shows, **no new** properties at risk from flooding on the right bank of the Elwy for the 1 in 1000 annual chance flood. There are **19 new properties** at risk from flooding during the 1 in 1000 annual chance flood, all of which are located on the left bank of the Elwy. This is however **25 fewer** than for the preferred option without mitigation.

Lowering the defence reduces the standard of flood protection provided by the proposed works to all areas on the left bank downstream of St Asaph Old Bridge e.g. including Roe Park. The River Elwy ISIS/Tuflow model shows that the proposed defences might still contain a 1 in 200 annual chance flood with the lowered defence but there would be no freeboard allowance. It

would be incorrect to say that the lowered defences provides a 1 in 200 annual chance standard and good practice would dictate inclusion of freeboard in this figure.

There is also the possibility of objections from the local community as the proposals will provide a higher standard of protection to properties on the opposing bank.

Figure 2.6 – Impact of Option 2.5 on Property Detriment



Recommendation

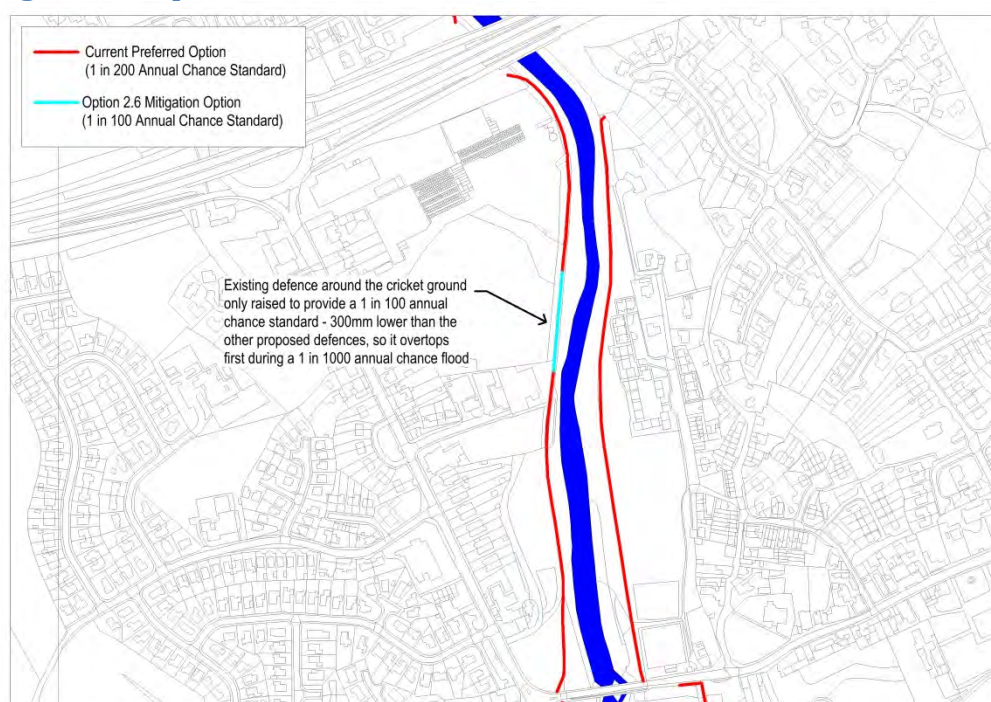
Number of new properties at risk for a 1 in 1000 annual chance flood:	19 – 25 less than the current preferred option
Impact on scheme economics	Providing a 1 in 100 annual chance scheme is a viable option for St Asaph and it is possible this option could be justified
Recommended Option:	No – different standards of protection on directly opposing banks of the river is not considered to be acceptable

Option 2.6 – Lower Left Bank Defence B

Option Description

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard except for the defence on the left bank around the cricket ground, which is raised to provide a 1 in 100 annual chance standard. Spring Gardens Bridge replaced and raised;
Detriment Mitigation:	The section of defence on the left bank around the cricket ground is only raised to provide a 1 in 100 annual chance standard, which is 300mm lower than the rest of the proposed defences. Overtopping of this section of the defence first would be preferable as there are no properties immediately adjacent to it.

Figure 2.7– Option 2.6 Lower Left Bank Defence B



Results & Discussion

Lowering the proposed defences on the left bank around the cricket ground has little impact on the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme. There are **40 new properties** at risk from flooding during the 1 in 1000 annual chance flood. This is only **4 less** than for the preferred option without mitigation.

As for option 2.5, lowering the defence reduces the standard of flood protection provided by the proposed works to all areas on the left bank downstream of cricket ground. The River Elwy ISIS/Tuflow model shows that the proposed defences might still contain a 1 in 200 annual chance flood with the lowered defence, but there would be no freeboard allowance. It would be incorrect to say that the lowered defences provides a 1 in 200 annual chance standard and good practice would dictate inclusion of freeboard in this figure.

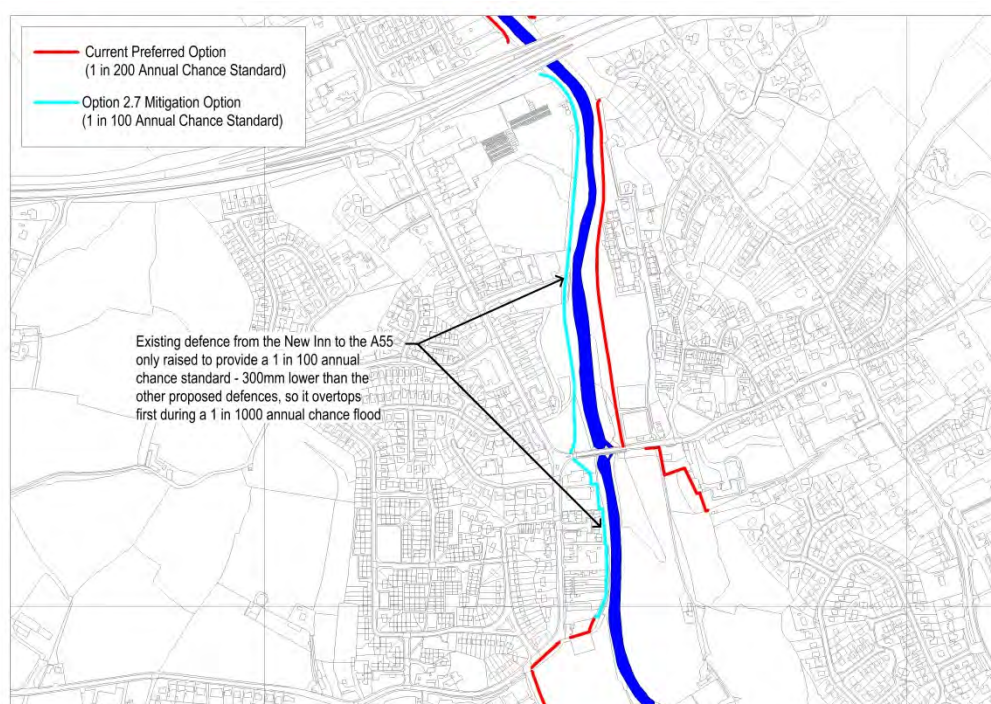
There would also be the possibility of objections from the local community as the proposals will provide a higher standard of protection to properties on the opposing bank of the river.

Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:	40 – 4 less than the current preferred option
Impact on scheme economics	Providing a 1 in 100 annual chance scheme is a viable option for St Asaph and could be justified
Recommended Option:	No – the option does not deliver a significant reduction in the number of new properties at risk from flooding as a consequence of the scheme.

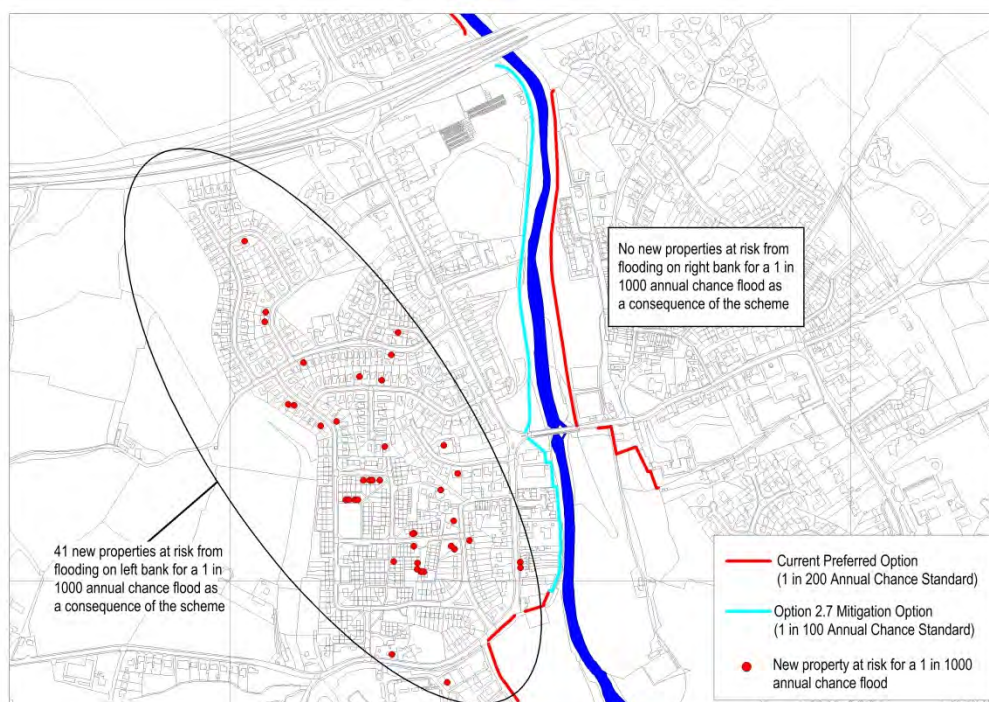
Option 2.7 – Lower Left Bank Defence C*Option Description*

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard except for the defence on the left bank from the New Inn to the A55, which is raised to provide a 1 in 100 annual chance standard. Spring Gardens Bridge replaced and raised;
Detriment Mitigation:	The section of defence on the left bank from the New Inn to the A55 is only raised to provide a 1 in 100 annual chance standard, which is 300mm lower than the rest of the proposed defences.

Figure 2.8– Option 2.7 Lower Left Bank Defence C*Results & Discussion*

Lowering the proposed defences on the left bank over this length leads to additional flooding on the left bank of the Elwy. There is therefore little impact on reducing the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme. There are **41 new properties** at risk from flooding during the 1 in 1000 annual chance flood, all of these are located on the left bank of the Elwy; refer to Figure 2.9. This is only **3 less** than for the preferred option without mitigation.

Figure 2.9 – Impact of Option 2.7 on Property Detriment



The results confirm that the impacts of the scheme on flood risk for a 1 in 1000 annual chance flood is very sensitive to the length over which a lower standard of protection is provided. It appears, it does not automatically follow that providing a longer length of 'lower' defence on one bank reduces the scheme detriment. Compared to option 2.5, which significantly lowered the number of new properties at risk for a 1 in 1000 annual chance flood compared to the preferred option, option 2.7 provides a longer length of lowered defence but has made flooding much worse on the left bank of the Elwy.

Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:	41 – 3 less than the current preferred option
Impact on scheme economics	Providing a 1 in 100 annual chance scheme is a viable option for St Asaph and could be justified
Recommended Option:	No – the option does not deliver a significant reduction in the number of new properties at risk from flooding and is likely to make flooding on the left bank worse.

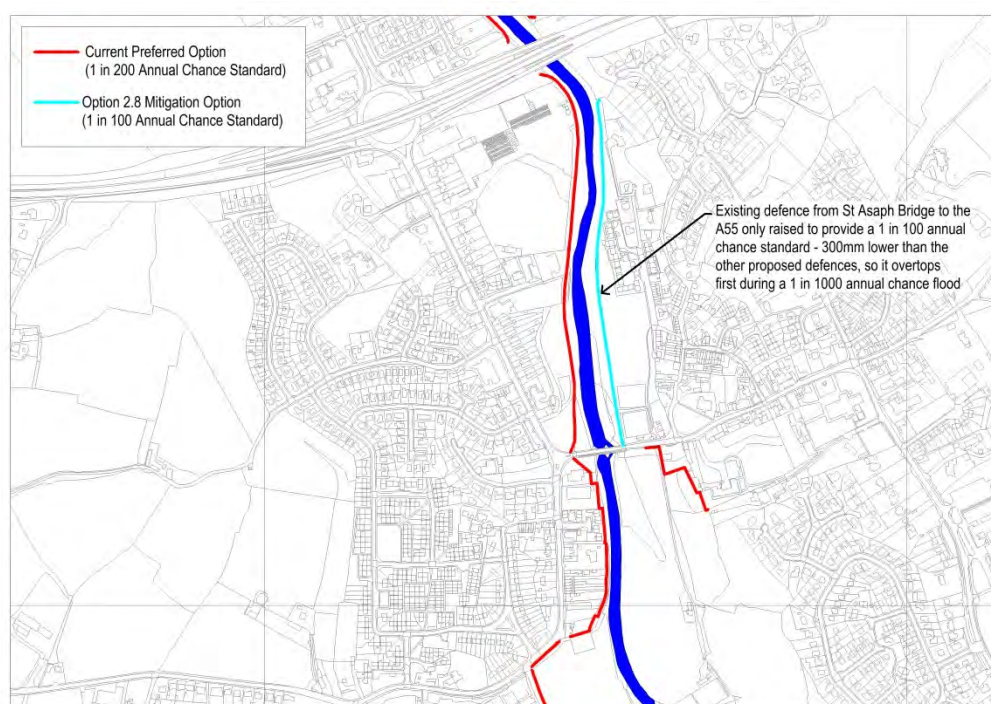
2.7 Lower Right Bank Defence Options

Option 2.8 – Lower Right Bank Defence A

Option Description

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard except for the defence on the right bank from St Asaph Old Bridge to the A55, which is raised to provide a 1 in 100 annual chance standard. Spring Gardens Bridge replaced and raised;
Detriment Mitigation:	The section of defence on the right bank from St Asaph Old Bridge to the A55 is only raised to provide a 1 in 100 annual chance standard, which is 300mm lower than the rest of the proposed defences. This is to encourage overtopping of the defences which more closely matches the existing situation and reduce flood depths on the landward side of the Mill Street defences; refer to Figure 2.10

Figure 2.10– Option 2.8 Lower Right Bank Defence A

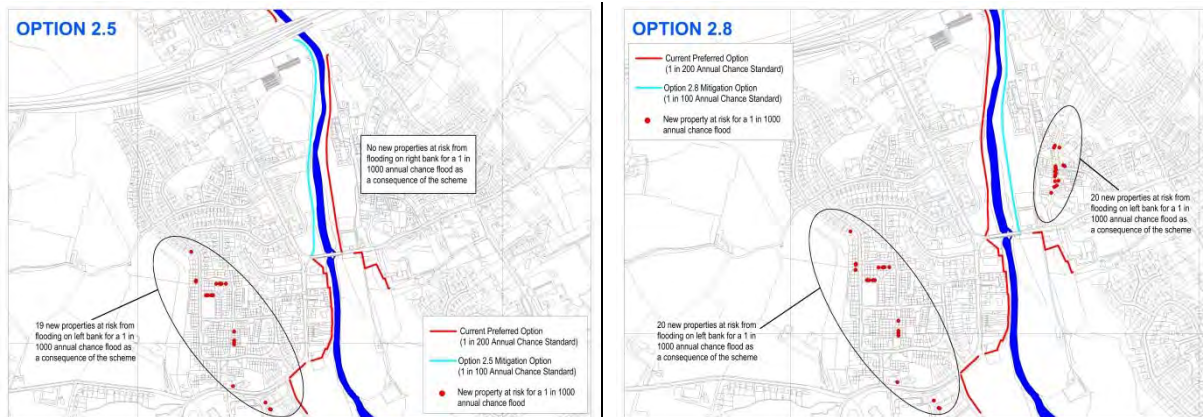


Results & Discussion

Lowering the proposed defences on the right bank from St Asaph Old Bridge to the A55 has little impact on the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme. There are **37 new properties** at risk from flooding during the 1 in 1000 annual chance flood, located on both banks of the Elwy. This is only **7 less** than for the preferred option without mitigation.

By contrast to option 2.5, Figure 2.11 also shows that lowering the defence on the right bank also does not remove new properties at risk from flooding on the left bank for the 1 in 1000 annual chance flood. This is attributed to additional flows spilling back over the defence and into the channel, reducing the overall benefit. For option 2.5, flows spilling over the lowered defence continue downstream on the floodplain under the A55 and into Roe Park.

Figure 2.11 – Comparison of Options 2.5 and 2.8 on Property Detriment



Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:	37 – 7 less than the current preferred option
Impact on scheme economics	Providing a 1 in 100 annual chance scheme is a viable option for St Asaph and could be justified
Recommended Option:	No – the option does not deliver a significant reduction in the number of new properties at risk from flooding.

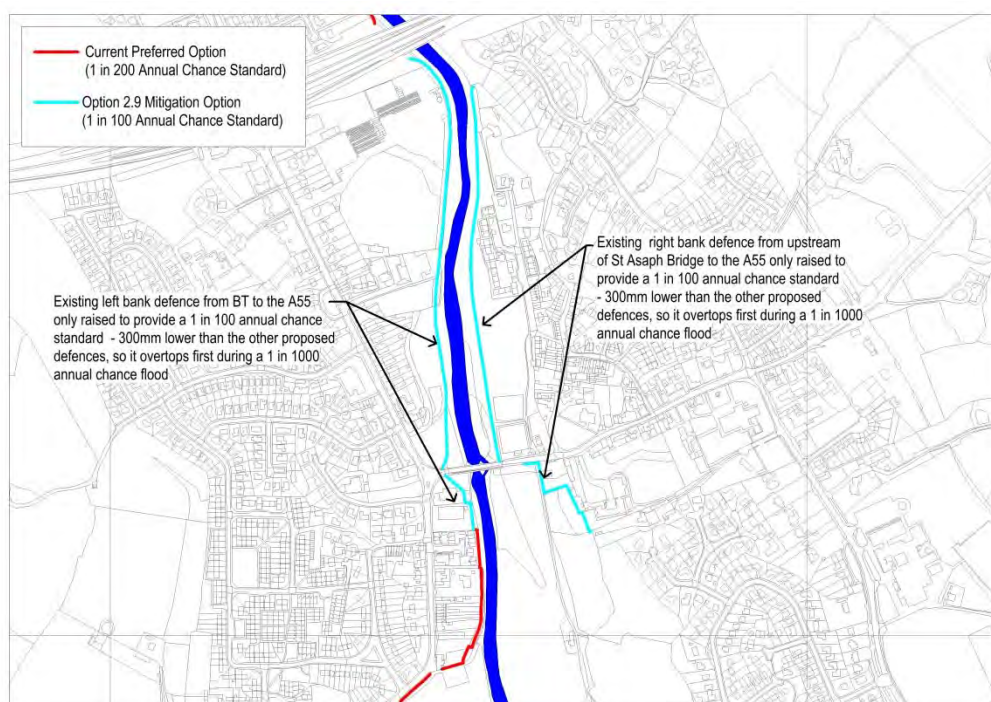
2.8 Lower Both Bank Defences Options

Option 2.9 – Lower Both Bank Defences A

Option Description

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard except for the defences on the: <ul style="list-style-type: none"> - Left bank from BT to the A55, which is raised to provide a 1 in 100 annual chance standard; and - Right bank from upstream of St Asaph Old Bridge to the A55, which is raised to provide a 1 in 100 annual chance standard. Spring Gardens Bridge replaced and raised;
Detriment Mitigation:	Existing defences on the left and right banks from BT to the A55 are only raised to provide a 1 in 100 annual chance standard, which is 300mm lower than the rest of the proposed defences. This is to encourage overtopping of the defences which more closely matches the existing situation; refer to Figure 2.12

Figure 2.12– Option 2.9 Lower Bank Defences A

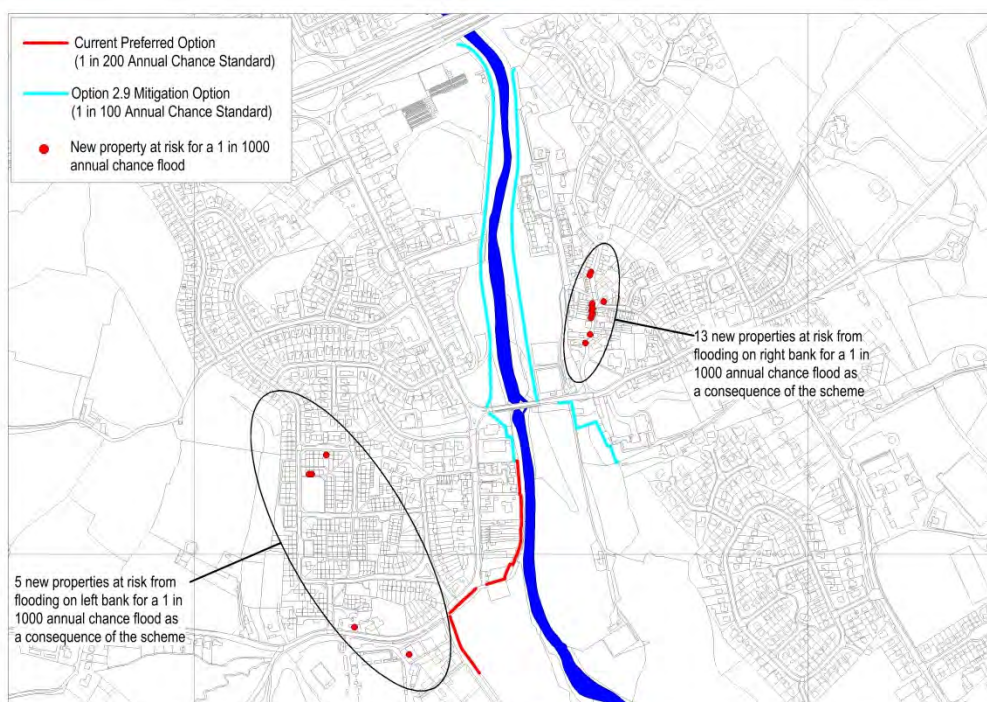


Results & Discussion

Lowering the proposed height of the defences on both banks from BT to the A55, has a significant impact on the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme. There are **18 new properties** at risk from flooding during the 1 in 1000 annual chance flood. This is **26 fewer** than for the preferred option without mitigation.

Figure 2.13 shows that the 18 new properties at risk from flooding for the 1 in 1000 annual chance flood are predominantly located on the right bank, just downstream of St Asaph Old Bridge.

Figure 2.13 – Impact of Option 2.9 on Property Detriment



Recommendation

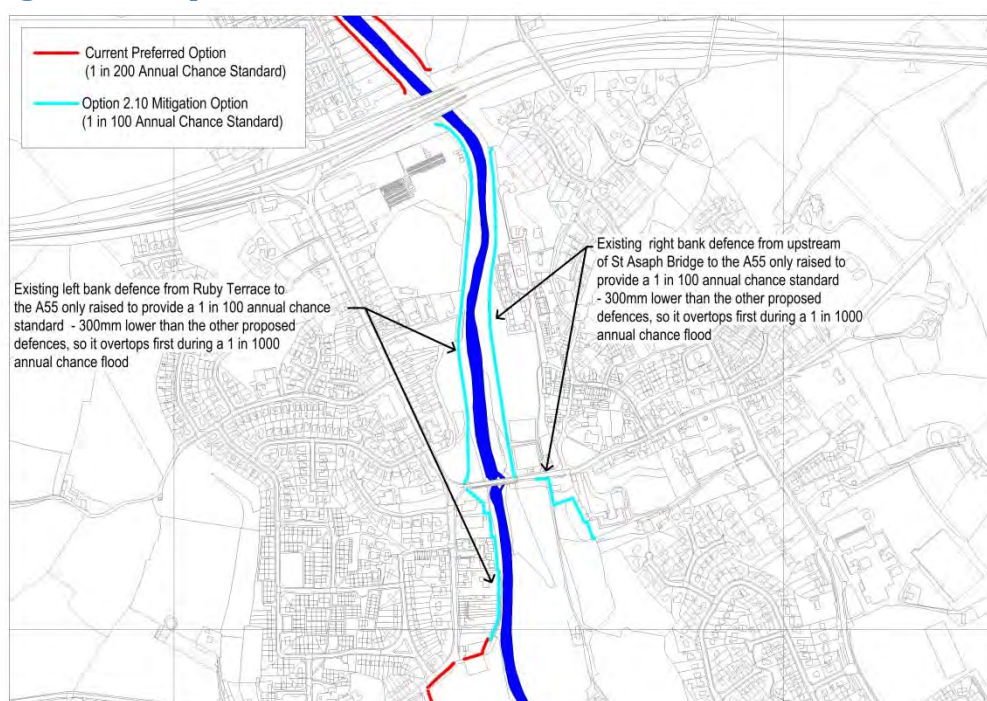
Number of new properties at risk for a 1 in 1000 annual chance flood:	18 – 26 less than the current preferred option
Impact on scheme economics	Providing a 1 in 100 annual chance scheme is a viable option for St Asaph and could be justified
Recommended Option:	No – option 2.10 is much more effective and will provide similar benefits for a much lower construction cost

Option 2.10 – Lower Both Bank Defences B

Option Description

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard except for the defences on the: <ul style="list-style-type: none"> - Left bank from Ruby Terrace to the A55, which is raised to provide a 1 in 100 annual chance standard; and - Right bank from upstream of St Asaph Old Bridge to the A55, which is raised to provide a 1 in 100 annual chance standard. Spring Gardens Bridge replaced and raised;
Detriment Mitigation:	Existing defences on the left and right banks from Ruby Terrace to the A55 are only raised to provide a 1 in 100 annual chance standard, which is 300mm lower than the rest of the proposed defences. This is to encourage overtopping of the defences which more closely matches the existing situation; refer to Figure 2.14

Figure 2.14– Option 2.10 Lower Bank Defences B

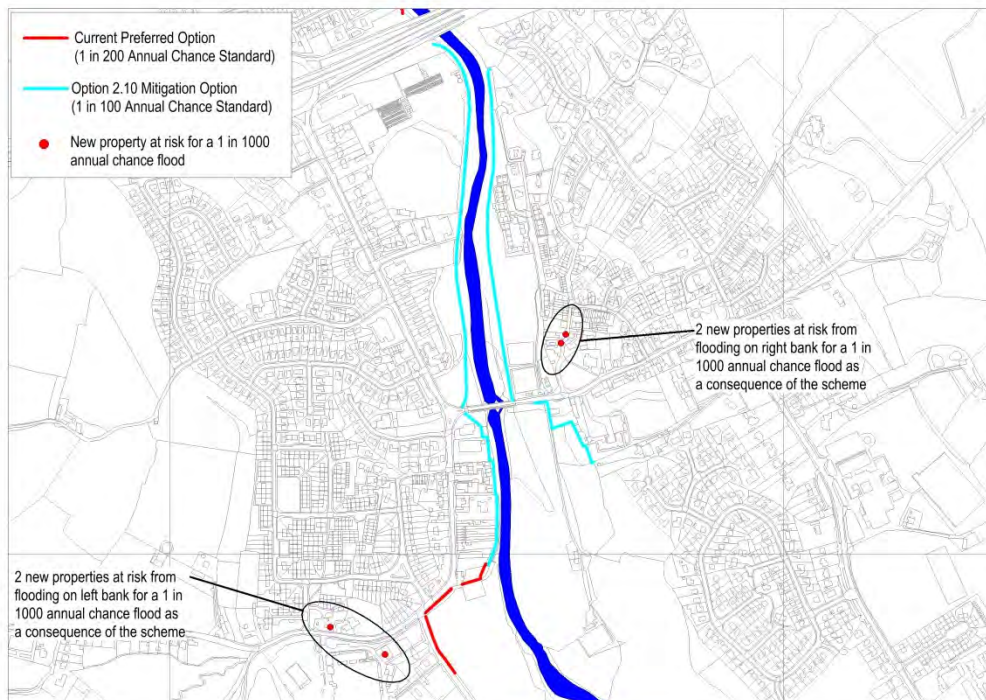


Results & Discussion

Lowering the proposed height of the defences on the left bank from Ruby Terrace to the A55, and on the right bank upstream of the A55, has a significant impact on the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme. There are **4 new properties** at risk from flooding during the 1 in 1000 annual chance flood. This is **40 fewer** than for the preferred option without mitigation.

Figure 2.13 shows that the 4 new properties at risk from flooding for the 1 in 1000 annual chance flood as a consequence of the scheme are predominantly located near the New Inn on the left bank and just downstream of St Asaph Old Bridge on the right bank..

Figure 2.13 – Impact of Option 2.9 on Property Detriment



Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:

4 – 40 less than the current preferred option

Impact on scheme economics

Providing a 1 in 100 annual chance scheme is a viable option for St Asaph and could be justified

Recommended Option:

Possible – the option does deliver a significant reduction in the number of new properties at risk from flooding and is likely to be economically acceptable. The same standard of flood protection is also maintained on opposing banks of the river.

2.9 Hybrid Options

Option 2.11 – Hybrid Option A

Option Description

Proposed Scheme:

Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard of protection to St Asaph; Spring Gardens Bridge replaced and raised; No new defence on right bank upstream of St Asaph Old Bridge, increasing the risk of flooding to the 'Fountain Car Sales' garage for a 1 in 200 annual chance event (Figure 2.2).

Detriment Mitigation:

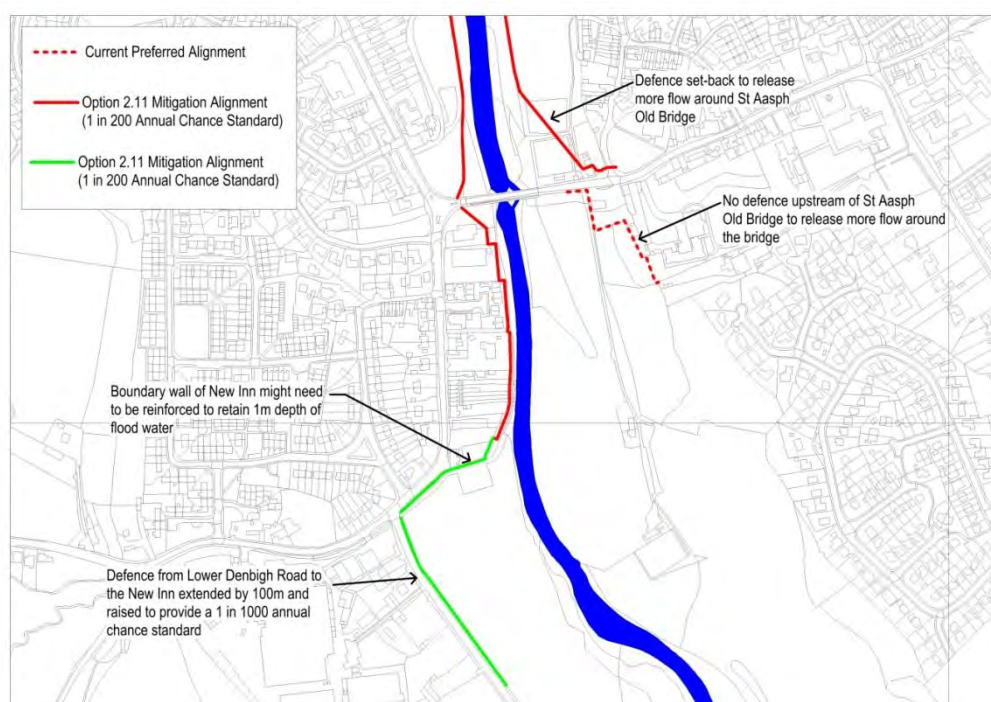
Combination of Options 2.2 and 2.4.

Defence tie-ins to St Asaph Old Bridge are set-back as follows to increase the rate of flows bypassing the bridge for a 1 in 1000 annual chance event:

- Up to 6m on the left bank
- Across the bowling green and play area on the right bank with both these facilities relocated;
- No new defence upstream on the right bank upstream of St Asaph Old Bridge

The section of defence from Lower Denbigh Road to the New Inn is raised to provide a 1 in 1000 annual chance standard to encourage overtopping of the defences downstream, which more closely matches the existing situation; refer to Figure 2.15

Figure 2.15– Option 2.11 Hybrid Option A



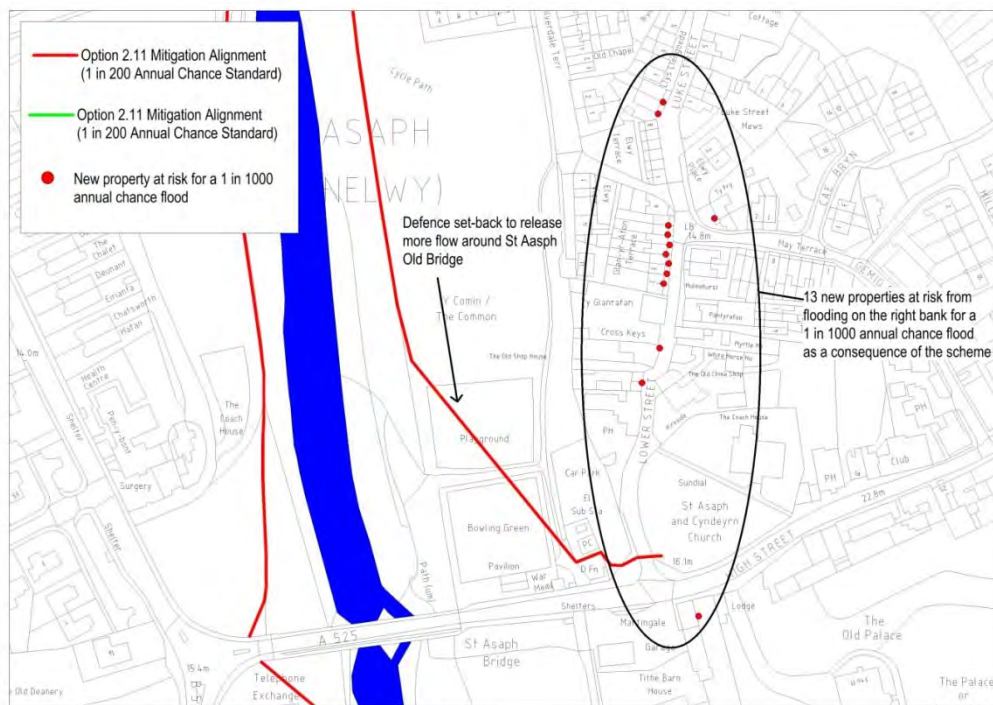
Results & Discussion

Raising the defence from Lower Denbigh Road to the New Inn and setting back the defences at St Asaph Old Bridge, significantly reduces the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme. There are **13 new properties** at risk from

flooding during the 1 in 1000 annual chance flood. This is **31 fewer** than for the preferred option without mitigation.

Figure 2.16 shows that the 13 new properties at risk from flooding for the 1 in 1000 annual chance flood as a consequence of the scheme are located on the right bank, with all but one downstream of St Asaph Old Bridge..

Figure 2.16 – Impact of Option 2.11 on Property Detriment

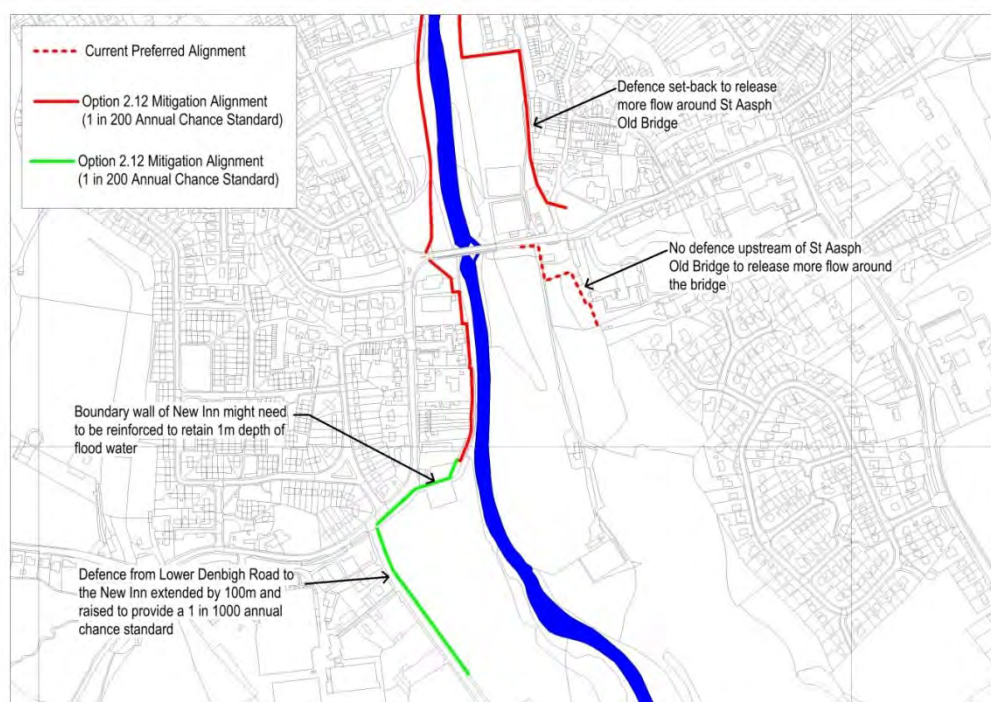


Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:	13 – 31 less than the current preferred option
Impact on scheme economics	This would increase scheme delivery costs but would not significantly increase scheme benefits.
Recommended Option:	Possible – the option does deliver a significant reduction in the number of new properties at risk from flooding. Omitting the defence on the right bank upstream of St Asaph Old Bridge may also offset additional costs from having to move the bowling green.

Option 2.12 – Hybrid Option B*Option Description*

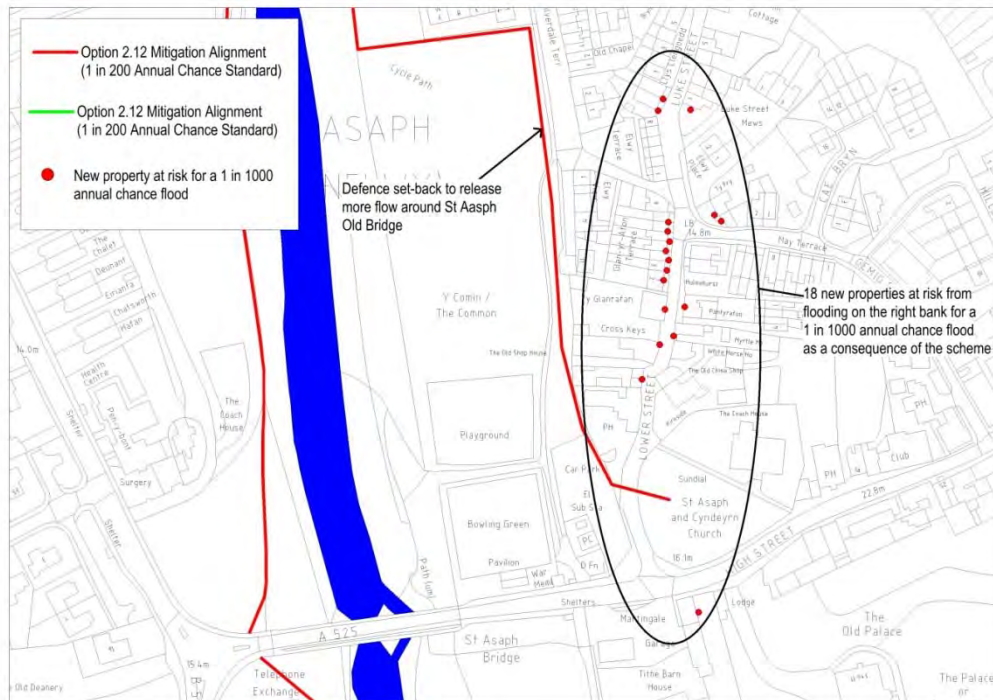
Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard of protection to St Asaph; Spring Gardens Bridge replaced and raised; No new defence on right bank upstream of St Asaph Old Bridge, increasing the risk of flooding to the 'Fountain Car Sales' garage for a 1 in 200 annual chance event (Figure 2.2).
Detriment Mitigation:	Variation of Option 2.11. Defence tie-ins to St Asaph Old Bridge are set-back as follows to increase the rate of flows bypassing the bridge for a 1 in 1000 annual chance event: <ul style="list-style-type: none"> - Up to 6m on the left bank - Along the boundary of the common (recreation ground) on the right bank; - No new defence upstream on the right bank upstream of St Asaph Old Bridge The section of defence from Lower Denbigh Road to the New Inn is raised to provide a 1 in 1000 annual chance standard to encourage overtopping of the defences downstream, which more closely matches the existing situation; refer to Figure 2.17

Figure 2.17– Option 2.12 Hybrid Option B*Results & Discussion*

Raising the defence from Lower Denbigh Road to the New Inn and setting back the defences along the boundary of the common (Recreation Ground), reduces the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme. There are **18 new properties** at risk from flooding during the 1 in 1000 annual chance flood. This is **26 fewer** than for the preferred option without mitigation.

Figure 2.18 shows that the 18 new properties at risk from flooding for the 1 in 1000 annual chance flood as a consequence of the scheme are located on the right bank, with all but one downstream of St Asaph Old Bridge. It is noticeable this is a higher number of properties than for Option 2.11. This is likely to be because setting-back the defence closer to the properties, reduces the floodplain volume on the landward side of the defences. When the set-back defences are overtopped, this reduced volume fills, raising the flood depth on the landward side of the defence.

Figure 2.18 – Impact of Option 2.12 on Property Detriment



Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:

18 – 26 less than the current preferred option

Impact on scheme economics

This would increase scheme delivery costs but would not significantly increase scheme benefits.

Recommended Option:

No – a smaller set-back as option 2.11 is more effective and would be much cheaper to construct

Option 2.13 – Hybrid Option C

Option Description

Proposed Scheme:

Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard of protection to St Asaph; Spring Gardens Bridge replaced and raised; No new defence on right bank upstream of St Asaph Old Bridge, increasing the risk of flooding to the ‘Fountain Car Sales’ garage for a 1 in 200 annual chance event (Figure 2.2).

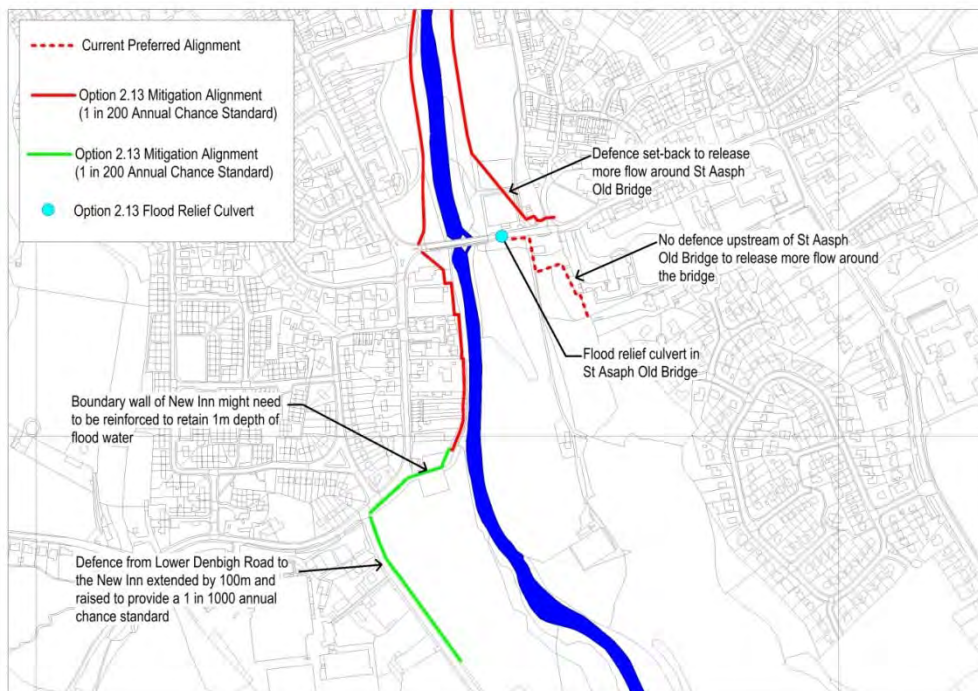
Detriment Mitigation:

Variation of Option 2.11.
 Defence tie-ins to St Asaph Old Bridge are set-back as follows to increase the rate of flows bypassing the bridge for a 1 in 1000 annual chance event:

- Up to 6m on the left bank
- Across the bowling green on the right bank;
- No new defence upstream on the right bank upstream of St Asaph Old Bridge
- New flood relief culvert in the right bank abutment of St Asaph Old Bridge measuring 6m (wide) by 1.6m (high) based on the size of the existing flood relief arches

The section of defence from Lower Denbigh Road to the New Inn is raised to provide a 1 in 1000 annual chance standard to encourage overtopping of the defences downstream, which more closely matches the existing situation; refer to Figure 2.19

Figure 2.19– Option 2.12 Hybrid Option C



Results & Discussion

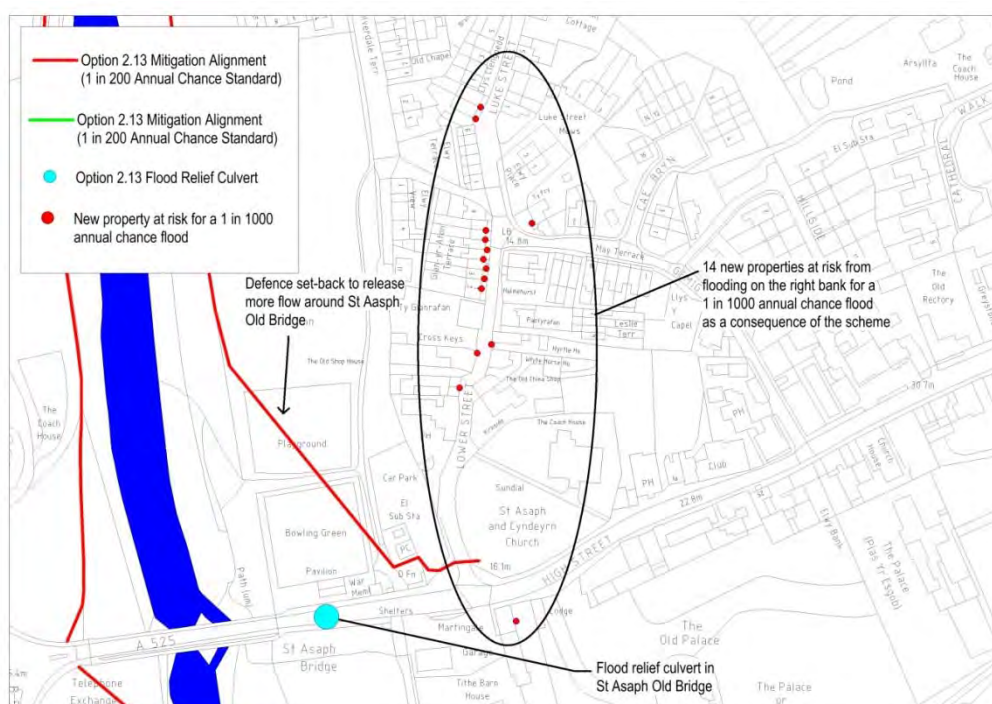
Raising the defence from Lower Denbigh Road to the New Inn, setting back the defences across the bowling green and providing a new flood relief culvert through St Asaph Old Bridge, reduces the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of

the scheme. There are **14 new properties** at risk from flooding during the 1 in 1000 annual chance flood. This is **30 fewer** than for the preferred option without mitigation.

Figure 2.20 shows that the 14 new properties at risk from flooding for the 1 in 1000 annual chance flood as a consequence of the scheme are located on the right bank, with all but one downstream of St Asaph Old Bridge.

It is apparent releasing more water around St Asaph Old Bridge with a flood relief culvert does not deliver a further reduction in the number of properties at detriment compared to Option 2.11. This is because the flood relief culvert is submerged during a 1 in 1000 annual chance flood so is hydraulically less effective.

Figure 2.20 – Impact of Option 2.13 on Property Detriment



Recommendation

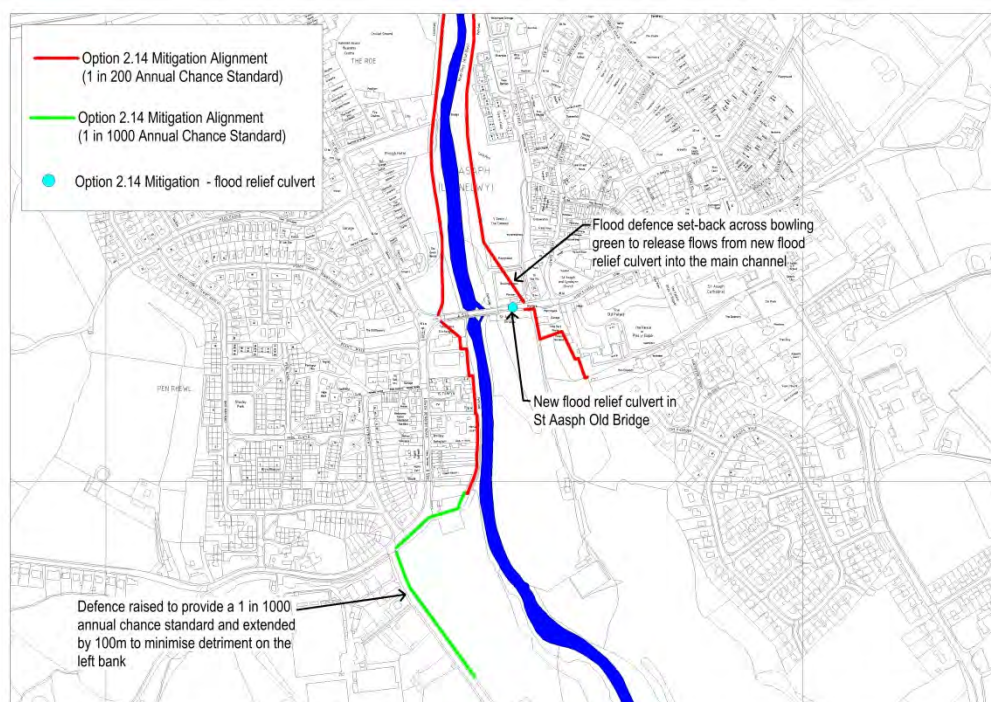
Number of new properties at risk for a 1 in 1000 annual chance flood:	14 – 30 less than the current preferred option
Impact on scheme economics	This would increase scheme delivery costs but would not significantly increase scheme benefits.
Recommended Option:	No – providing the flood relief culvert does not deliver any additional benefit compared to option 2.11 and would be very expensive to construct.

Option 2.14 – Hybrid Option D

Option Description

Proposed Scheme:	Existing defences are raised and new defences built to provide a 1 in 200 annual chance standard of protection to St Asaph; Spring Gardens Bridge replaced and raised; Flood relief culvert through St Asaph Old Bridge
Detriment Mitigation:	Variation of Option 2.4. A new flood relief culvert in the right bank abutment of St Asaph Old Bridge measuring 6m (wide) by 1.6m (high) based on the size of the existing flood relief arches, to release more flow around the bridge without flooding the Fountains Garage. The section of defence from Lower Denbigh Road to the New Inn is raised to provide a 1 in 1000 annual chance standard to encourage overtopping of the defences downstream, which more closely matches the existing situation; refer to Figure 2.21

Figure 2.21– Option 2.14 Hybrid Option D



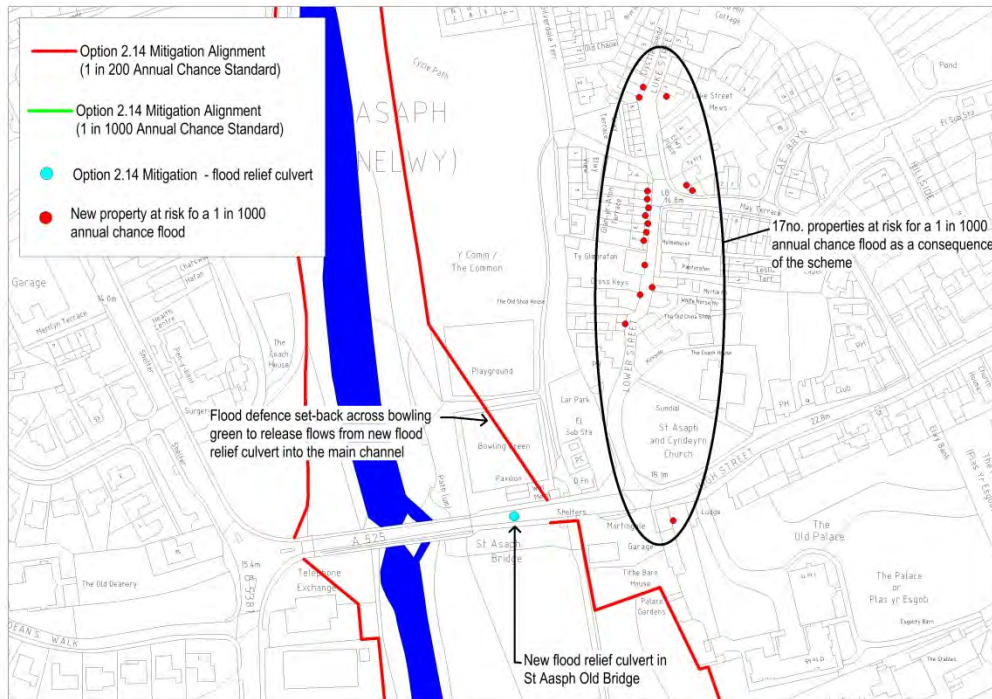
Results & Discussion

Raising the defence from Lower Denbigh Road to the New Inn and providing a new flood relief culvert through St Asaph Old Bridge, reduces the number of new properties at risk for the 1 in 1000 annual chance flood as a consequence of the scheme. There are **17 new properties** at risk from flooding during the 1 in 1000 annual chance flood. This is **27 fewer** than for the preferred option without mitigation.

Figure 2.22 shows that the 17 new properties at risk from flooding for the 1 in 1000 annual chance flood as a consequence of the scheme are located on the right bank, with all but one located downstream of St Asaph Old Bridge.

It is apparent releasing more water around St Asaph Old Bridge with a flood relief culvert does not deliver a further reduction in the number of properties at detriment compared to Option 2.4. This is because the flood relief culvert is submerged during a 1 in 1000 annual chance flood so is hydraulically less effective.

Figure 2.22 – Impact of Option 2.14 on Property Detriment



Recommendation

Number of new properties at risk for a 1 in 1000 annual chance flood:	17 – 27 less than the current preferred option
Impact on scheme economics	This would increase scheme delivery costs but would not significantly increase scheme benefits.
Recommended Option:	No – providing the flood relief culvert does not deliver any additional benefit compared to option 2.4 and would be very expensive to construct.

3. Discussion

The results of the detriment mitigation options are presented in Appendix B and summarised in Table 3.1 below. The options are grouped by reference to the effect they have on reducing the number of new properties at risk from flooding for a 1 in 1000 annual chance flood as a consequence of the scheme.

Table 3.1 – Options Summary

Option Group	Options	No of New Properties at risk for 1 in 1000 Flood	Change in no. of New Properties from preferred option
Very Significant Effect	2.10 – Lower Both Banks B	4	-40
Significant Effect	2.11 – Hybrid Option A 2.13 – Hybrid Option C	13 to 14	-30 to -31
Moderate Effect	2.4 – New Inn Defence 2.5 – Lower Left Bank A 2.9 – Lower Both Banks A 2.12 – Hybrid Option B 2.14 – Hybrid Option D	18 to 19	-25 to -26
Limited Effect	2.2 – St Asaph Bridge B 2.3 – Channel Roughness Sensitivity 2.6 – Lower Left Bank B 2.7 – Lower Left Bank C 2.8 – Lower Right Bank A	34 to 41	-3 to -10
No Effect	2.1 – St Asaph Bridge A	44	0

Eight of the 14no. options assessed are deemed to have a moderate or greater effect in reducing the number of new properties at risk from flooding for a 1 in 1000 annual chance scheme. It is suggested that all the options shown to have a '**limited effect**' can be discounted as they offer only a marginal improvement on the current preferred option and in a number of cases, will be much more expensive to construct. Option 2.1 is retained as it provides an enhancement to St Asaph Old Bridge by setting-back of the defences at no additional construction cost. The options shown to have a **moderate effect** or greater, are discussed further in the paragraphs below.

3.1 Options Discounted

The paragraphs below outline the options which it is advised can also be discounted.

Option 2.9 and 2.10 - Lower Both Banks A and B

Option 2.10 is not recommended for further consideration, whilst it only results in 4no. new properties at risk for a 1 in 1000 annual chance flood, it only provides a present day 1 in 100 annual chance standard of flood protection to St Asaph. By 2025, the standard of protection provided would be less than a 1 in 75 annual chance due to climate change. Previous analysis has shown that the preferred economic option is to provide a present day 1 in 200 annual chance standard of flood protection to St Asaph.

Option 2.9 is therefore also discounted as it does not meet the target standard of flood protection.

Options 2.12, 2.13 and 2.14 – Hybrid Options B, C & D

These options are discounted as they do not deliver a further reduction in the number of new properties at risk for a 1 in 1000 annual chance flood compared to Option 2.11 and would also be more expensive to construct.

Option 2.5 – Lower Left Bank A

This option is discounted. Providing a different standard of flood protection on opposing banks of the river might be objected to by the local community. It also only provides a 1 in 100 annual chance standard of flood protection, which is below the economically preferred standard to much of the city.

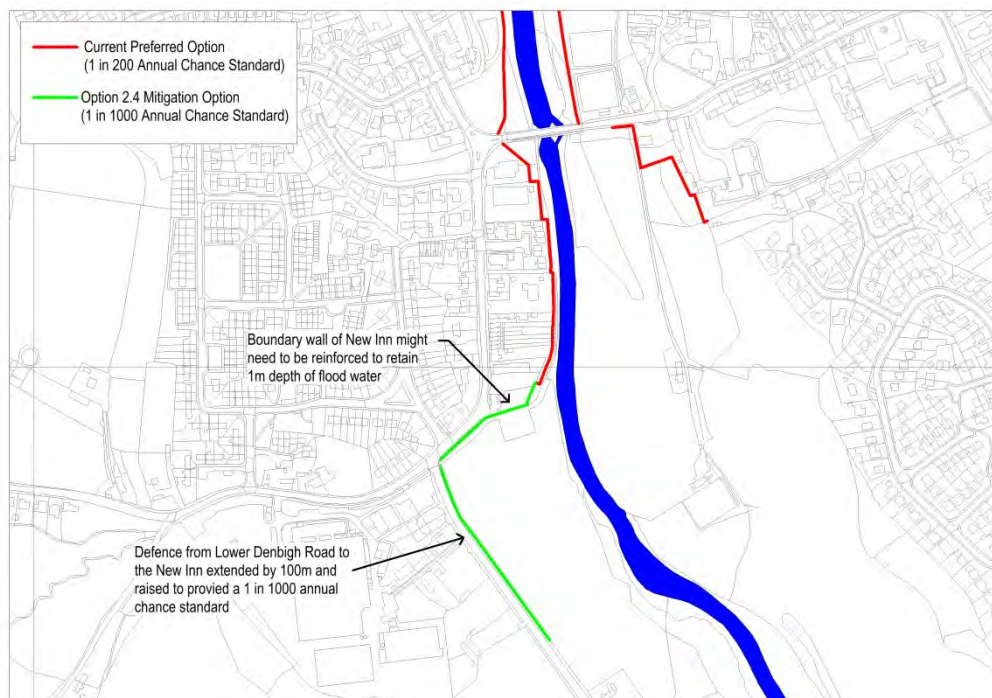
3.2 Options for Further Consideration

The paragraphs below outline the options which are recommended for further consideration. For completeness, Figures 3.1 and 3.2 show details of each option.

Option 2.4 – New Inn Defence

This option is recommended for further assessment as it delivers the fourth smallest number of new properties at risk for a 1 in 1000 annual chance flood as a consequence of the scheme. It also raises **all existing** defences to provide at least a present day 1 in 200 annual chance standard of flood protection. It also provides a new defence that protects the ‘Fountains Garage’ from a 1 in 200 annual chance flood.

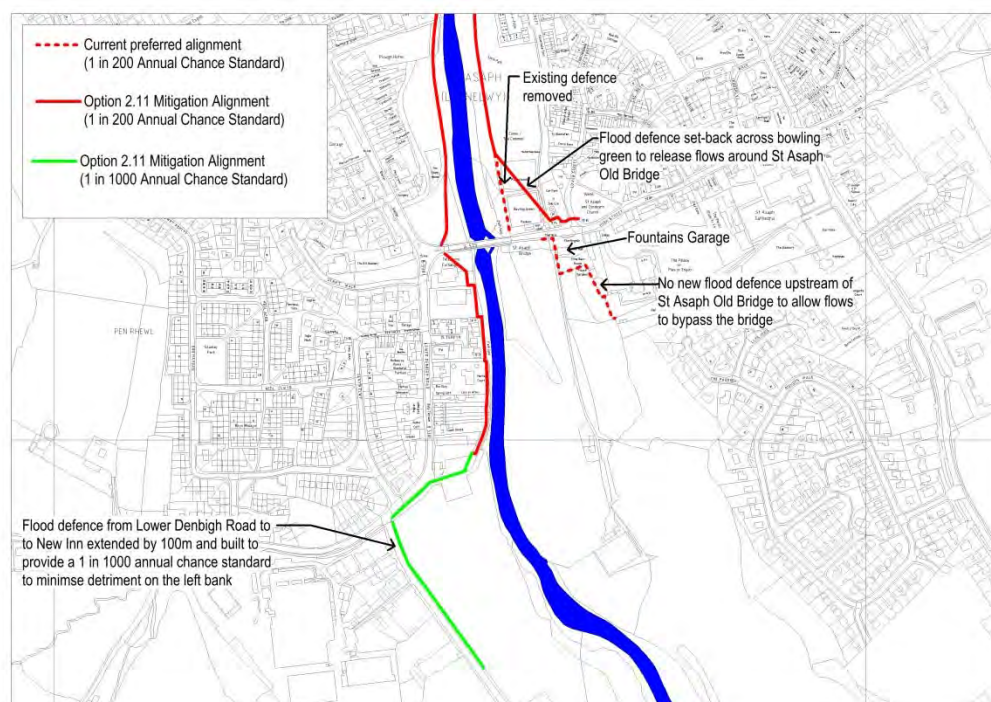
Figure 3.1 – Option 2.4 New Inn Defence



Option 2.11 – Hybrid Option A

This option is recommended for further assessment as it delivers the second smallest number of new properties at risk for a 1 in 1000 annual chance flood as a consequence of the scheme. It also raises **all existing** defences to provide a present day 1 in 200 annual chance standard of flood protection. It does however protect the 'Fountains Garage', which would be subject to an increased risk of flooding for a 1 in 200 annual chance flood and might need to be relocated.

Figure 3.2 – Option 2.11 Hybrid Option A



3.3 Other Return Periods

Options 2.4 and 2.11 have been assessed against other return periods to see if there would be any further properties at detriment as a consequence of the scheme. Whilst a property may not be at detriment for the 1 in 1000 annual chance flood, it is possible it could be for a 'less extreme' flood. The results of this assessment are presented in Table 3.2.

Table 3.2 – Options Summary: Other Return Periods

Option	No of New Properties at Risk by Flood Event		
	1 in 200	1 in 500	1 in 1000
2.100.RSA (current preferred option)	0	14	44
2.4 – New Inn Defence	0	3	17
2.11 – Hybrid A ^{Note 1}	1	5	13

1. The bowling green is excluded from these figures as it would be relocated as part of this option

Option 2.11 results in 1no. property at risk for the 1 in 200 annual chance flood. This is the Fountains Garage which is located riverward of the proposed flood defences. It is possible this business could be relocated as part of the works. Option 2.11 also results in 5 new properties at risk for the 1 in 500 annual chance event, this also includes the Fountains Garage.

Option 2.4 does not result in any new properties at risk for the 1 in 200 annual chance flood. It results in 3 new properties at risk for the 1 in 500 annual chance flood, including the Fountains Garage and Bowling Pavilion. There are however more new properties at risk for the 1 in 1000 annual chance flood for Option 2.4, which is attributed to flows overtopping the new defence required for this option upstream of St Asaph Old Bridge.

To judge the respective impact of each option on property detriment, a scoring system is proposed which weights the new properties at risk by flood frequency. It is applied as follows:

1 in 200 annual chance flood detriment score = no. of properties x **0.5**

1 in 500 annual chance flood detriment score = no. of properties x **0.2**

1 in 1000 annual chance flood detriment score = no. of properties x **0.1**

The results of this assessment are given in Table 3.3.

Table 3.3 – Options Summary Detriment Scores

Option	Flood Event Detriment Score			Total Detriment Score
	1 in 200	1 in 500	1 in 1000	
2.100.RSA (current preferred option)	0 (0)	2.8 (14)	4.4 (44)	7.2
2.4 – New Inn Defence	0 (0)	0.6 (3)	1.7 (17)	2.3
2.11 – Hybrid A	0.5 (1)	1 (5)	1.3 (13)	2.8
2.11 – Hybrid A (garage relocated)	0 (0)	0.8 (4)	1.3 (13)	2.1

Numbers of properties at detriment of each option are given in (red)

Option 2.4 gives the lowest overall detriment score of **2.3**. Option 2.11 gives a slightly higher detriment score of **2.8** due to a higher number of properties at risk for 1 in 200 and 1 in 500 annual chance floods. This could be reduced to a detriment score of **2.1** for option 2.11, if Fountains Garage is relocated to a location at a lower risk of flooding as part of the scheme. Both options give a lower detriment score than the current preferred option which is **7.2**. If providing the lowest overall impact of the numbers of new properties at risk from flooding, this assessment suggests that **Option 2.4 will be the preferred option**.

3.4 Cost Impacts

The Do Something options were costed previously to determine the preferred standard of protection using [the] *Flood Risk Management Estimating Guide – Update 2010* (Environment Agency). The two proposed options namely, options 2.4 and 2.11, have also been costed using this methodology and compared against the economically preferred option (2.100.RSA); refer to Table 3.4

Table 3.4 – Alternative Scheme Construction Costs

Construction Item	Cost (£k)			Difference vs 2.100.RSA	
	2.100.RSA	Option 2.4	Option 2.11	Option 2.4	Option 2.11
Defence Construction Costs	2,354	2,763	2,440	409	86
Spring Gardens Bridge	495	4,95	495	0	0
Other Fixed Items e.g. service diversions, outfalls, footpaths	428	4,28	428	0	0
Sub Total	3,276	3,685	3,362	409	86
Optimisation Bias Adjustment (60%)	1,966	2,211	2,017	245	51
Total Costs	5,243	5,896	5,379	653	136

Table 3.4 shows implementation of Option 2.4 will increase scheme construction costs by approximately £650k, including optimisation bias compared to the preferred option (2.100.RSA). This because extending and raising the defence along Lower Denbigh Road to the New Inn, significantly impacts the overall costs of the scheme. Importantly, an initial assessment of the benefits assessments for the scheme suggests this option still likely to be economically viable despite the additional cost.

Option 2.11 results in an increase in scheme construction costs of around £140k. This is a much smaller increase as there is a reasonable saving in costs from omitting the defence on the right bank upstream of St Asaph Old Bridge. It should noted however that this cost **does not** include any allowance for relocation of the bowling green and its pavilion or compensation for the Fountains Garage. A new bowling green was provided for the Nottingham Left Bank FAS (B&V were lead designers for the scheme) at a cost of £120k excluding any works to the pavilion. It is reasonable to assume therefore that Option 2.11, will increase scheme costs in the order of at least £350k when these additional works are included.

4. Conclusions

Fourteen options were assessed to minimise the impacts of the proposed flood defence scheme for St Asaph on property detriment from 'over-design' flood events within the city. Following discussions with Denbighshire County Council, the assessment focussed on minimising the numbers of new properties at risk from flooding as a consequence of the scheme.

Two options were found to be most effective in reducing the numbers of new properties at risk from flooding due to the St Asaph scheme, namely:

Option 2.4 – New Inn Defence

Option 2.11 – Hybrid Option A

Both options comprise providing a 1 in 1000 annual chance standard defence from Lower Denbigh Road to the New Inn, to cut-off the detriment flowpath on the left bank of the Elwy. The main difference between the two options is that Option 2.11 allows flows to bypass St Asaph Old Bridge on the right bank.

Option 2.11 gives a smaller number of new properties at risk for the 1 in 1000 annual chance flood of 13no. compared 17no. for Option 2.4. Option 2.11 does however give rise to a higher number of new properties at risk for the 'lesser' flood events, including the Fountains Garage which would be newly at risk for a 1 in 200 annual chance flood. A weighted detriment score was applied to both options based on property numbers and the frequency flooding, which suggested that option 2.4 gave the overall lowest impact on new properties at risk from flooding as a consequence of the scheme.

It is therefore suggested that Option 2.4 (Figures 4.1 to 4.3) be taken forward as the preferred option to reduce flood risk to St Asaph. This would be subject to:

- A check of potential costs to ensure economic viability;
- Further discussion with Denbighshire County Council and NRW stakeholders to ensure acceptance of this paper's methodology and initial conclusions

Figure 4.1 – Option 2.4 New Inn Defence

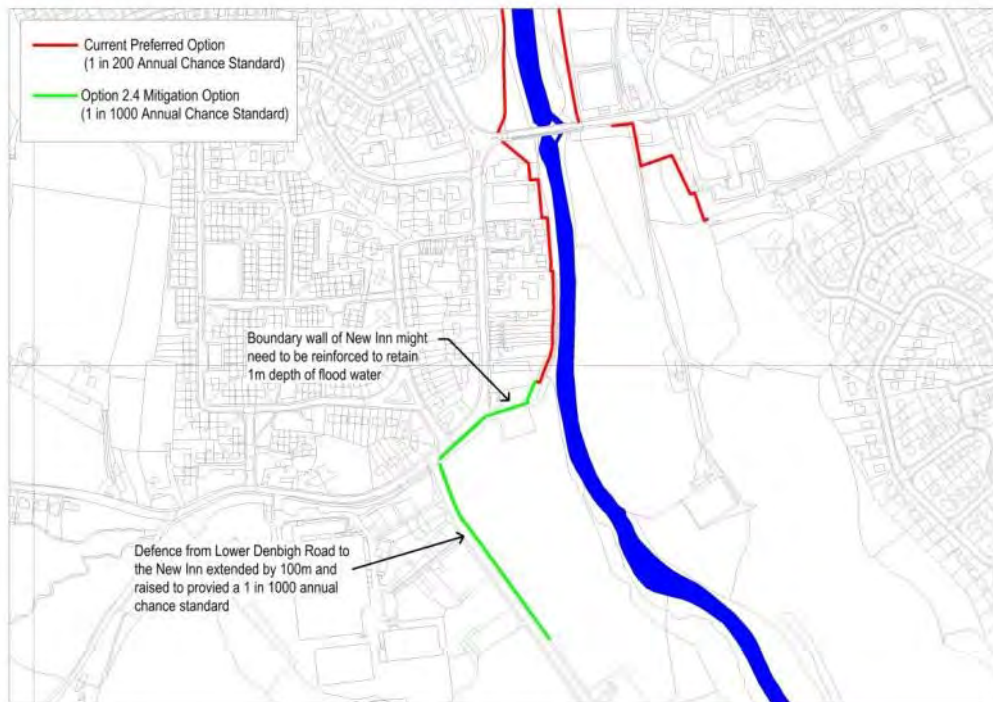


Figure 4.2 – Impact of Option 2.4 on Property Detriment for a 1 in 1000 Annual Chance Flood

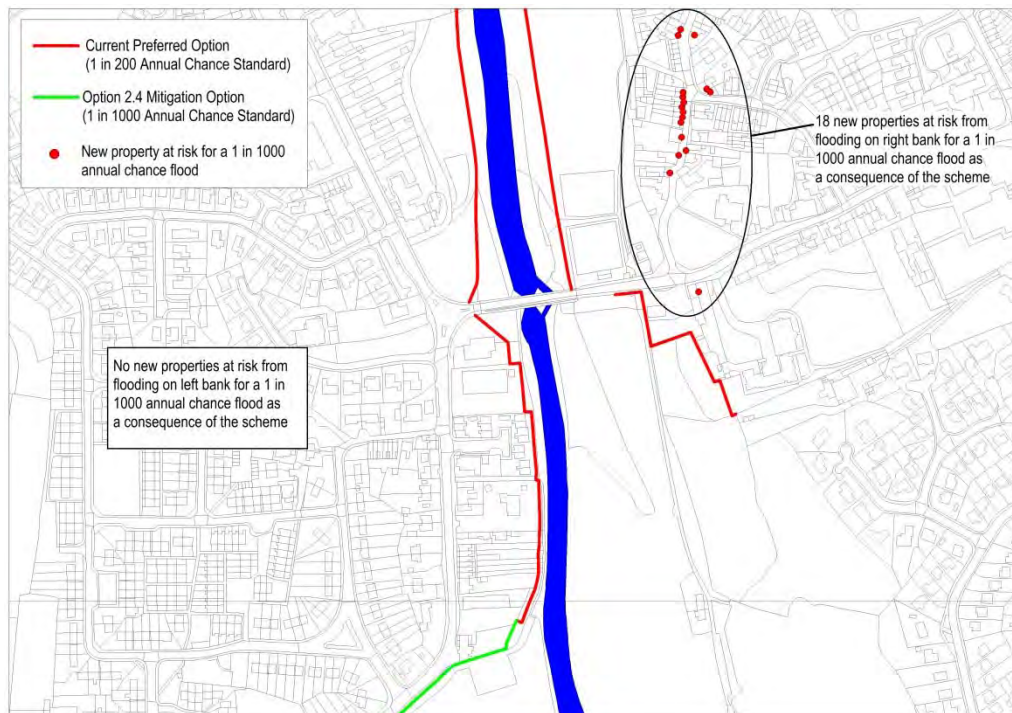
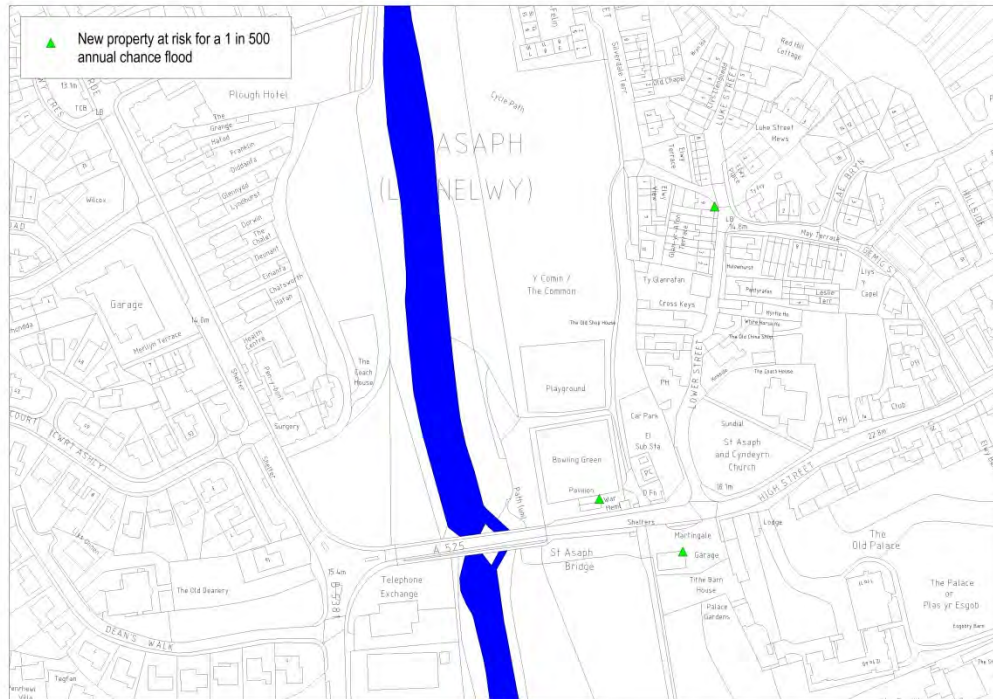


Figure 4.3 – Impact of Option 2.4 on Property Detriment for a 1 in 500 Annual Chance Flood



Note - no property detriment for option 2.4 for the 1 in 200 annual chance flood.

Appendix A – Denbighshire County Council Meeting Minutes

Title of Meeting: St Asaph FRMS – Detriment discussion

Date of Meeting: 25 March 2015 **Time:** 11:00 **Venue:** NRW Buckley

Present: Angela Ellis, Abby Downing (by phone), Andy Brown, Rob Green, Keith Ivens, Ryan Knowles, Emyr Gareth (NRW), Nick Stokes (GBV), Dave Roberts (Denbighshire CC).

Apologies: Richard Weston (NRW), Wayne Hope (DCC)


Item No:	Item	Action
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1. Meeting Objective

The St Asaph Flood Risk Management Scheme is currently in appraisal stage and the outline design involves raising existing defences and constructing new defences to provide a standard of protection against a 1 in 200 year event.

As a result of this design, detriment has been identified to 204 no. properties within the city during a 1 in 1000 year AEP event. 44 of these were not previously at risk of flooding. However, 290 properties are at betterment during a 1 in 1000 year AEP.

The aim of this meeting is to discuss the options to reduce the no. of properties at detriment and the approach to any remaining properties at risk.

Nick Stokes from GBV presented the scheme and the detriment issue (click [HERE](#):  for presentation), which was followed by a general discussion.

2. Discussion

- A change in onset of flooding in a 1 in 1000 year event would allow more time for warnings to the Mill St area.
- An outfall will be installed as part of the scheme at Mill St to allow the area to drain following overtopping.
- There is some detriment in the 1 in 200 year event, but to farmland, not property.
- Major question – is the increase of risk to properties in a 1 in 1000 year event acceptable to allow betterment to the greater community? From a planning perspective there will be great focus on any new properties which are being put at



risk, more so than those with an increased risk due to the likely number of objections that will be raised.

- St Asaph currently has a SoP around 1 in 75, which will go down to 1 in 30 by 2040 without raising the existing defences.
- The approach will be to provide simple information to the public and not to present options that have no realistic chance of happening. Will there be pre-planning application consultation?
- The St Asaph Flood Partnership Group & Local Flood Wardens may be a good platform for engagement and helping to disseminate information to the community.
- It only takes 4 objections to a planning application to bring it to the planning committee. Expectation from DCC was that there would be sufficient lobby objecting to the current detriment issues for the scheme to be taken to committee.
- Everything should be included in the planning application. We need to emphasize the overall reduction in risk, and be clear with the facts.
- Locals are very keen to see no detriment to Rhuddlan as a result of the St Asaph scheme.
- Any betterment to flood risk in the land identified in the Denbighshire Local Area for development could be presented as a positive impact of the scheme from a planning perspective.
- The greater risk to the 'triangle' of land at Rhuddlan is tidal. The scheme will only address fluvial flooding
- Betterment to potential development land close to Rhuddlan is not likely to be achieved by the St Asaph scheme; the Clwyd Strategy would be the mechanism to achieve this but this has not been signed off by Welsh Government and is extremely costly.
- We've focused solely on the internal flooding of properties, not flooding to gardens, external spaces, etc. For the planning application we should categorise any detriment as internal flooding, gardens & farmland.
- Regarding detriment to farmland, the main problem won't be an increase in flood depths but rather the length of time the land is inundated. The usability of the land won't change.
- Any discounted options should not be included. Focus should be on the proposed scheme.

- If this was a housing scheme with detriment, then the planning application would likely be rejected. There may be questions from the public as to why a FRM scheme should then approved – this could cause problems elsewhere?
- Has IPP been considered? This isn't a good solution, but if it aids in acceptance of the scheme and provides peace of mind to the affected residents then it could be worth exploring. This is only really going to be applicable if the number of properties at detriment can be reduced. Likely to need to be proper flood doors (i.e. replacing the front door of property) rather than a barrier. Passive design options would be the preferred option if taken forward.

3. The Way Forward

- | | |
|---|-------|
| <ul style="list-style-type: none"> • Further options are to be explored in order to reduce the number of properties at detriment, including options for flows to get around the historic bridge. This may alleviate upstream water levels flow routes. Focus should be on new properties at risk rather than those subject to a slight increase in flood depth | NS |
| <ul style="list-style-type: none"> • Consultation with affected properties will be required. • The PAR is not to be submitted before consultation is undertaken. | AD/AB |
| <ul style="list-style-type: none"> • Properties in St Asaph were made aware of their flood risk as part of the Flood Awareness Wales campaign in December 2010 – AD to contact Eirian Redmayne to find list of properties contacted and who is signed up to the Flood line Flood Warning service. | AD |
| <ul style="list-style-type: none"> • Check the outline map on EA website to confirm the information currently provided for the public about their flood risk. | AD |
-

Appendix B – Detriment Assessment Summary Results

Option Name & No.	Detriment Mitigation Description ²	Present Day Proposed Scheme Standard of Protection	No of New Properties at risk for 1 in 1000 Flood	Change in no. of New Properties from preferred option	Recommended Option
Economically Viable Options from Economics Benefit Report					
2.100.RSA ¹	None – preferred economic option	1 in 200 for all defences	44	-	Recommended as preferred economic option; possible need to discount due to detriment issues
2.100.FA ¹	None – economically viable option, not preferred due to lower standard of flood protection	1 in 100 for all defences	42	-2	No – not economically preferred & detriment issues
2.200.RSA ¹	None – high risk economically viable option, not preferred due to cost uncertainty arising from technical challenge to build such high defences	1 in 380 for all defences	38	-6	No – uncertainty in scheme costs & detriment issues
Detriment Mitigation Options (applied to current preferred option 2.100.RSA)					
2.1 – St Asaph Bridge A	Defence tie-ins on left bank to St Asaph Old Bridge set-back by 6m to increase the rate of flows bypassing the bridge	1 in 200 for all defences	44	0	Yes – negligible impact on detriment but enhancement for St Asaph Old Bridge used for all options
2.2 – St Asaph Bridge B	Defence tie-ins on left bank to St Asaph Old Bridge set-back by 6m; Defence tie-in on right bank set-back across play area, bowling green and Lower Street No new defence on right bank upstream of bridge	1 in 200 for all defences	36	-8	No – high risk and only delivers a slight improvement in property nos
2.3 – Channel Roughness sensitivity	Channel bank roughness lowered to 0.15 to reflect more intensive maintenance regime	1 in 200 for all defences	34	-10	No – negligible reduction in detriment properties and maintenance benefits cannot be guaranteed
2.4 – New Inn Defence	Defence from Lower Denbigh Road to the New Inn built to provide a 1 in 1000 annual chance standard	1 in 1000 for Lower Denbigh Road to New Inn 1 in 200 for all other defences	17	-27	Possible – need to ensure viability of providing such a high defence at the New Inn
2.5 – Lower Left Bank A	Left bank defence from St Asaph Old Bridge to A55 only raised to provide a 1 in 100 annual chance standard to encourage overtopping of the defences which more closely matches the existing situation	1 in 100 for all left bank properties downstream of the A55 i.e. including Roe Park 1 in 200 for all other areas.	19	-25	No – different standards of flood protection on opposing banks would not be acceptable
2.6 – Lower Left Bank B	Left bank defence around cricket pitch only raised to provide a 1 in 100 annual chance standard to encourage overtopping of the defences where there are no properties immediately adjacent to the defence	1 in 100 for all left bank properties downstream of the cricket ground 1 in 200 for all other areas.	40	-4	No – negligible reduction in detriment properties
2.7 – Lower Left Bank C	Left bank defence from Ruby Terrace to A55 only raised to provide a 1 in 100 annual chance standard to encourage overtopping of the defences which more closely matches the existing situation	1 in 100 for all left bank properties downstream of Ruby Terrace 1 in 200 for all other areas	41	-3	No – additional flooding on left bank as flows are preferentially diverted over lowered defence at Ruby Terrace
2.8 – Lower Right Bank A	Right bank defence from St Asaph Old Bridge to the A55 only raised to provide a 1 in 100 annual chance standard to encourage overtopping of the defences which more closely matches the existing situation and reduce flood depths on the landward side of the defences at Mill Street	1 in 100 for right bank properties from St Asaph Old Bridge to the A55 1 in 200 for all other areas	38	-6	No – negligible reduction in detriment properties
2.9 – Lower Both Banks A	Left and right bank defences from St Asaph Old Bridge to the A55 only raised to provide a 1 in 100 annual chance standard to encourage overtopping of the defences which more closely matches the existing situation	1 in 200 for defences upstream of St Asaph Old Bridge; 1 in 100 for all areas downstream of St Asaph Old Bridge	18	-26	No – does provide economically preferred standard of flood protection
2.10 – Lower Both Banks B	Left bank defence only raised to provide a 1 in 100 annual chance standard from Ruby Terrace to the A55; New right bank defence upstream of St Asaph Old Bridge built to a 1 in 100 annual chance standard Right bank defence only raised to provide a 1 in 100 annual chance standard from the St Asaph Old Bridge to the A55;	1 in 200 for Lower Denbigh Road to the New Inn; 1 in 100 for all other areas	4	-40	No – does provide economically preferred standard of flood protection

Appendix B – Detriment Assessment Summary Results

Option Name & No.	Detriment Mitigation Description ²	Present Day Proposed Scheme Standard of Protection	No of New Properties at risk for 1 in 1000 Flood	Change in no. of New Properties from preferred option	Recommended Option
Detriment Mitigation Options (applied to current preferred option 2.100.RSA)					
2.11 – Hybrid Option A	Defence from Lower Denbigh Road to the New Inn built to provide a 1 in 1000 annual chance standard (as Option 2.4); Defence tie-ins on left bank to St Asaph Old Bridge set-back by 6m, defence tie-in on right bank set-back across play area, bowling green and Lower Street and no new defence on right bank upstream of bridge (Option 2.2)	1 in 1000 for Lower Denbigh Road to New Inn 1 in 200 for all other defences	13	-31	No – increased risk of flooding of the A525 is not acceptable as it is a key evacuation route
2.12 – Hybrid Option B	Defence from Lower Denbigh Road to the New Inn built to provide a 1 in 1000 annual chance standard (as Option 2.4); Defence tie-ins on left bank to St Asaph Old Bridge set-back by 6m, defence tie-in on right bank set-back on boundary of recreation ground and no new defence on right bank upstream of bridge (Option 2.2)	1 in 1000 for Lower Denbigh Road to New Inn 1 in 200 for all other defences	18	-26	No – not as effective as Option 2.11, but more expensive to build
2.13 – Hybrid Option C	Defence from Lower Denbigh Road to the New Inn built to provide a 1 in 1000 annual chance standard (as Option 2.4); Defence tie-ins on left bank to St Asaph Old Bridge set-back by 6m, defence tie-in on right bank set-back across play area, bowling green and Lower Street and no new defence on right bank upstream of bridge (Option 2.2); New flood relief culvert on right bank through St Asaph Old Bridge	1 in 1000 for Lower Denbigh Road to New Inn 1 in 200 for all other defences	14	-30	No – not as effective as Option 2.11, but more expensive to build
2.14 – Hybrid Option D	Defence from Lower Denbigh Road to the New Inn built to provide a 1 in 1000 annual chance standard (as Option 2.4); Defence tie-ins on left bank to St Asaph Old Bridge set-back by 6m, defence tie-in on right bank set-back across bowling green; New flood relief culvert on right bank through St Asaph Old Bridge	1 in 1000 for Lower Denbigh Road to New Inn 1 in 200 for all other defences			No – not as effective as Option 2.11, but more expensive to build

1. Option taken from St Asaph FRMS Economic Benefit Appraisal Report, GBV, February 2015

2. Detriment mitigation is applied to the currently preferred economic option '2.100.RSA'

Notes on Proposed Scheme Standard of Protection

- 1 in 200 annual chance standard = present day 1 in 200 modelled level +300mm freeboard
- 1 in 100 annual chance standard = present day 1 in 100 modelled level +300mm freeboard – this is equivalent to present day 1 in 200 modelled level **without** freeboard
- The model shows a 1 in 100 annual chance flood defence might still contain a 1 in 200 annual chance flood but there would be **no** freeboard on the defences. A zero freeboard allowance **is not** recommended for St Asaph.

APPENDIX D – RIVER CLWYD DETRIMENT ASSESSMENT

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Project name:	St Asaph PAR
Document name:	Impact of Scheme on Clwyd Flood Risk

Project component: Impact of St Asaph Scheme on Clwyd Flood Risk

Document description: Describes how an assessment of the impact of flood risk along the Clwyd has been Assessed using the available modelling of St Asaph and the River Clwyd.

Summary of revision history:

Rev.	Issue date	Description of revision	Preparer	Checker	Reviewer	Approver
A	14-Nov-14	Initial version	TSP		NSt	NSt

The full revision history of the document should normally be recorded by using the attributes in Cygnet or ProjectWise. If there are several reviewers (such as for different disciplines), enter the details in successive rows.



Project name:	St Asaph PAR
Document name:	Impact of Scheme on Clwyd Flood Risk

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Project name:	St Asaph PAR
Document name:	Impact of Scheme on Clwyd Flood Risk

ST ASAPH PAR IMPACT OF SCHEME ON CLWYD FLOOD RISK

1. INTRODUCTION

As part of the St Asaph PAR, Black & Veatch have undertaken an assessment of the impact that the proposed flood defence scheme in St Asaph would have on water levels along the Afon Clwyd. Of primary concern is the impact this may have to flood risk near Rhuddlan Bridge. The assessment has been carried out for a scheme providing protection against a 1 in 200 annual probability flood on the Elwy through St Asaph.

2. CLWYD MODEL – STAGE 1

To carry out the assessment, a model of the Clywd has been used. This model was developed by JBA as part of the Tidal Clwyd Flood Mapping study in 2011. The model starts just upstream of the Elwy confluence and extends to where the Clwyd discharges into the sea at Rhyl. The model also includes a section of the Elwy from the St Asaph model, extending downstream of the A55.

Model Inflows

To allow a comparison of water levels before and after the implementation of a proposed flood defence scheme, the two inflows to the Tidal Clywd model have been set-up to match the St Asaph PAR model. This includes the hydrograph at the dismantled railway embankment (node: SA004); and the hydrograph used to represent the Clwyd (node: Clwyd_DS). The hydrographs for the existing situation (Do Minimum) and with scheme models have been exported from the 1 in 200 and 1 in 1000 annual probability flood model runs.

In the Tidal Clwyd model, the Elwy has then been glass-walled along both banks as far as the dismantled railway to ensure that no flow is lost to the floodplain.

Downstream Boundary Conditions

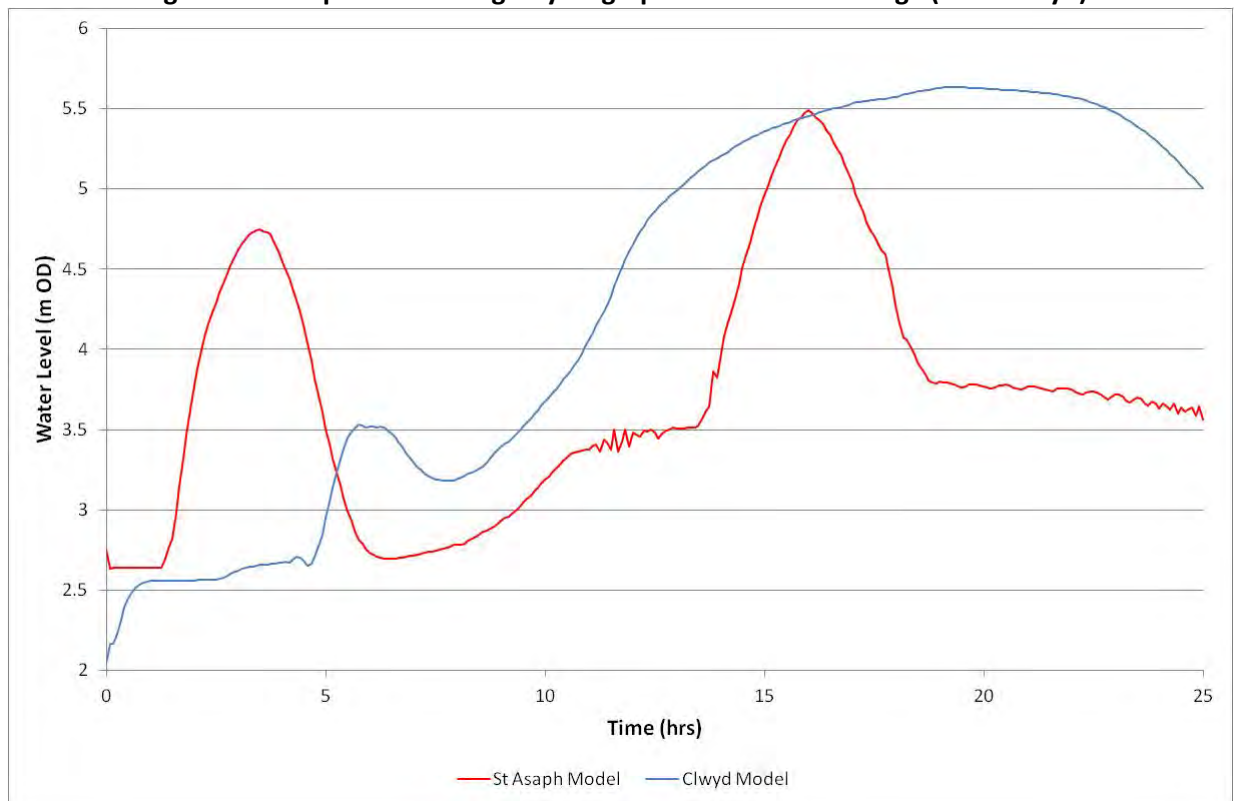
A HTBDY based on a MHWS tide has been applied at the downstream end of the Tidal Clwyd model (peak of 3.7m OD). A tidal boundary is similarly applied to the St Asaph PAR model at Rhuddlan Bridge. There is a level gauge at the bridge and this has been used to apply the highest tide from 2012 (peak of 5.07m OD). There are additional boundary conditions used within the TUFLOW domain to simulate the interaction of floodplain flows from the Elwy and Clwyd.

The St Asaph model therefore forces the Clwyd upstream of Rhuddlan Bridge to be tidally dominated, regardless of the fluvial input; whereas in the Tidal Clwyd model, the location of the downstream boundary means that a large fluvial flow can result in fluvial dominance upstream of Rhuddlan Bridge. The difference between the two models is shown clearly in Figure 1. As such this makes a direct comparison of flood levels generated by the two different models a pointless exercise (a case of comparing apples with pears) and the analysis presented in this note is based entirely on the results of the adapted Tidal Clwyd model.



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Figure 1 – Comparison of Stage Hydrographs at Rhuddlan Bridge (Afon Clwyd)



Assessment of Detriment

The assessment provided refers only to the results obtained from the Tidal Clwyd model. The inflows to the Tidal Clwyd model were matched to the St Asaph PAR model and a MHWS tidal boundary applied (see above for more details). The model was then re-run to represent the following conditions:

- 1 in 200 annual probability flood with existing defence levels in St Asaph.
- 1 in 200 annual probability flood with 1 in 200-year standard of protection in St Asaph.
- 1 in 1000 annual probability flood with existing defence levels in St Asaph.
- 1 in 1000 annual probability flood with 1 in 200-year standard of protection in St Asaph.

Figure 2 compares the flood outlines from the 1 in 1000 annual probability flood for the two defence scenarios. The 1 in 200 annual probability flood outlines have not been shown because the difference between the two outlines is negligible. A table is provided on Figure 2 showing the impact that the St Asaph scheme has on peak water levels along the Clwyd and also provides information on the crest levels along the Clwyd defence embankment between the Elwy confluence and Rhuddlan Bridge.

For the 1 in 200 annual probability flood, although the flood outline is unchanged, the proposed St Asaph scheme results in a maximum of a 60mm increase in peak water levels. However, the flooding is contained by the Clwyd food defence embankment and so this increase in flood depth is restricted to field that flood on a regular basis.

In the 1 in 1000 annual probability flood the flood extent is increased by the proposed St Asaph flood defence scheme. In both scenarios the Clwyd defences are overtopped, but an increase in peak water level of around 100mm results in a greater flood extent in the field bounded by the dismantled railway,



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Station Road and the Clwyd defences. The depth of flooding in the field itself is similarly increase by around 100mm. This flooding does not impact any buildings.

3. CLWYD MODEL – STAGE 2

The first assessment demonstrates limited detriment caused by the St Asaph scheme along the Afon Clywd. There is some increase in flood depth that results, but it is restricted to farmland and causes no flooding to buildings. The modeling however does not take account of the flows routed via the Elwy floodplain onto the Clwyd floodplain. Stage 2 of the modeling has taken account of this by including this floodplain flow.

Elwy Floodplain Flow

The St Asaph PAR model was re-run for each of the four scenarios listed above. A PO line (*2d_po_St_Asaph_001*) was included between the A525 and the Afon Elwy opposite Pentre-uchaf (i.e. east of the A525) and a second PO line extended westwards across the floodplain from Blairmore Nurseries (i.e. west of the A525) to record the flow across the Elwy floodplain. The flow record was then applied to the Tidal Clwyd model at the same locations using a sa layer (*2d_sa_Elwy_floodplain_flow_002*) and the Tidal Clwyd model re-run.

The peak flow values for each section of floodplain and each scenario are shown in Table 1. This shows that the proposed scheme results in a slight increase in flow across the floodplain the east of the A525, but a more significant reduction in flow along the floodplain to the west of the A525.

Table 1 – Comparison of Afon Elwy Floodplain Flows

Scenario	Peak Flow on Floodplain (m3/s)	
	East of A525	West of A525
Existing – 1 in 200-year	20	17
With Scheme – 1 in 200-year	21	10
Existing – 1 in 1000-year	52	105
With Scheme – 1 in 1000-year	56	89

Figure 3 compares the flood outlines and flood levels for the 1 in 200 annual probability flood and Figure 4 similarly compares the 1 in 1000 annual probability flood.

These results show that for the 1 in 200 annual probability flood, the flood levels to the west of the A525 are lower with the scheme in place. This would be expected because the floodplain flow recorded upstream is lower and there is no interaction with the floodplain flow to the east of the A525. To the east of the A525 the flood levels are around 10mm higher with the scheme until crossing the dismantled railway line into the field upstream of Station Road. In this area the flood levels with the scheme in place are around 10mm lower. This difference in flood level is 10-20mm in the low lying area between Station Road and the A525.

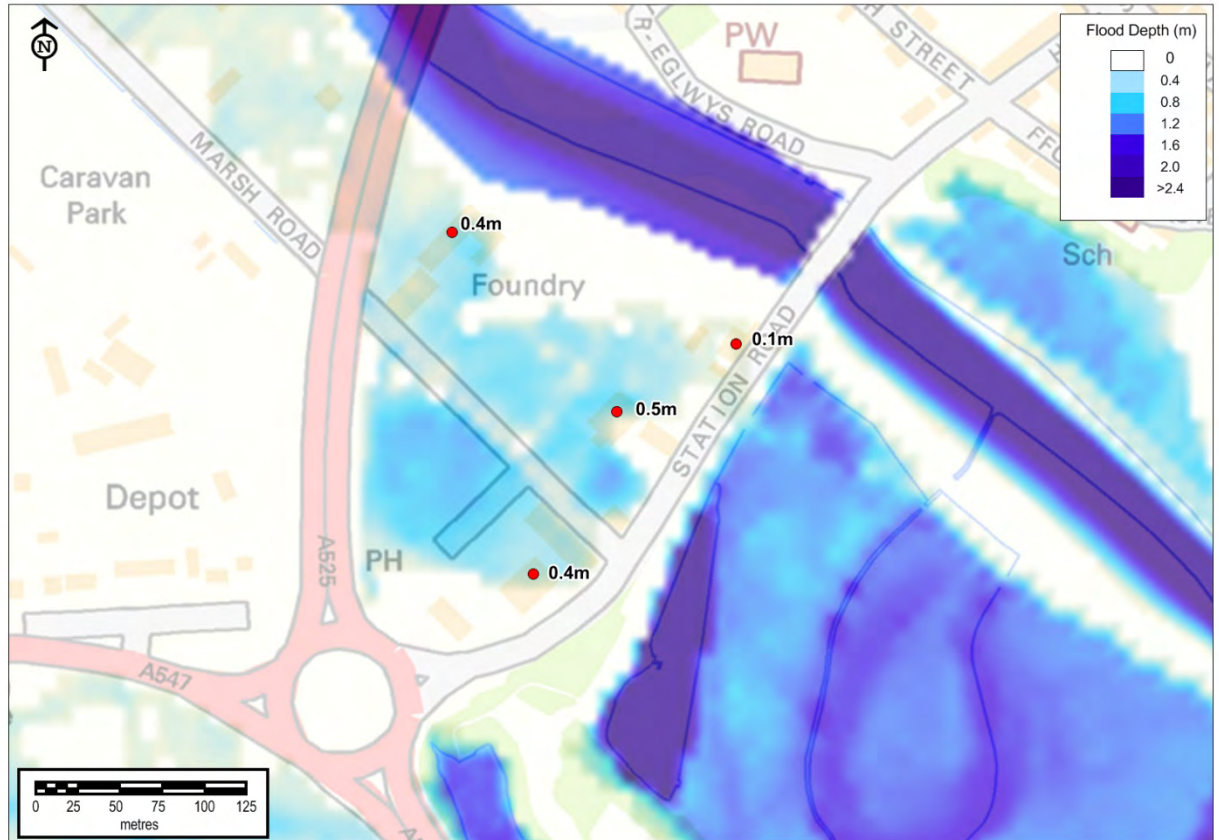
This slight reduction in water levels appears to be a modeling quirk because there is no interaction between the Clwyd and the floodplain flow from the Elwy (i.e. the Clywd Defences are not overtopped). Regardless, the flooding across Station Road is realistic having been observed and occurs at a low spot in



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the road where a field access track joins Station Road. Figure 5 shows the resulting flood depths in the area between Station Road and the A525. The Foundry is flooded to a depth of around 0.4m and the worst affected properties adjacent to Station Road to a depth of 0.5 – 0.75m.

Figure 5 – Flood Depths for the 1 in 200 annual probability flood

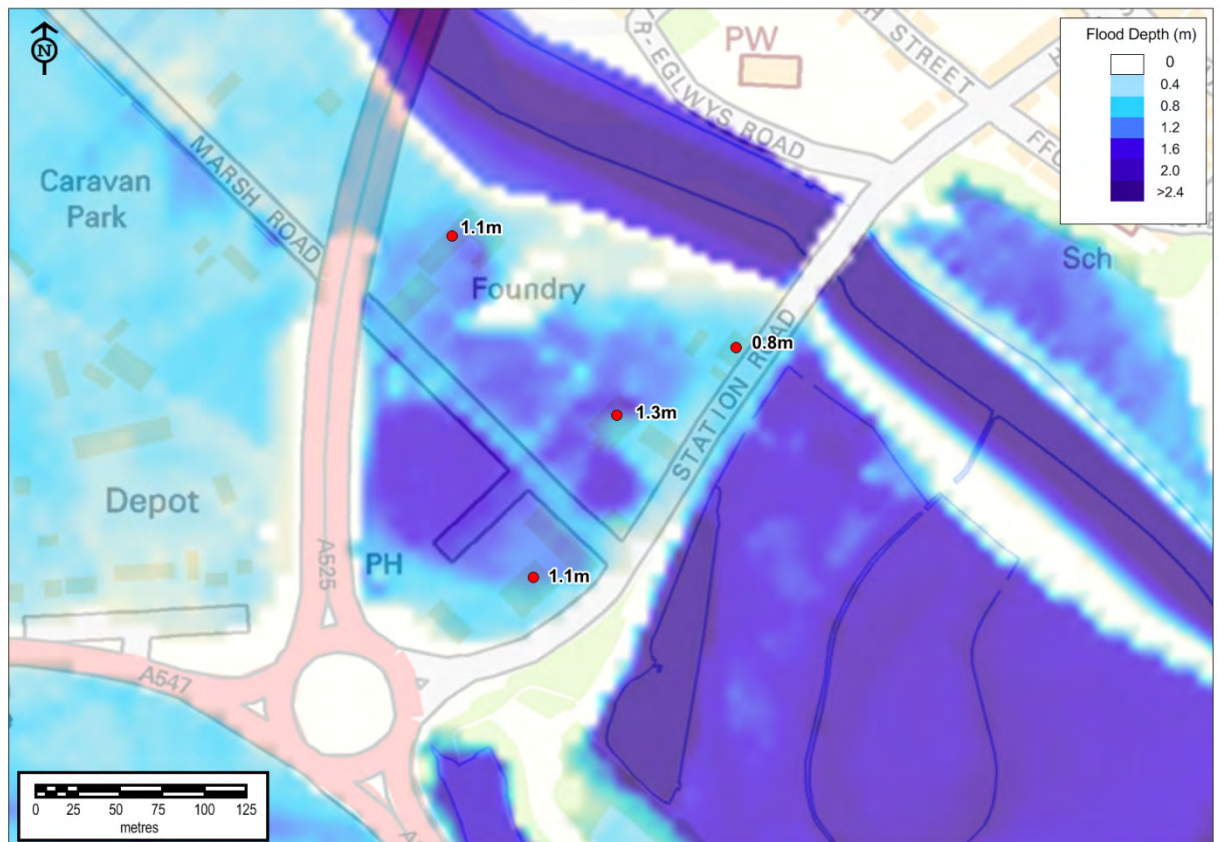


At the 1 in 1000 annual probability flood, the results show a slight reduction in peak water level to the west of the A525 with the scheme in place, whilst to the east of the A525, the flood levels are 20-30mm higher. This difference is also found in the field upstream of station road and a maximum difference of 30mm are shown in the area between Station Road and the A525. Although there is a slight increase in the depth of flooding to properties in this area Figure 6 shows that, flooding depths in this area is in excess of 1m for several properties and in excess of 0.5m for all the properties. An increase of 30mm is therefore relatively inconsequential.



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Figure 6 – Flood Depths for the 1 in 1000 annual probability flood



4. FLOOD COINCIDENCE

The Afon Alwy and Afon Clwyd are one of the same catchment and it would be expected that to some extent there would be coincidence of flood events on the two rivers. However, at the confluence of the two rivers, the Clwyd catchment is nearly 200km² larger than the Elwy, and the Clwyd is known to attenuate flows on its wide floodplain. Using the available gauging station data from HiFlows-UK an assessment of the coincidence of large floods on the two rivers has been carried out. The gauging station closest to the confluence on each river has been selected:

- Elwy @ Pont-y-Gwyddel (ref: 66006)
- Clwyd @ Pont-y-Cembwll (ref: 66001)

On the HiFlows-UK website both gauging stations have records extending back to 1974 for the AMAX series (39 years) and 1982 for the POT series (31 years). The numbers of events that coincide within a day of each other have been counted. For the AMAX series this indicates that 16 events of the 39 have coincided (or 41%) and for the POT series there are 83 events of coincidence from a possible 146 (or 57%). This implies that around half the time flood flows will coincide on the two rivers.



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If we look at those events from the AMAX series that do coincide, we find that with only one exception, the peak of the flood on the Clwyd occurs after than on the Elwy and that on average the time difference is 11 hours. The two gauging stations are located a similar distance upstream of the confluence and so it is a reasonable to assume that a similar situation occurs at the confluence.

5. CONCLUSIONS

An assessment of the impact that a proposed flood defence scheme on the Afon Elwy through St Asaph may have on flooding along the Clwyd has been carried out. The Tidal Clwyd model was adapted to take inflows from the St Asaph PAR model and a comparison of flooding under existing and with scheme conditions was carried out.

- Stage 1 did not include floodplain flow from the Elwy and indicated that although flood depths were increased by up to 60mm and 100mm for the 1 in 200 and 1 in 1000 annual probability floods respectively, this was restricted to farmland. No impact on property building was identified.
- Stage 2 included flow coming across the Elwy floodplain. Notwithstanding a modeling anomaly, the indication is that along the east side of the A525, peak water levels are increased by 10-30mm. This includes increasing flood depths on properties flooded between Station Road and the A525; however the detriment caused is relatively inconsequential when considering flood depths in the 1 in 1000 annual probability flood in excess of 1m.

Finally, an assessment of the coincidence of flood events of the Clwyd and Elwy was carried out. This indicated that around 50% of flood events coincide within a day of each other on the two rivers. Further analysis indicates that in general the Clwyd peaks after the Elwy, on average by 11 hours.

Figure 2

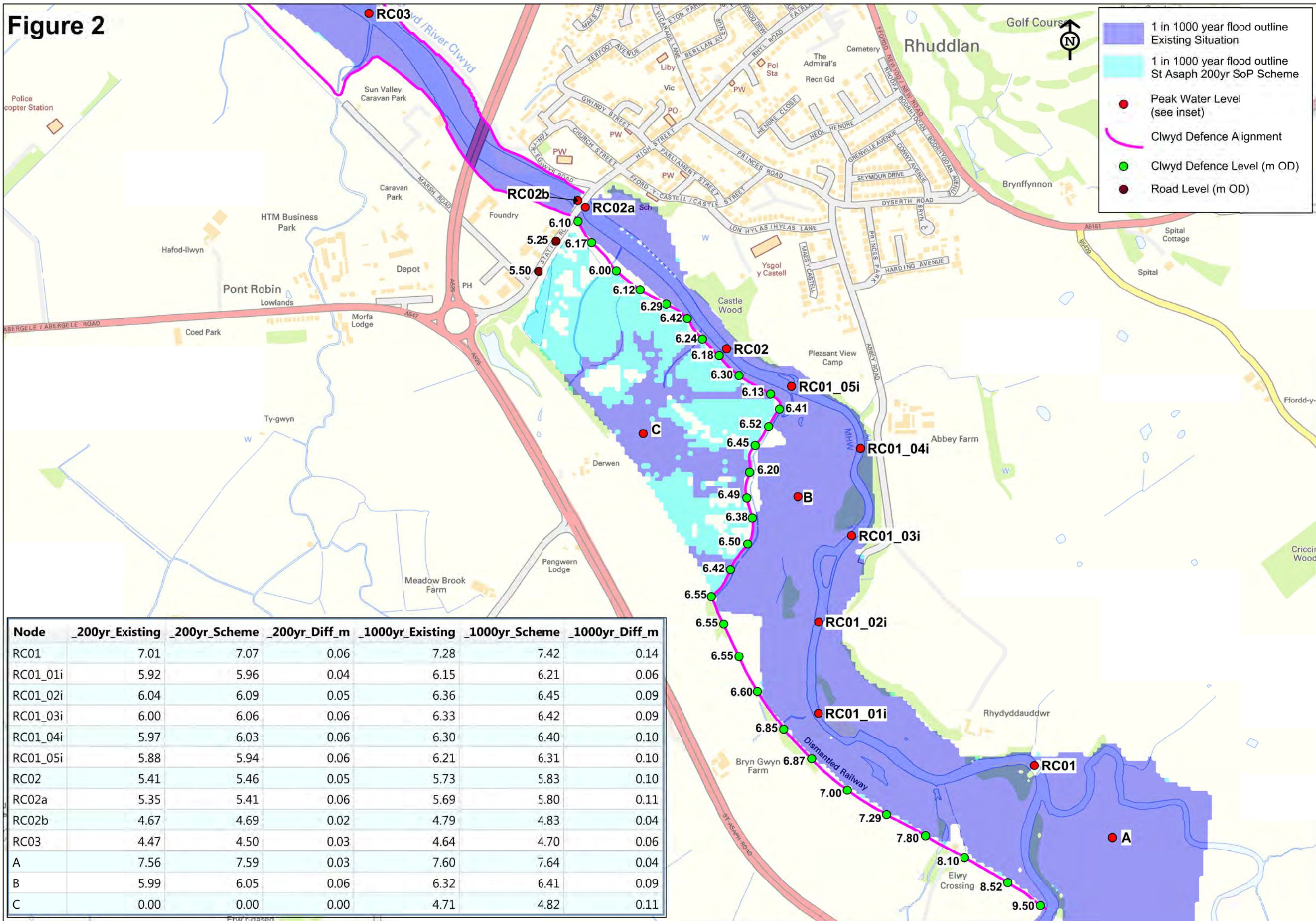


Figure 3

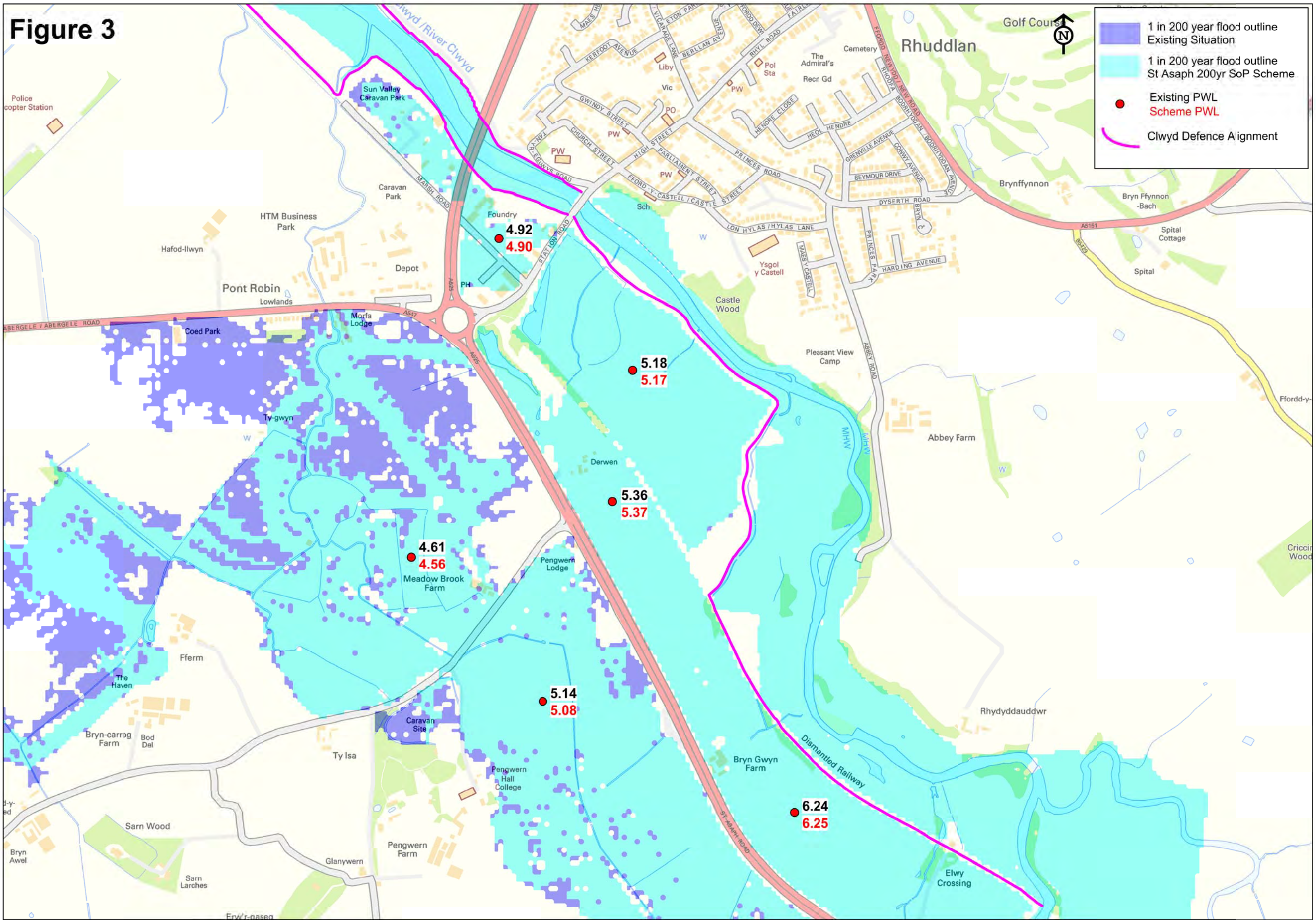


Figure 4

