

Francis Sant

Redevelopment of the Conservative Club, Glyncorrwg Flood Consequence Assessment Report



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Signed

Date

CONTENTS

	Page
1 Introduction	1
2 Background	3
3 Flow Estimation	9
4 Modelling	10
5 Flood Risk	26
6 Flood Proofing Measures	31
7 Conclusion and Recommendations	33
Appendix A – Flow Estimation	

1 INTRODUCTION

It is proposed to redevelop a club, with residential accommodation, in into a single house in Glynorrwg. The client has been advised, however, that the building lies within C2 flood zone (see Figure 1.1), as defined by the development advice maps referred to in Technical Advice Note 15 - Development and Flood Risk (TAN 15). This means that the area is considered to be at risk of flooding during at least the 1 in 1000 year event and is not protected by recognised significant flood defences.

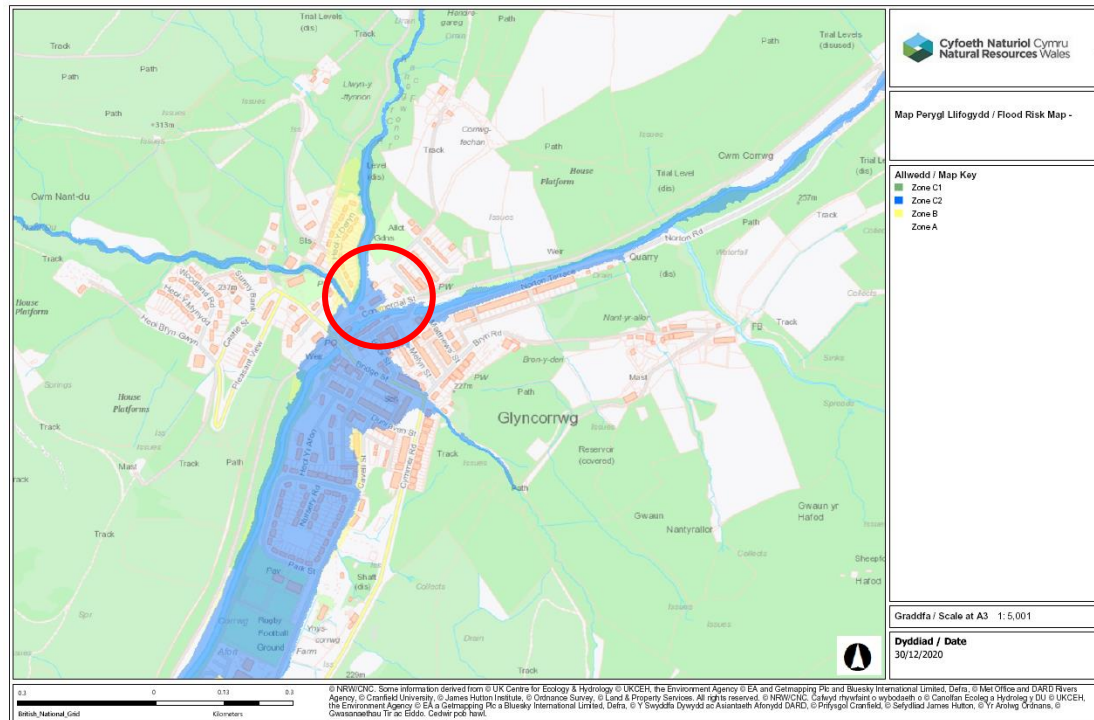
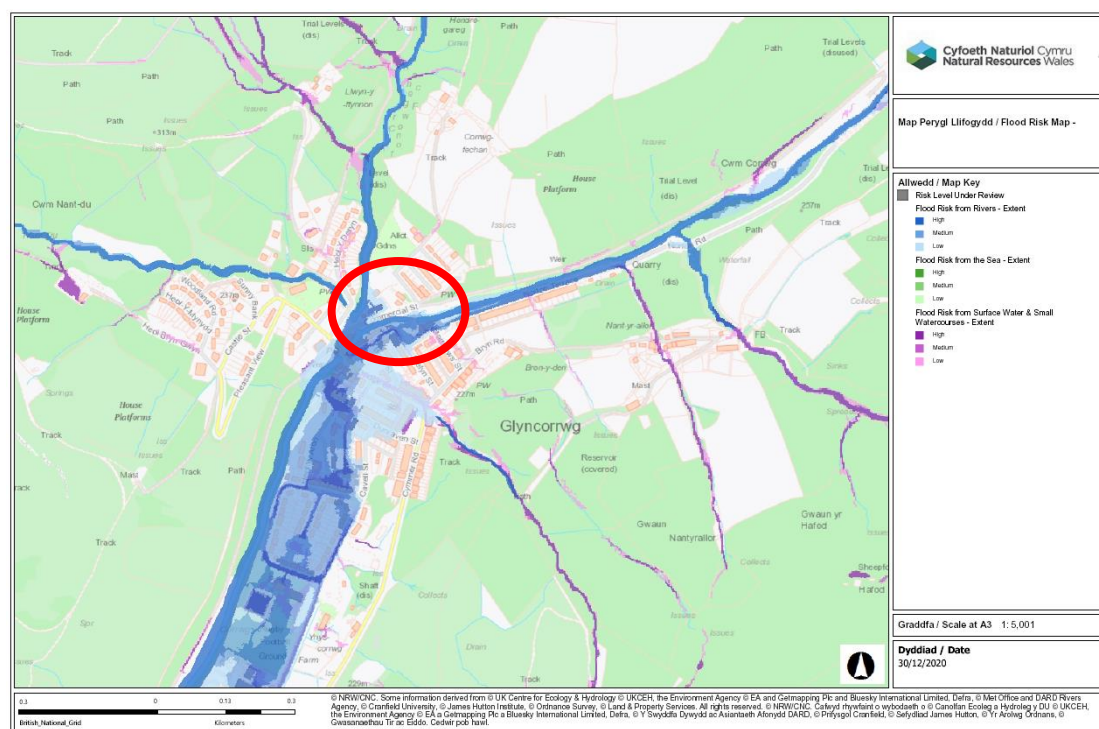


Figure 1.1 - Development Advice Flood Map

The development advice map is based on the Natural Resources Wales Flood Risk Map (see Figure 1.2) supplemented by sediment data, held by the British Geological Survey (BGS), of historical flooding. The map adopts the precautionary principle and is based on the best known information available at the time. However, a detailed examination of a site can refine an areas risk of flooding.

Considering the proximity of the building to a nearby stream the development could be at risk from fluvial flooding. As such the client recognises the need for a Flood Consequence Assessment undertaken in accordance with the requirements of Section 7 and Appendix 1 of TAN 15. Francis Sant have been employed to undertake this task.



2 BACKGROUND

It is proposed to convert the former Conservative Club at Glyncorrwg (coordinates 287565 199260) into a single dwelling. The club already has a residential element with living rooms and bedrooms on the first floor and a kitchen on the ground floor. The building is set in its own grounds with the Corrwg Fechan stream north west of the site (see Figure 2.1 to 2.3 and Plate 2.1 and 2.2). An access road runs to the south of the plot with Afon Corrwg located beyond. There is a paddock and a barn to the north and some buildings to the east. There is a single garage to the west.

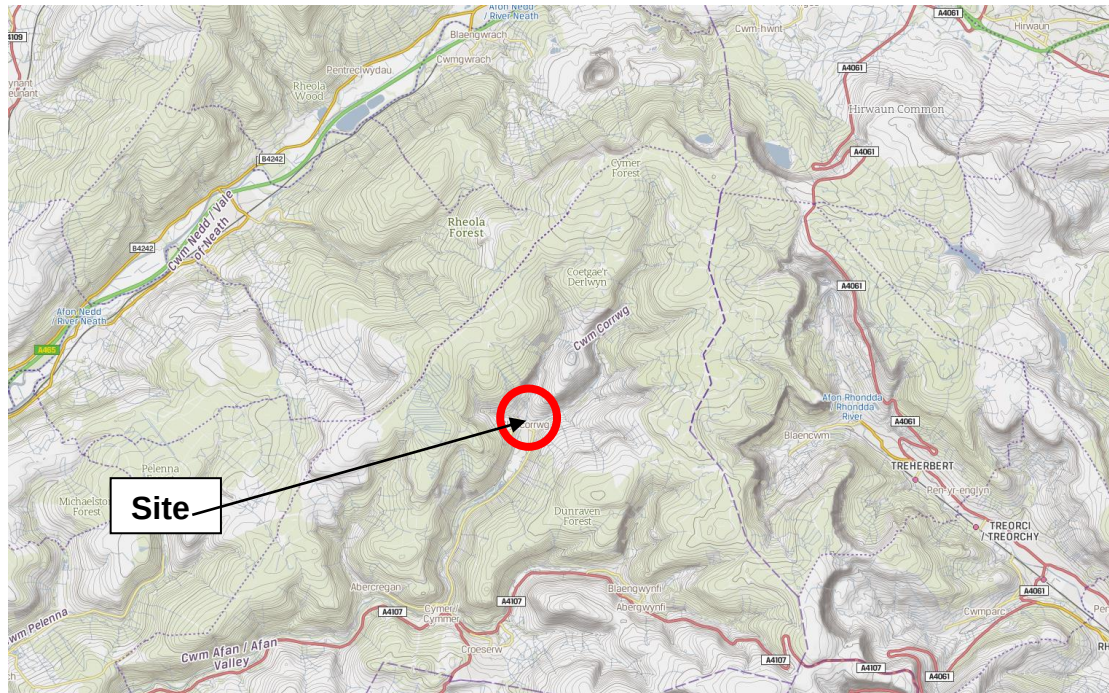


Figure 2.1 – Location Plan

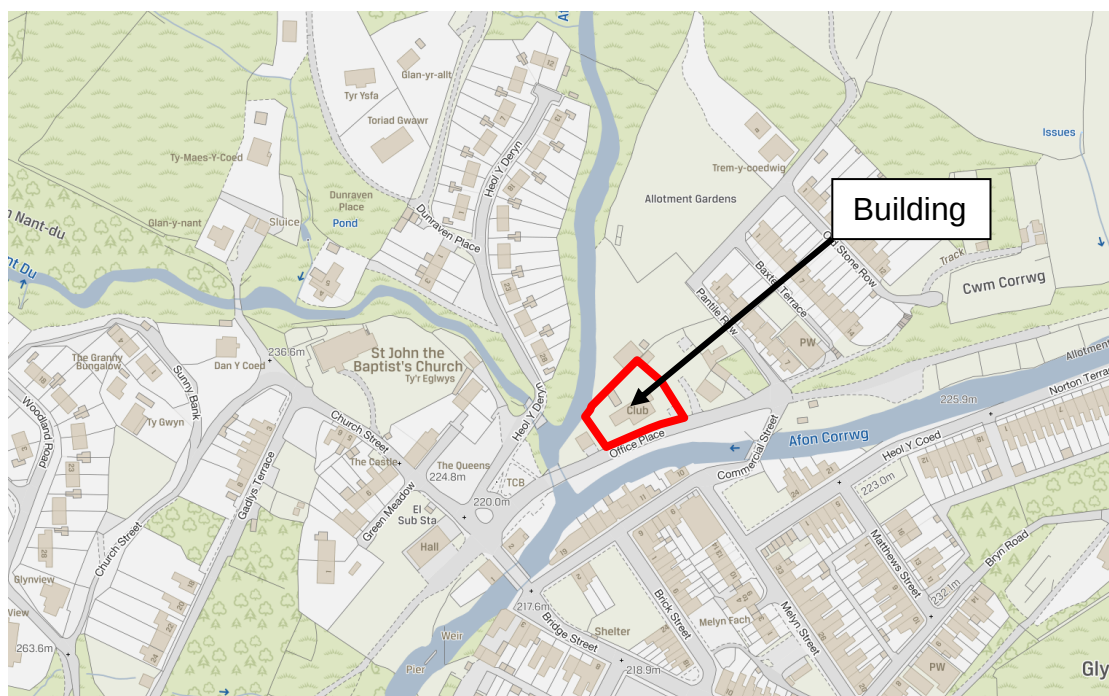


Figure 2.2 – Location of Site

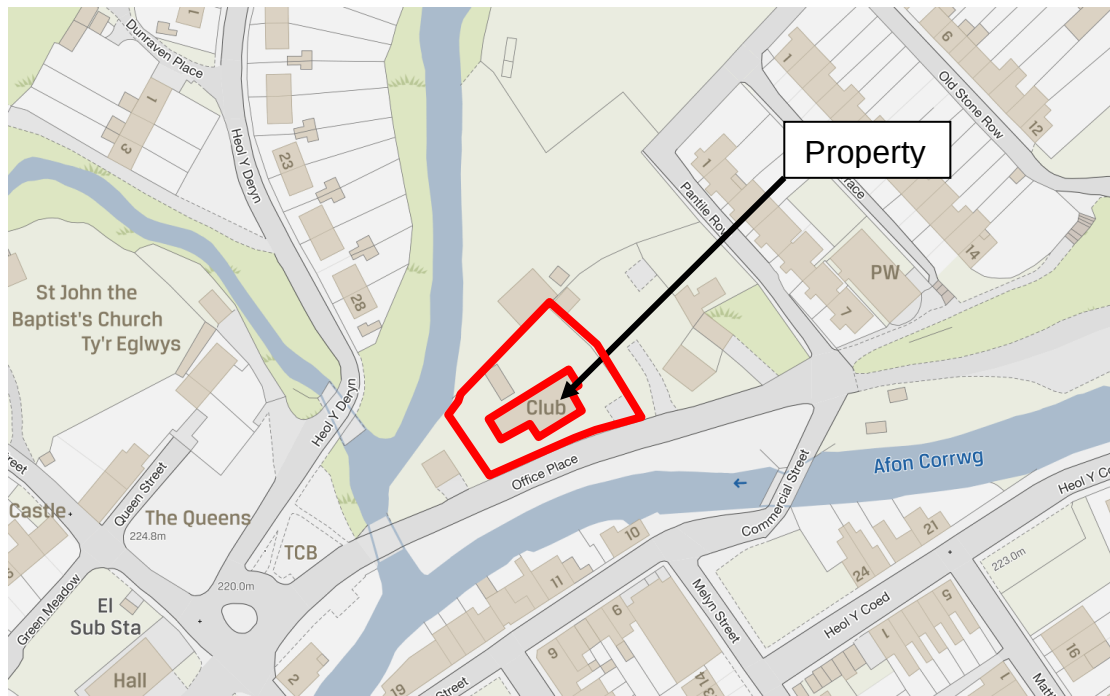


Figure 2.3 - Site Location

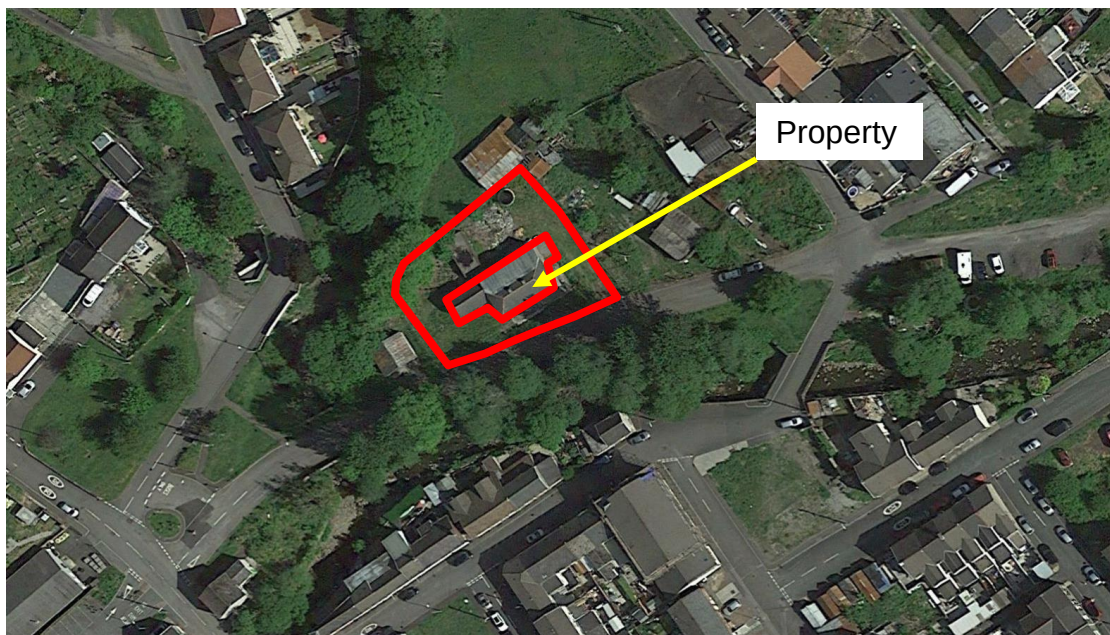


Plate 2.1 – Aerial View of Development



Plate 2.2 – Picture of Building

Afon Corrwg Fechan has its source some 4.1km north of the development at a height of around 570m AOD. The stream flows towards the site through a steep sided wooded valley. Just beyond the site the stream merges with the Nant Ddu before flowing beneath the Office Place Bridge and subsequently discharging into the Afon Corrwg some 40m downstream of the site. Nant Ddu has its source some 1.8km to the north west at a height of around 493m while Afon Corrwg has its source some 5km to the north east at a height of 565m with both streams flowing towards the village through a steep sided wooded valleys.

Details of the streams catchment are recorded as part of the IH Digital Terrain Model (IHDTM) as produced by the Centre of Ecology and Hydrology. Catchment descriptors, such as the annual average rainfall, storage capacity etc, are maintained for each catchment from which an estimate can be made of the flow rate with a 1 in 2 year return period (QMED). Values of some of the catchment descriptors are provided in Table 2.1. The catchment area was checked using OS 1:25000 Explorer maps and generally found to have a close correlation with the values provided in the FEH Web data (see Figure 2.4 to 2.6 – different scales).

Table 2.1 – Catchment Descriptors for the Glyncorrwg Streams

Descriptor	Nant Du	Corrwg Fechan	Afon Corrwg
AREA	1.5025	4.365	9.9625
ALTBAR	414	426	453
ASPBAR	115	168	256
ASPVAR	0.62	0.51	0.37
BFIHOST	0.356	0.346	0.332
BFIHOST19	0.278	0.271	0.268
DPLBAR	1.22	2.44	3.32
DPSBAR	195.5	175.4	193.1
FARL	1	1	1
FPEXT	0.0033	0.0115	0.0058
FPDBAR	0.053	0.146	0.099
LDP	2.18	5.4	6.36
PROPWET	0.54	0.61	0.58
RMED-1H	13.7	13.7	13.8
RMED-1D	72.8	72.9	74
RMED-2D	96.7	96.8	98.5
SAAR	2305	2361	2449
SAAR4170	2300	2362	2471
SPRHOST	49.83	50.84	51.94
URBEXT2000	0	0.0017	0.0019



Figure 2.4 - Catchment Area For Nant Du

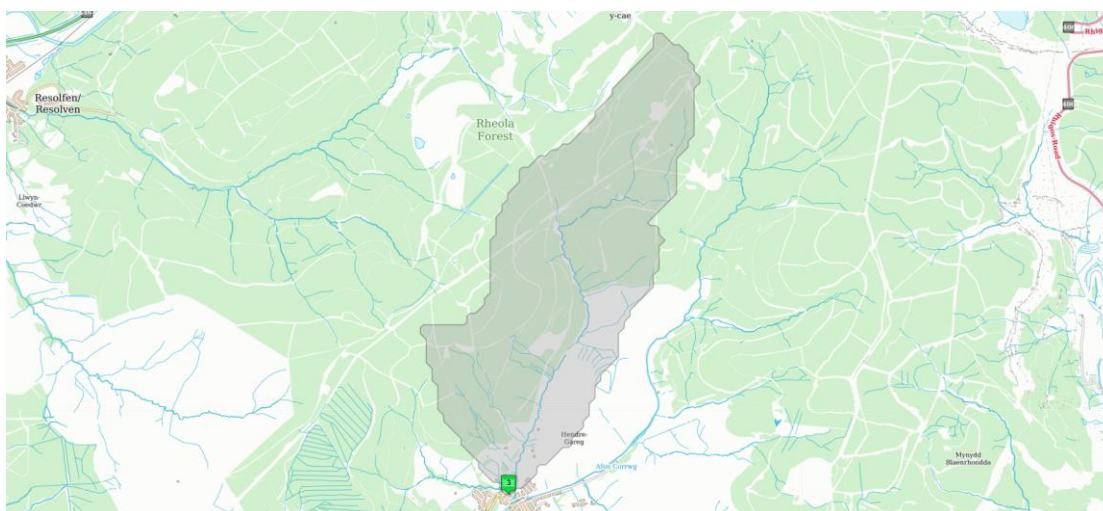


Figure 2.5 - Catchment Area For Corrwg Fechan

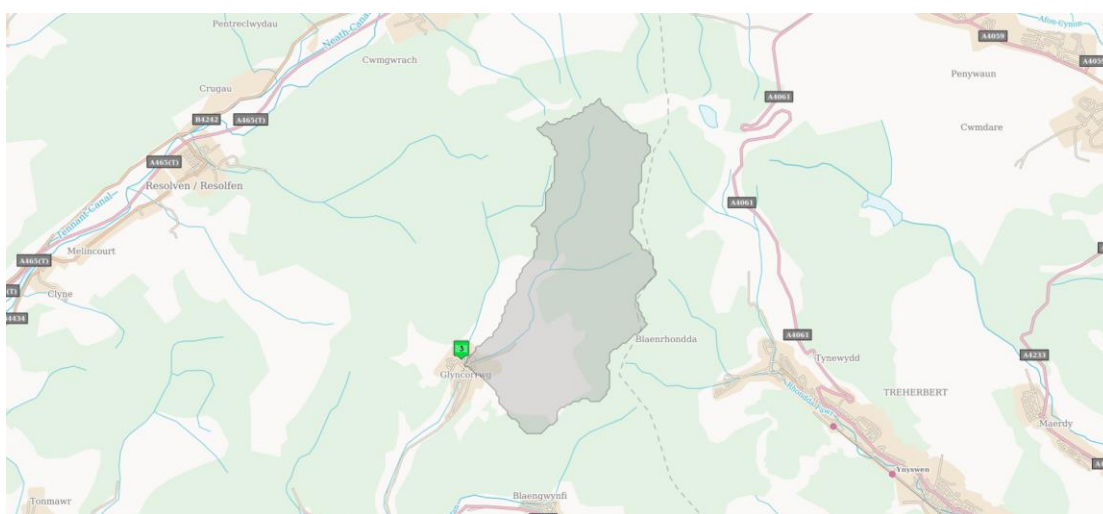


Figure 2.6 - Catchment Area For Afon Corrwg

Topographic Information

Lidar data of the area shows that the level of the site ranges between 219.5m AOD and 220.5m AOD (see Figure 2.5).



Figure 2.7 - LiDAR Data with 100mm Contours

3 FLOW AND TIDE LEVEL ESTIMATION

Flow Estimation

The site is potentially at risk of flooding from the nearby streams. This section considers the estimated flow in the watercourses.

The streams are not gauged at the point of interest, therefore, an estimate of the fluvial flows, for various return periods, was undertaken using the methods indicated in the Flood Estimation Handbook, as amended. For an ungauged site it is recommended, where suitable, that a donor site is used to adjust the flows obtained using catchment descriptors. A donor site is a gauged station located close to, and preferably either upstream or downstream of, the point of interest. In this instance three were chosen namely stations on the Afan at Macroft Weir, Rhondda Fawr at Tynewydd and the Dulais at Cilfrew. The estimated QMED flows, based on catchment descriptors, were changed using an average adjustment factor of eachstream based on measured flows at the gauging stations.

The adjusted The Q100 (1 in 100), Q100 + 30% (to account for climate change) and the Q1000 (1 in 1000) flows are provided in Table 3.1.

Table A.11 – Calculated Flow Rates Based on Catchment Descriptors and Q100 Increased by 30% to Account for Climate Change			
Return Period Years	Flow Rates for Afon Corrwg	Flow Rates for Corrwg Fechan	Flow Rates for Nant Du
100	50.631	23.948	10.163
100 + CC	65.820	31.132	13.212
1000	83.395	39.627	17.769

Hydrographs were also constructed for the rivers using the Revitalised FEH / FSR rainfall runoff method (ReFH2), as recommended by Centre of Ecology and Hydrology. The results are given in Appendix A and the peak flows are provided in Table 3.2

Table 3.2 – Calculated Peak Flow Rates Based on ReFH 2			
Return Period Years	Flow Rates for Afon Corrwg	Flow Rates for Corrwg Fechan	Flow Rates for Nant Du
100	52.211	22.565	7.567
1000	83.629	36.438	12.439

Consideration was given to obtaining the Q1000 value by multiplying the statistical FEH Q100 value by the ReFH2 (Q1000 / Q100). However, in this instance the Q1000 estimated using the FEH growth factor was considered more appropriate. The values provided in Table 3.3 should be used in any steady state modelling or to adjust the peak flows in a ReFH2 hydrograph.

Table 3.3 – – Flows to be Used in the Steady State Model			
Return Period Years	Flow Rates for Afon Corrwg	Flow Rates for Corrwg Fechan	Flow Rates for Nant Du
100	50.631	23.948	10.163
100 + CC	65.820	31.132	13.212
1000	83.395	39.627	17.769

4 MODELLING

To simulate the effects of the fluvial 1 in 100 (Q100), 1 in 100 plus climate change (Q100 + CC) and the 1 in 1000 (Q1000) events and to estimate the potential for flooding at the site, a 2D mathematical TUFLOW model was built. TUFLOW is a powerful computational engine that provides 1D and 2D solutions of the free surface flow equations to simulate flood propagation. It is ideal in modelling rivers with complex flow patterns and overland flooding.

The model extended upstream from the site some 250m, on the Afon Corrwg Fechan, 280m on the Nant Ddu and 500m on the Afon Corrwg. The model also extended downstream by some 300m.

1d Model

The 1d model, Estry, was built using a topographic survey from two sources. Five bridges were included in the model. The bridges were allowed to weir in the 1d domain with the bridge being removed from the 2d domain.

The Q100, Q100 plus climate change and the Q1000 hydrographs based on the estimated flows (see Section 3 and Appendix A) were used as the upstream boundary condition. The bed of the streams was given a Manning's number of 0.04 although scenarios with a Manning's number of 0.05 and 0.033 were also considered to test the sensitivity of the model.

The bridge immediately downstream of the site was reduced by 33%, 66% and 100%, by reducing the width of the bridge, to simulate a low medium and high blockage scenarios.

2d Model

The topography in the 2D domain was based on a 1m Lidar data with a cell size of 2m.

All areas within the model was initially given a Mannings number of 0.06 and subsequently superseded to reflect the actual ground surface (eg. 0.035 for Grass and Agricultural Land, 0.025 for Roads etc). Houses were given a high Manning's number of 1 to indicate that water moved very slowly through them with the flow through was also reduced to 10%.

The boundary between the 1d and 2d aspect of the model generally followed the top of stream bank as indicated in the Lidar data and reflected the widths of the 1d channel widths.

Table 4.1 Velocity and Depth Key			
Region	Depth	Region	Velocity
	0-0.1m		0 - 0.15m/s
	0.1m-0.2m		0.15m/s - 0.3m/s
	0.2m-0.3m		0.3m/s - 0.45m/s
	0.3m-0.6m		0.45m/s - 0.6m/s
	0.6m-1m		0.6m/s - 1m/s
	1m-2m		1m/s - 2m/s
	2m - 3m		2m/s - 3m/s
	> 3m		> 3m/s

The model showed that the site is expected to remain flood free during the Q100 event (see Figure 4.2 and 4.3) although some water could flow onto the site and reach the lower end of the building when climate change is taken into consideration although the depth is expected to be less than 0.3m and the velocity is expected to be less than 0.15m/s (see Figure 4.4 and 4.5). During the Q1000 event the flooding potentially surround the building with a flood depth of over 0.3m but the flood velocity generally remains below 0.15m/s (see Figure 4.6 and 4.7).

Increasing the friction value of the channel of the streams (Manning's number increased to 0.05) had a limited impact on the risk of flooding at the site although the flood depths did increase slightly in areas (see Figures 4.8 to 4.13). Reducing the friction of the channel (Manning's number reduced to 0.033) also had a limited impact for the Q100 and the Q100 +CC events although the flood depths were slightly greater around the site during the Q1000 event (see Figure 4.14 to 4.19).

Introducing a 33% blockage to the culvert immediately downstream of the site increased the risk of flooding during the Q100 event with water encroaching onto the western side of site with a flood depth of up to 300mm adjacent to the building (see Figure 4.20) although the flood velocity was less than 0.15m/s (see Figure 4.21). The flood depth increased when climate change is taken into consideration and the flooding extended along the front of the building (see Figure 4.22). The flow velocity could also exceed 0.15m/s on the north west corner of the building (see Figure 4.23). During the Q1000 event the flood depth could reach 0.6m on the western side of the building and the velocity could exceed 0.15m/s, although remained below this around most of the building (see Figure 4.24 and 4.25).

With a 66% blockage the flood depth, during the Q100 event, on the western side of the building exceeded 0.3m and the velocity approached 0.3m/s (see Figure 4.26 and 4.27). The depth and velocity of flooding increased marginally when climate change is taken into consideration (see Figure 4.28 and 4.29) while the flood depth is expected to exceed 0.6m during the Q1000 with the water flowing from north to south along the site's western boundary with the velocity exceeding 0.45m/s (see 4.30 and 4.31).

With a 100% blockage to the downstream culvert the flood depth on the western side of the building during the Q100 could reach 0.6m and while the flow velocity across most of the site remained less than 0.15m/s it increased on the western boundary (see Figure 4.32 and 4.33). The extent and depth of flooding increased with climate change (see Figure 4.34) and the flow velocity exceeded 0.3m/s west of the building although remained below 0.15m/s around the rest of the building (see Figure 3.5). The flood depth exceeded 0.6m for most of the land on the western side of the building during the Q1000 event (see Figure 4.36) and the flow velocity exceeded 0.45m/s (see Figure 4.37). The flow velocity around the building also seemed to generally exceed 0.15m/s.

To provide flood protection to the site it is proposed to erect a wall along the western boundary. As the site is not expected to flood during the Q100 event the defences will have no impact, however they will provide protection during both the Q100 + CC and Q1000 events (see Figure 4.38 and 4.39). It will also provide protection during the Q1000 with increase Manning's number (see Figure 4.40) and also the Q1000 with a 66% blockage to the downstream culvert (see Figure 4.41).



Figure 4.1 – Q100 Flood Depths Over Modelled Length

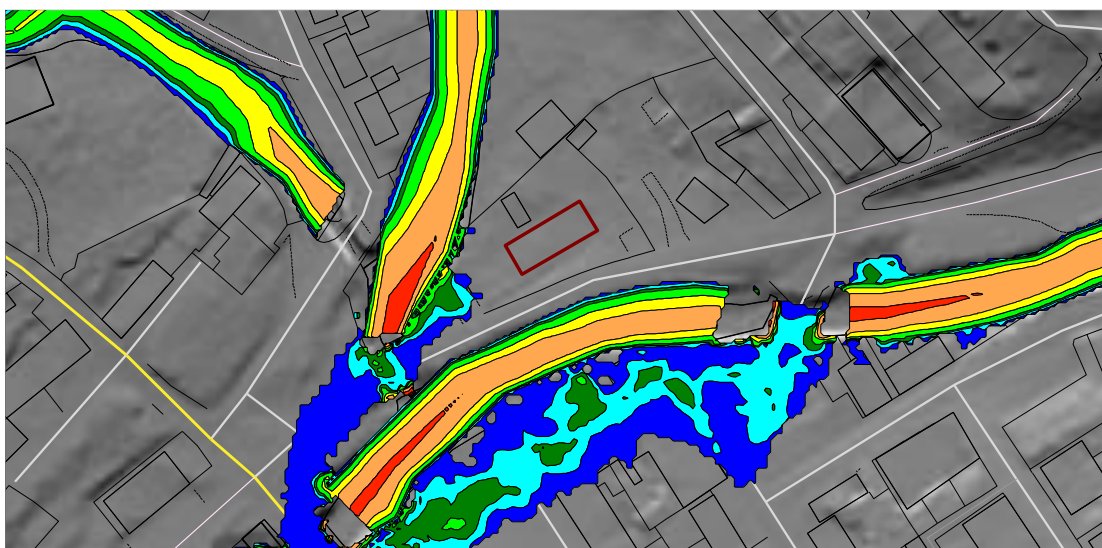


Figure 4.2 – Q100 Flood Depths

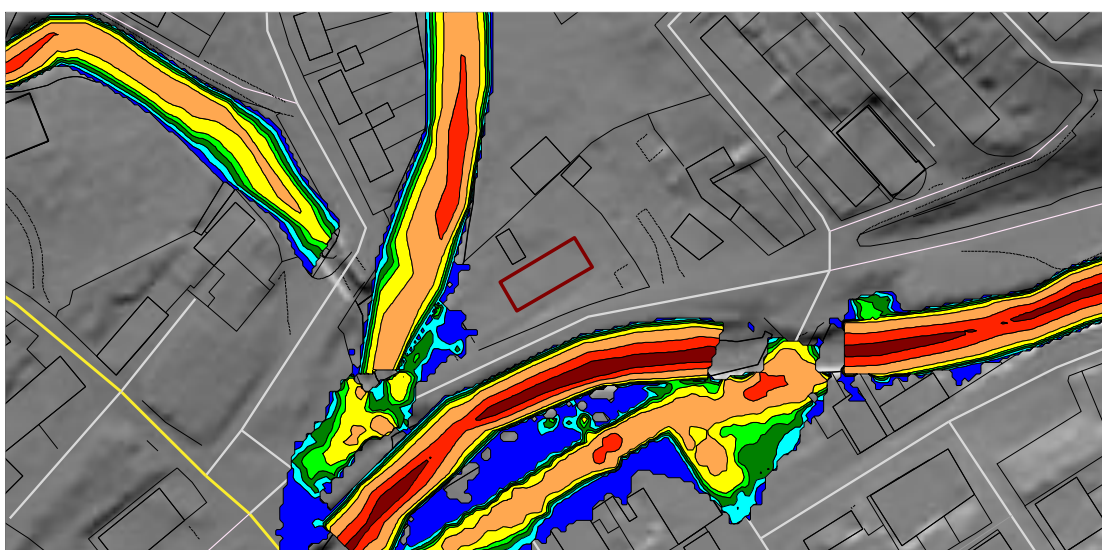


Figure 4.3 – Q100 Flood Velocity

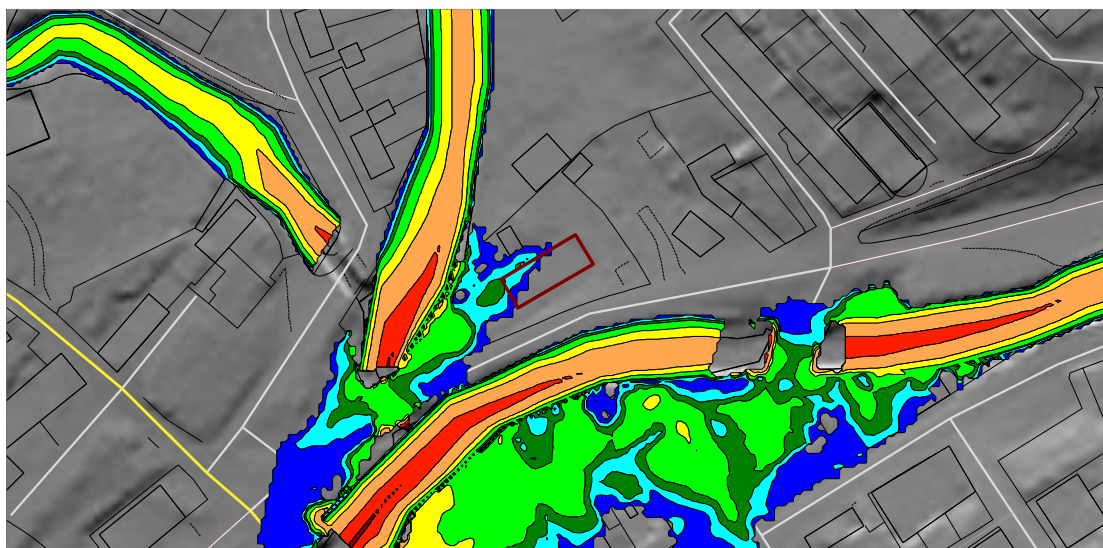


Figure 4.4 – Q100 + CC Flood Depths

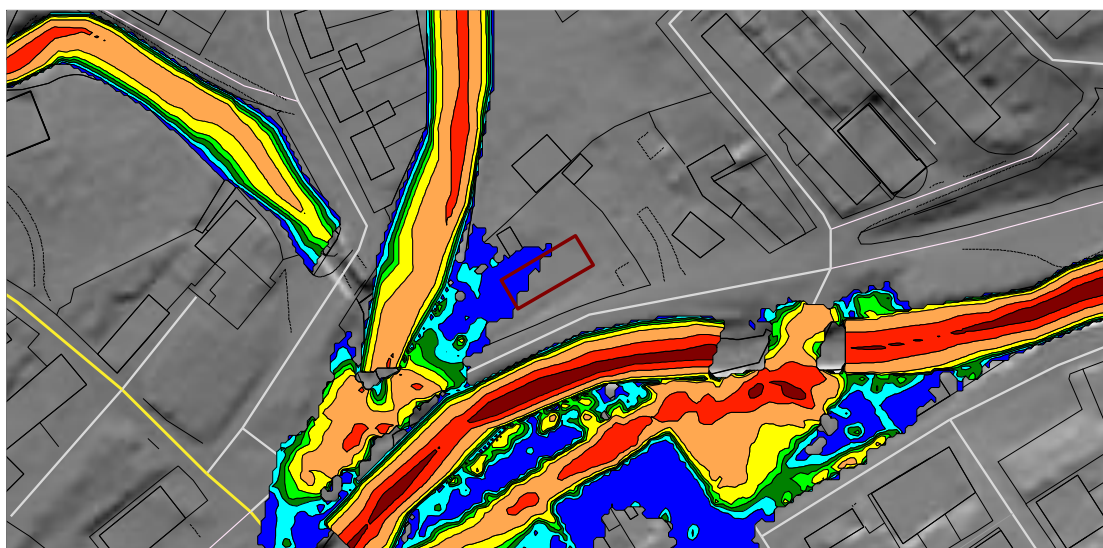


Figure 4.5 – Q100 + CC Flood Velocity

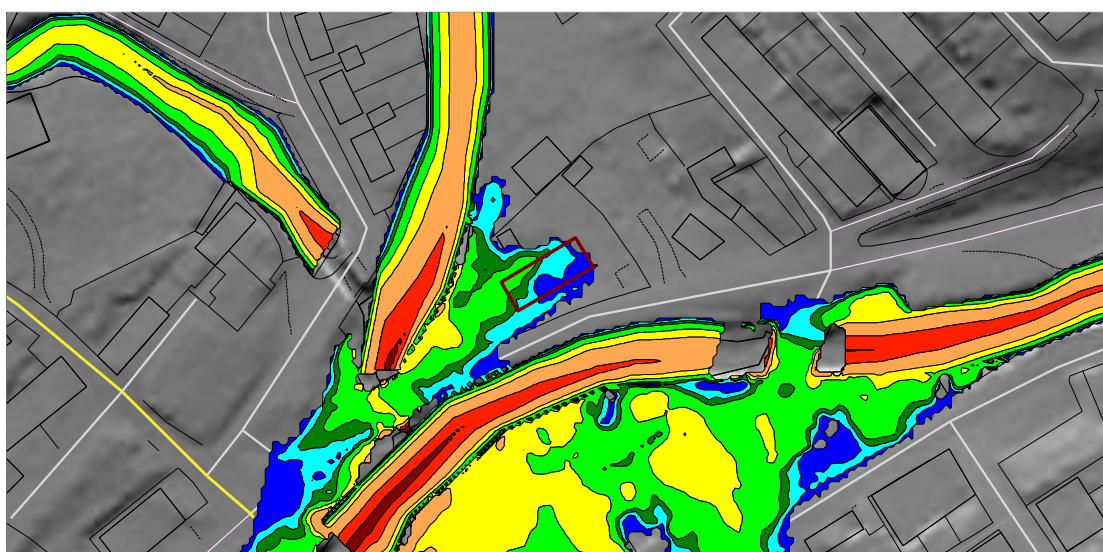


Figure 4.6 – Q1000 Flood Depths

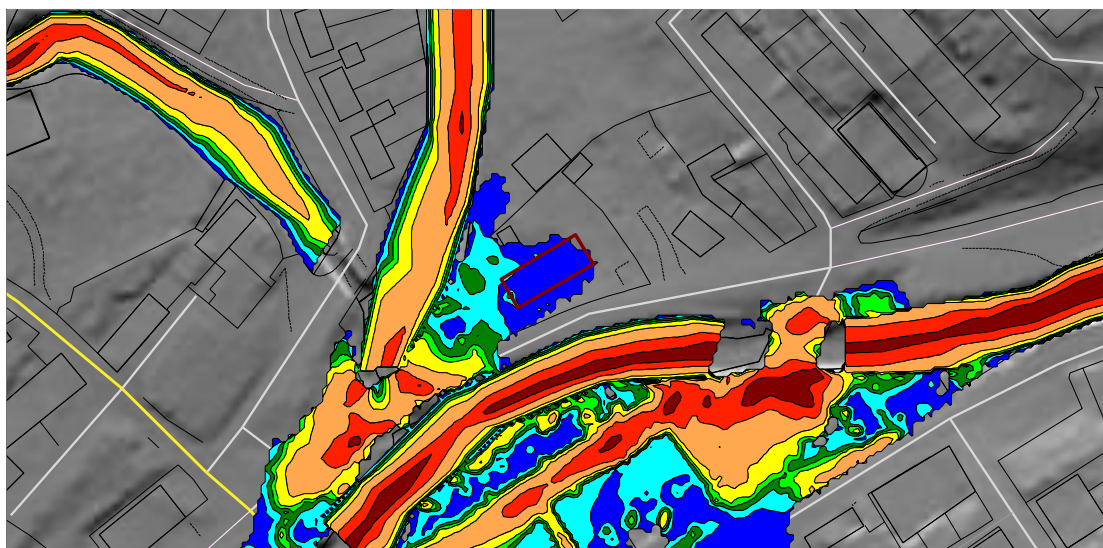


Figure 4.7 – Q1000 Flood Velocity

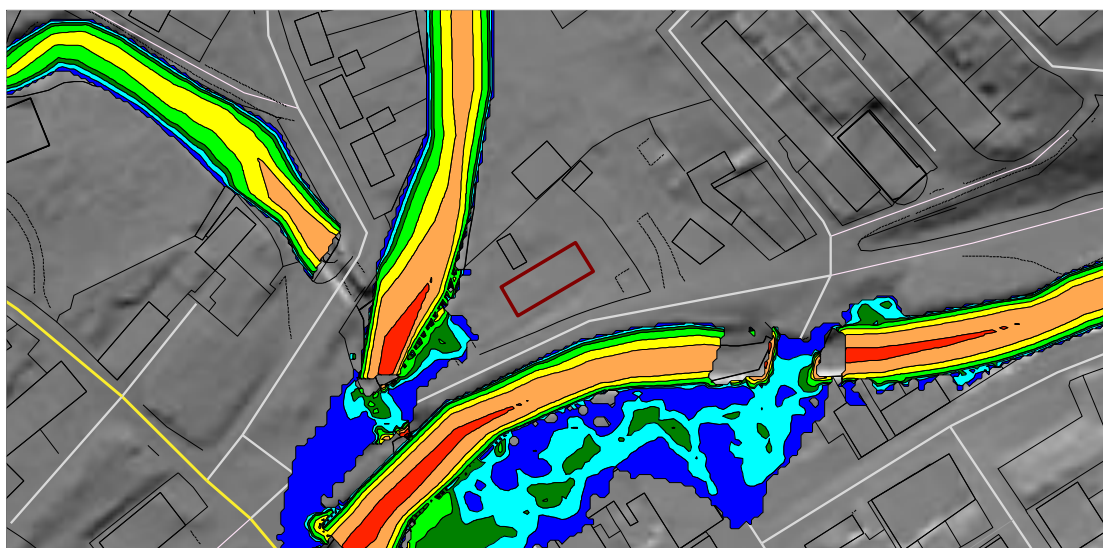


Figure 4.8 – Q100 Flood Depths - With $n = 0.05$

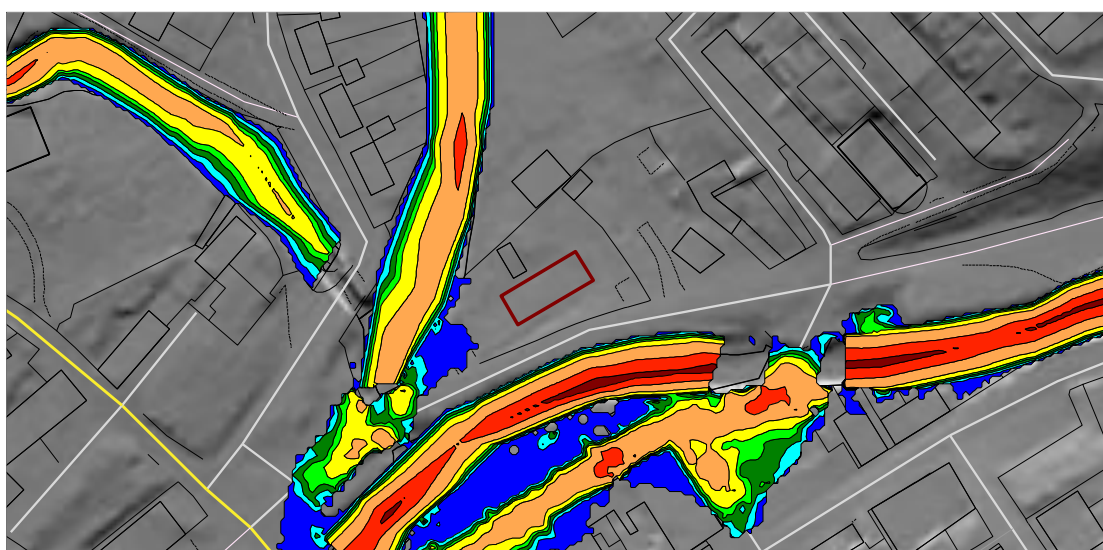


Figure 4.9 – Q100 Flood Velocity - With $n = 0.05$

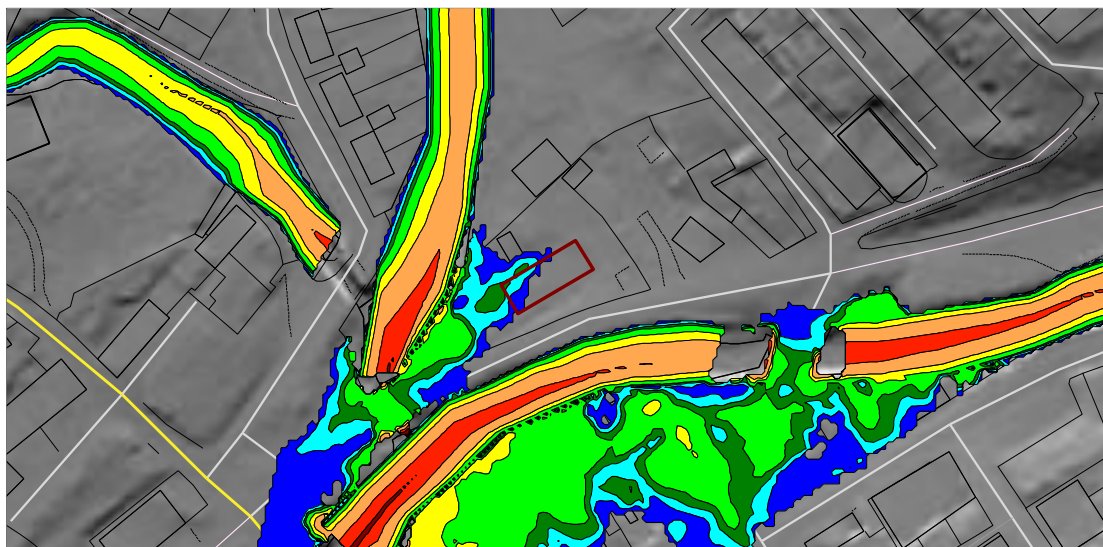


Figure 4.10 – Q100 + CC Flood Depths - With $n = 0.05$

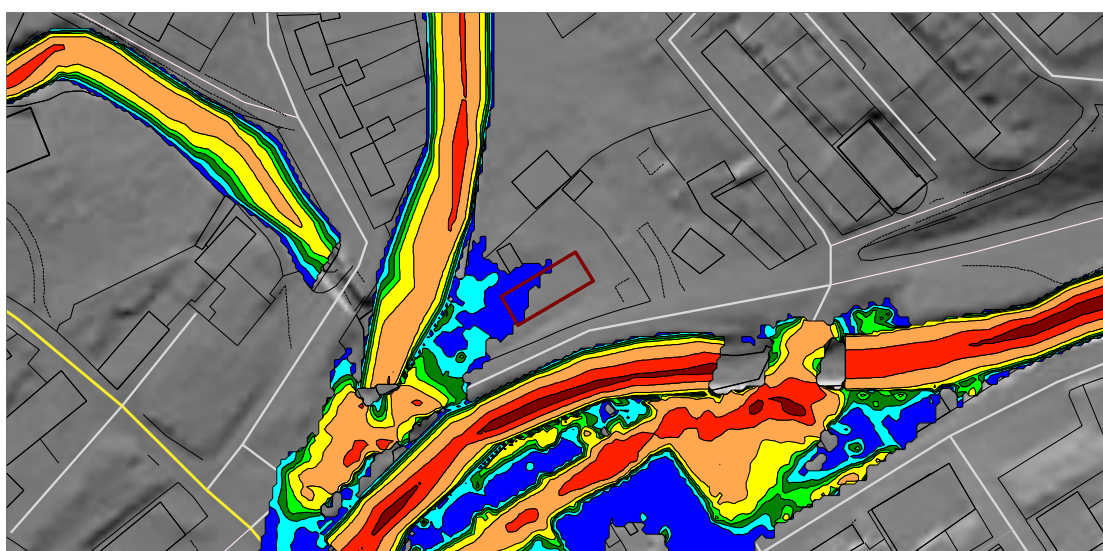


Figure 4.11 – Q100 + CC Flood Velocity - With $n = 0.05$

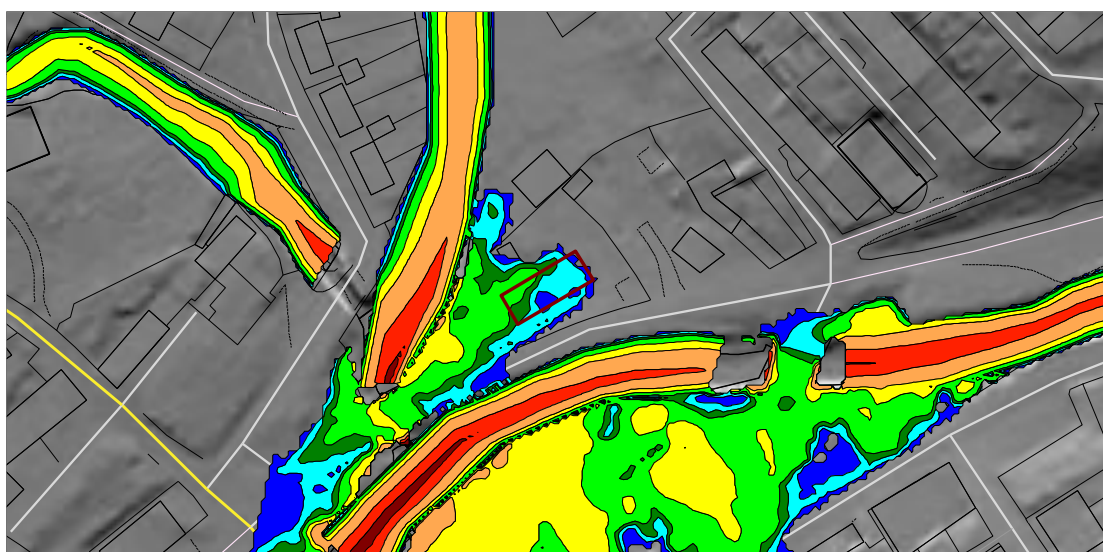


Figure 4.12 – Q1000 Flood Depths - With $n = 0.05$

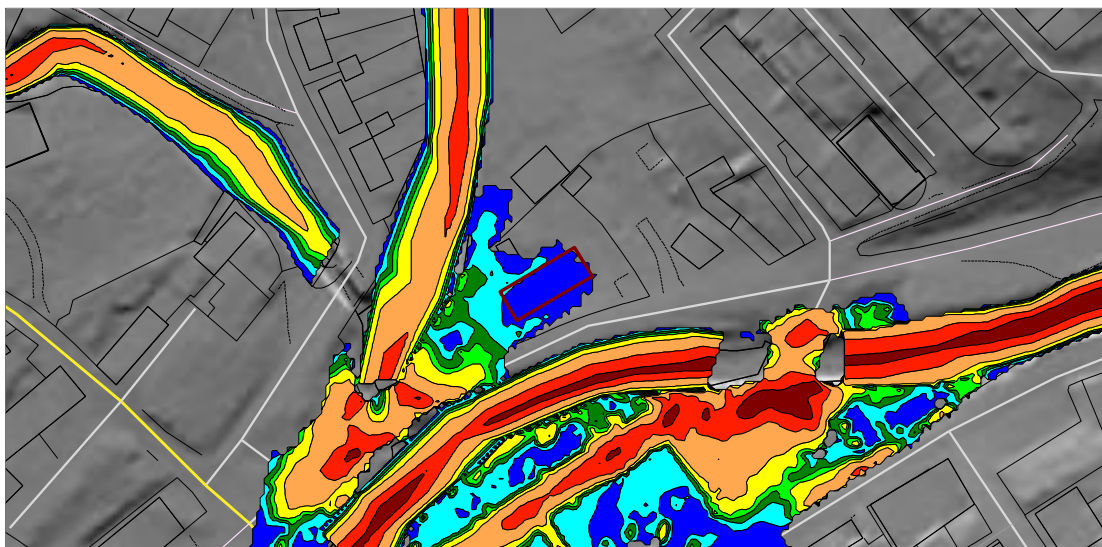


Figure 4.13 – Q100 Flood Velocity - With $n = 0.05$

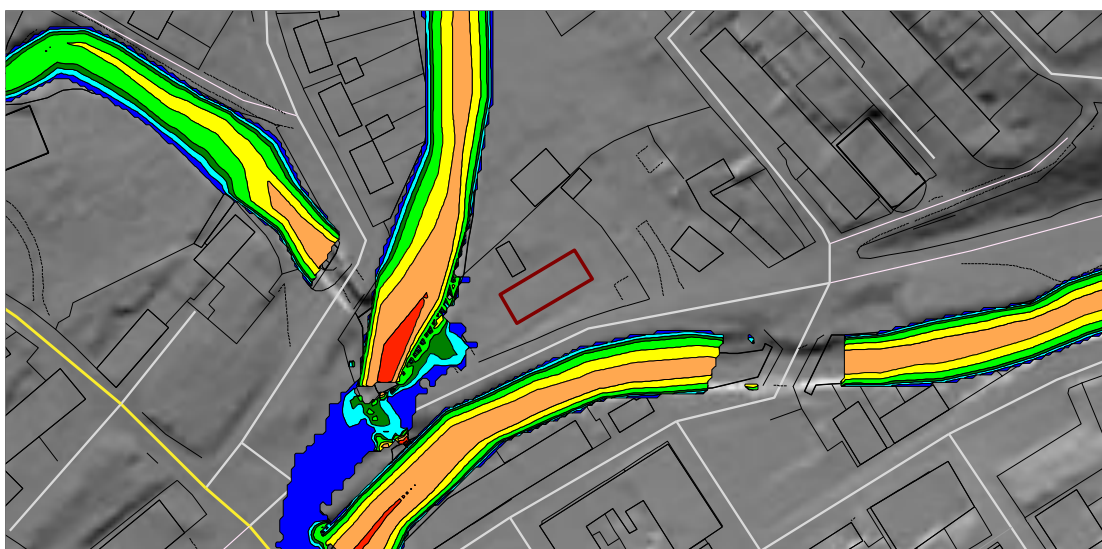


Figure 4.14 – Q100 Flood Depths - With $n = 0.033$

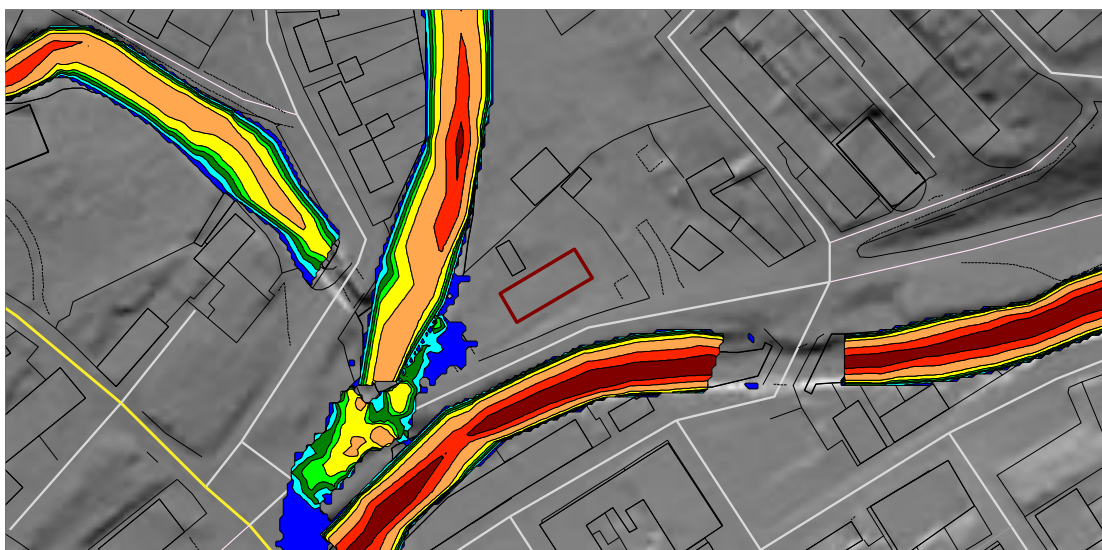


Figure 4.15 – Q100 Flood Velocity - With $n = 0.033$

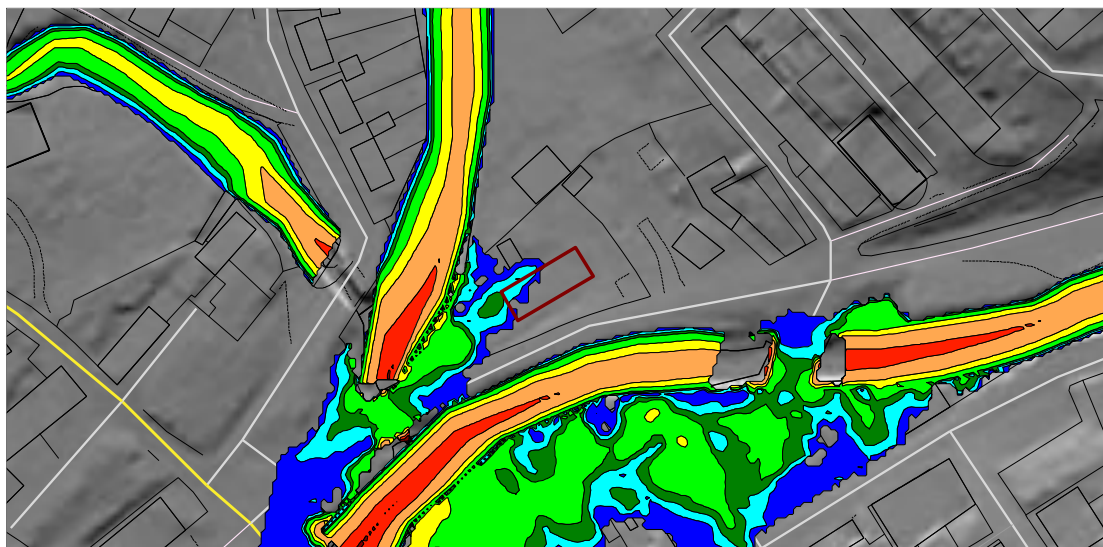


Figure 4.16 – Q100+CC Flood Depths - With $n = 0.033$

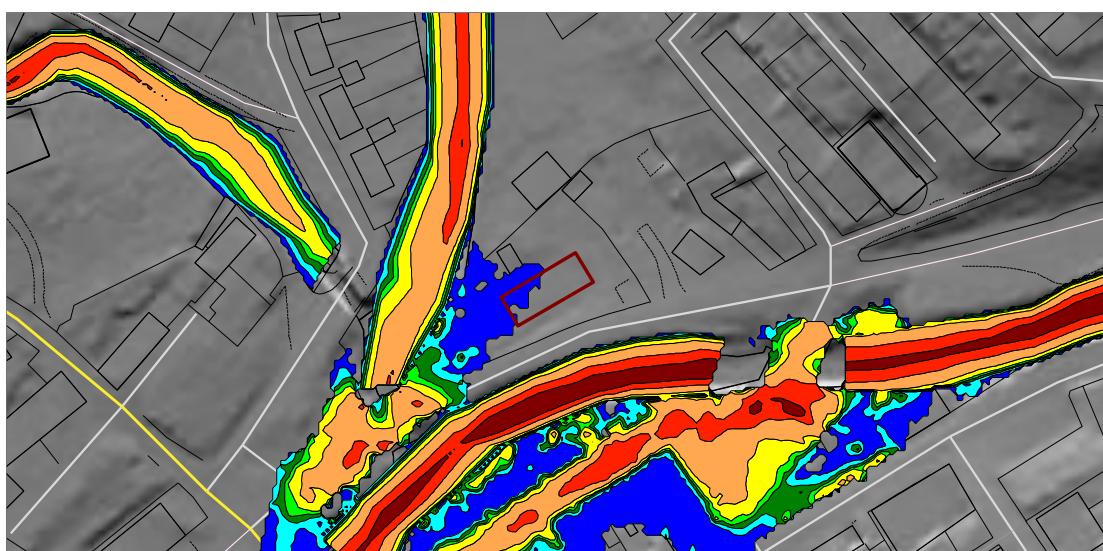


Figure 4.17 – Q100+CC Flood Velocity - With $n = 0.033$

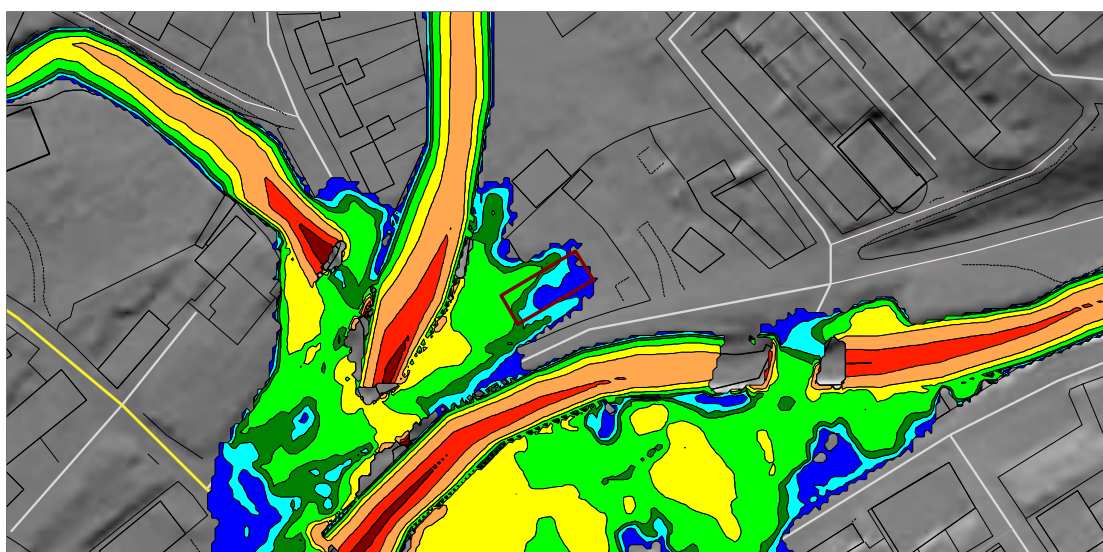


Figure 4.18 – Q1000 Flood Depths - With $n = 0.033$

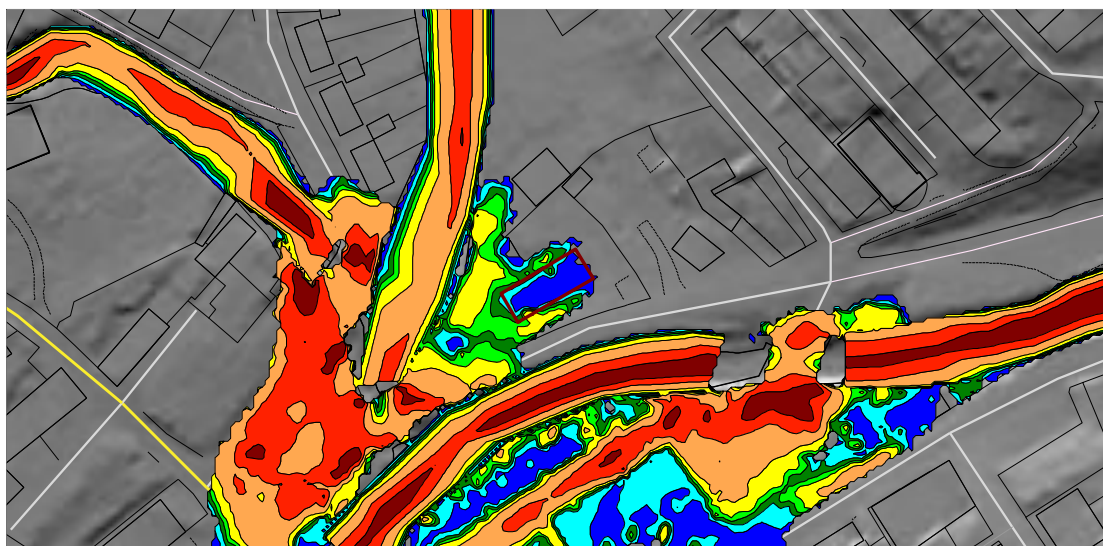


Figure 4.19 – Q1000 Flood Velocity - With $n = 0.033$

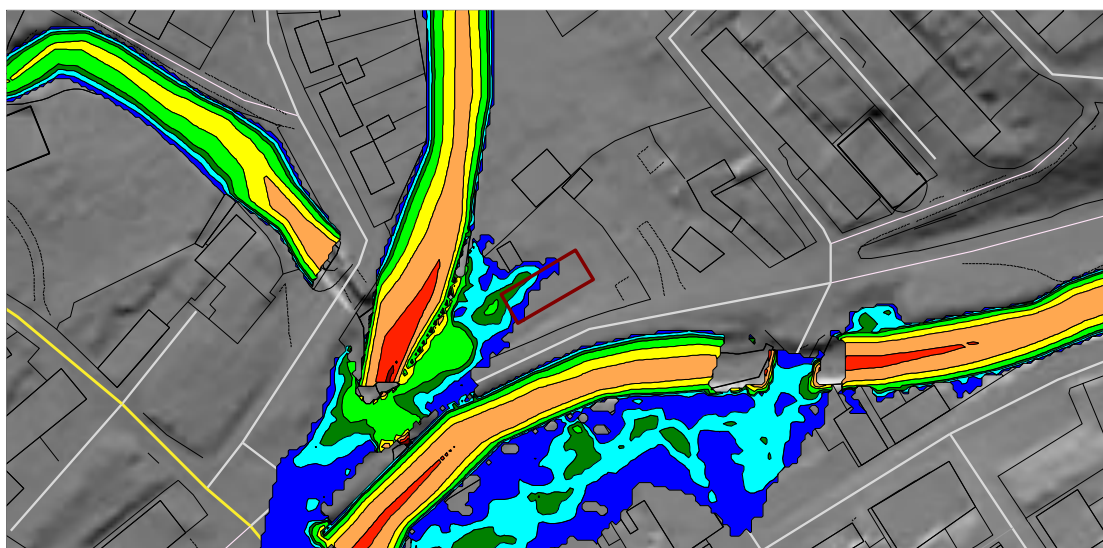


Figure 4.20 – Q100 Flood Depth - With 33% Blockage to the Downstream Bridge

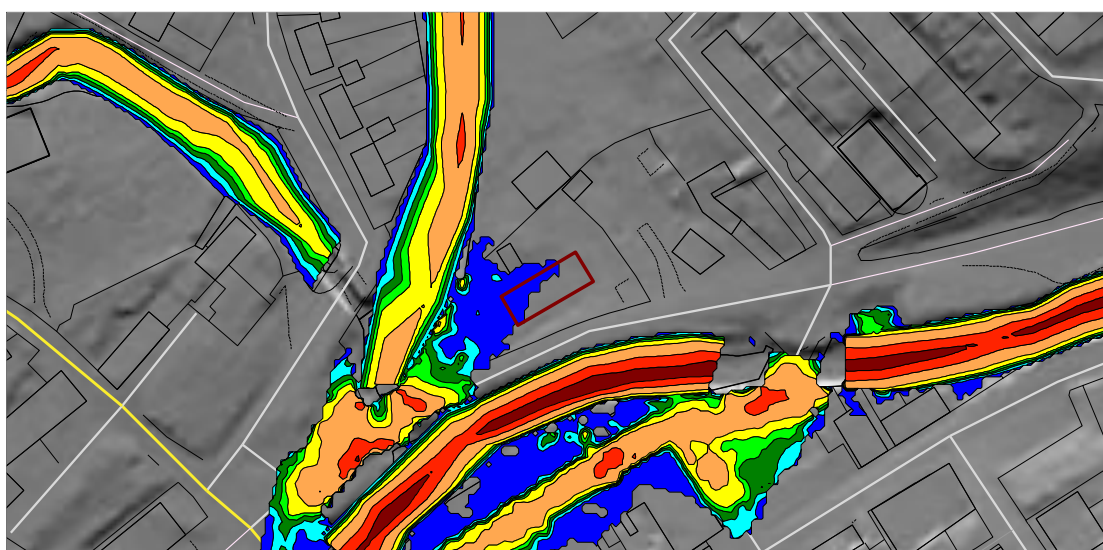


Figure 4.21 – Q100 Flood Velocity - With 33% Blockage to the Downstream Bridge

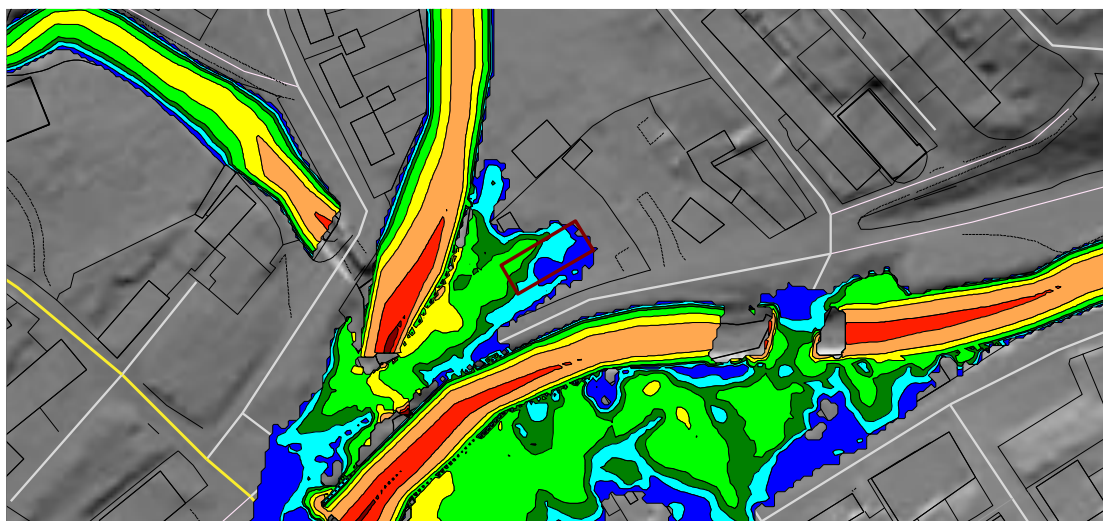


Figure 4.22 – Q100 + CC Flood Depth - With 33% Blockage to the Downstream Bridge

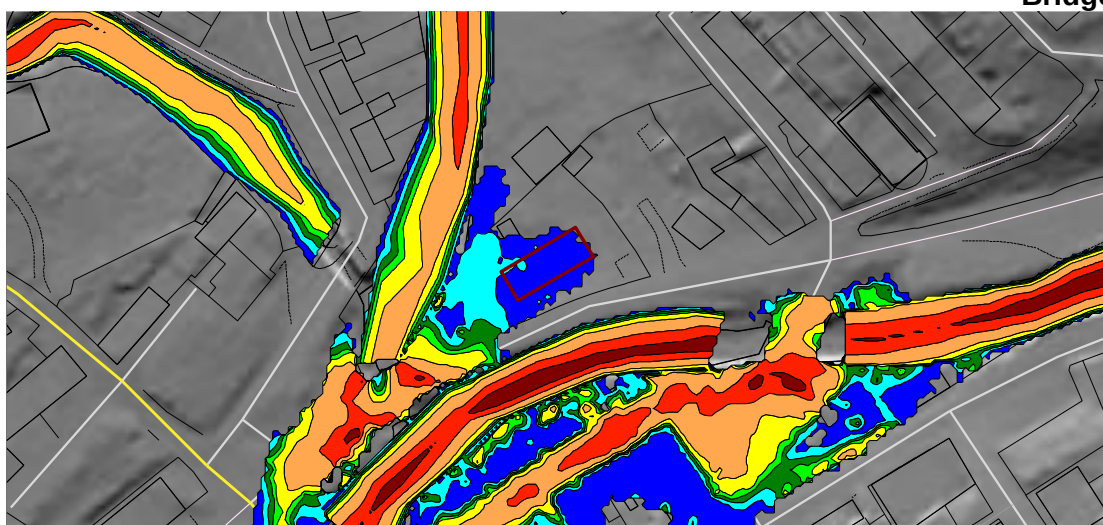


Figure 4.23 – Q100 + CC Flood Velocity - With 33% Blockage to the Downstream Bridge

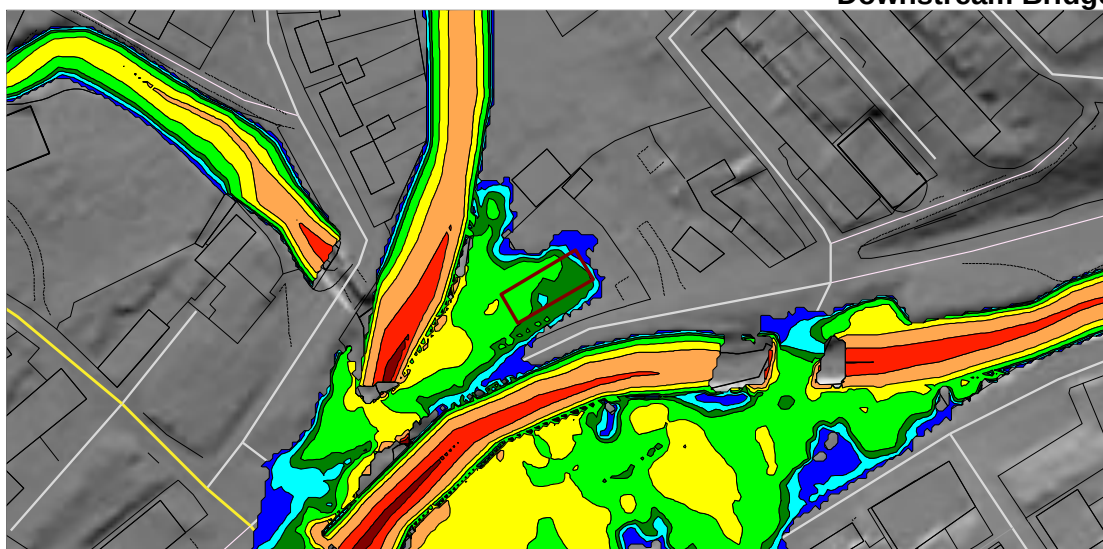


Figure 4.24 – Q1000 Flood Depth - With 33% Blockage to the Downstream Bridge

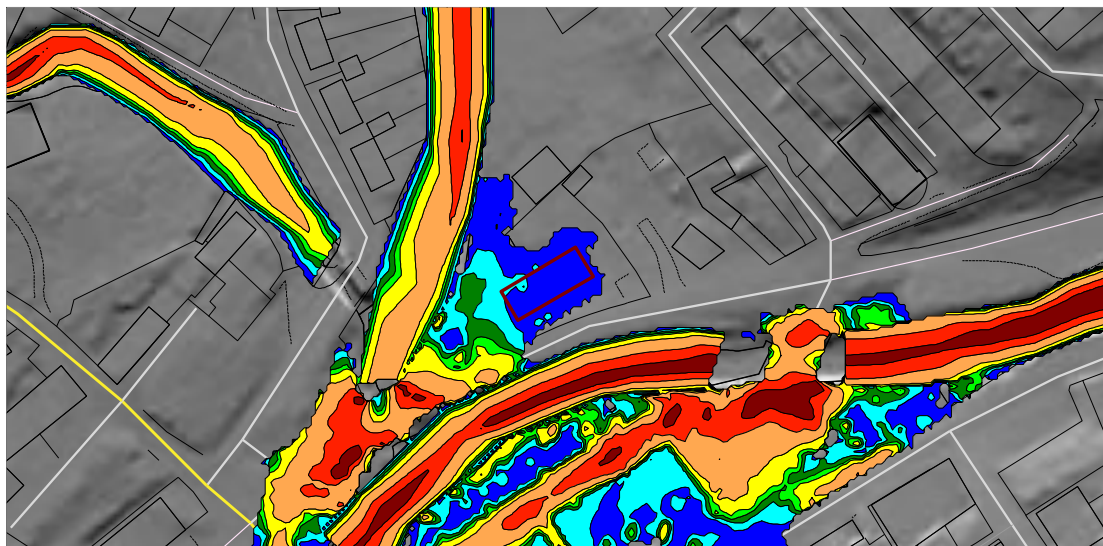


Figure 4.25 – Q1000 Flood Velocity – With 33% Blockage to the Downstream Bridge

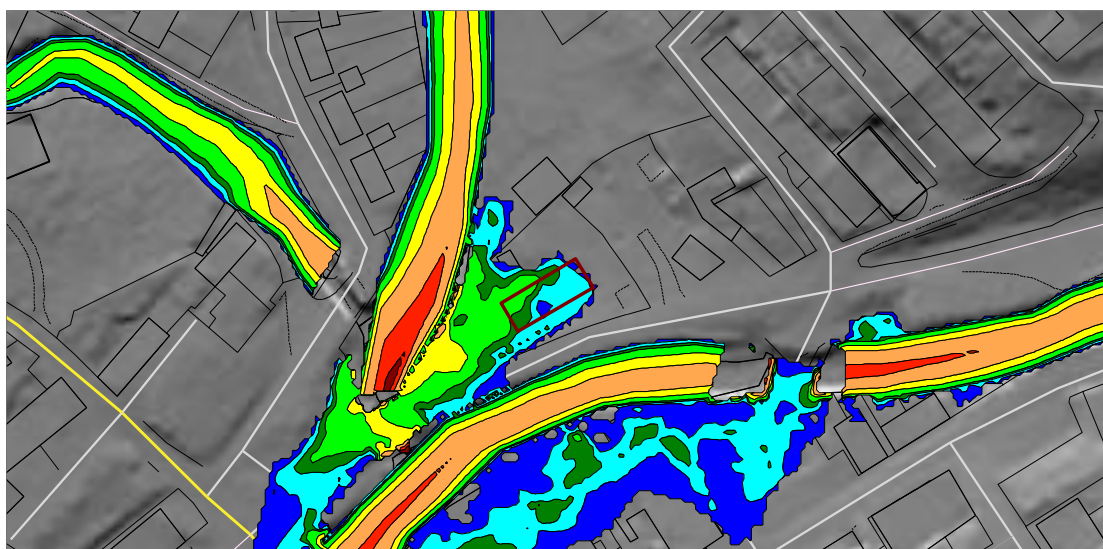


Figure 4.26 – Q100 Flood Depth - With 66% Blockage to the Downstream Bridge

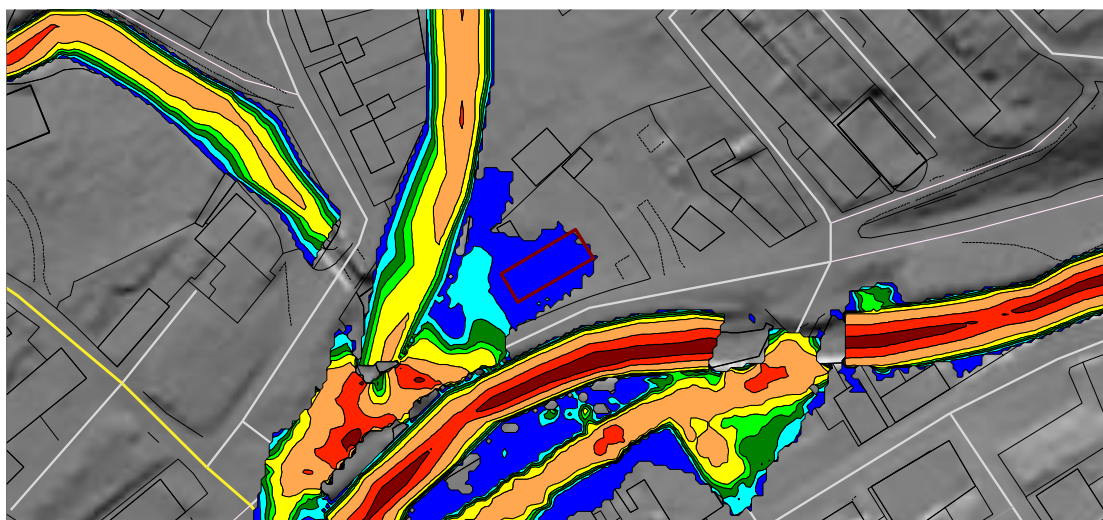


Figure 4.27 – Q100 Flood Velocity - With 66% Blockage to the Downstream Bridge

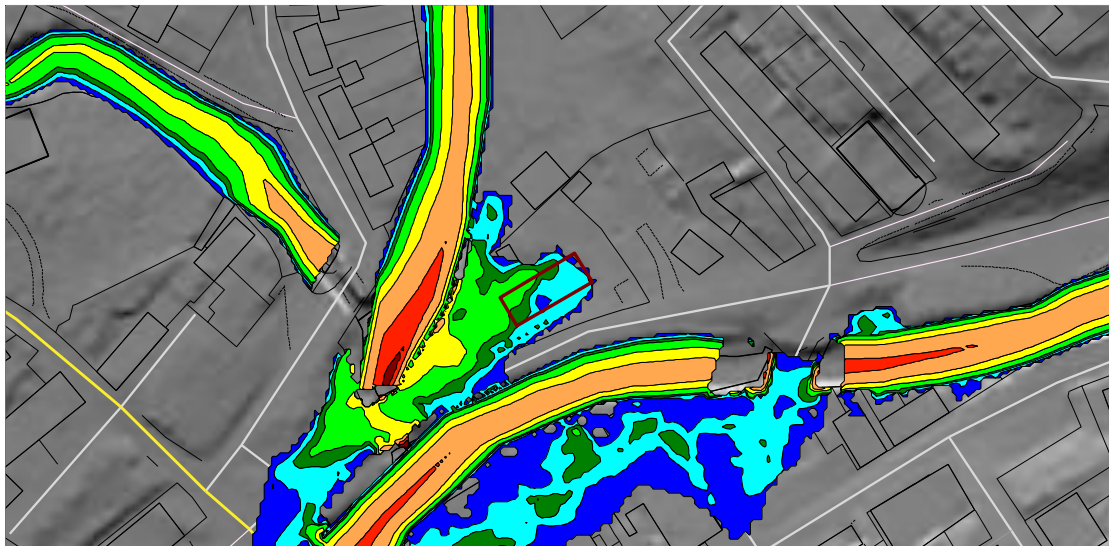


Figure 4.28 – Q100 + CC Flood Depth - With 66% Blockage to the Downstream Bridge

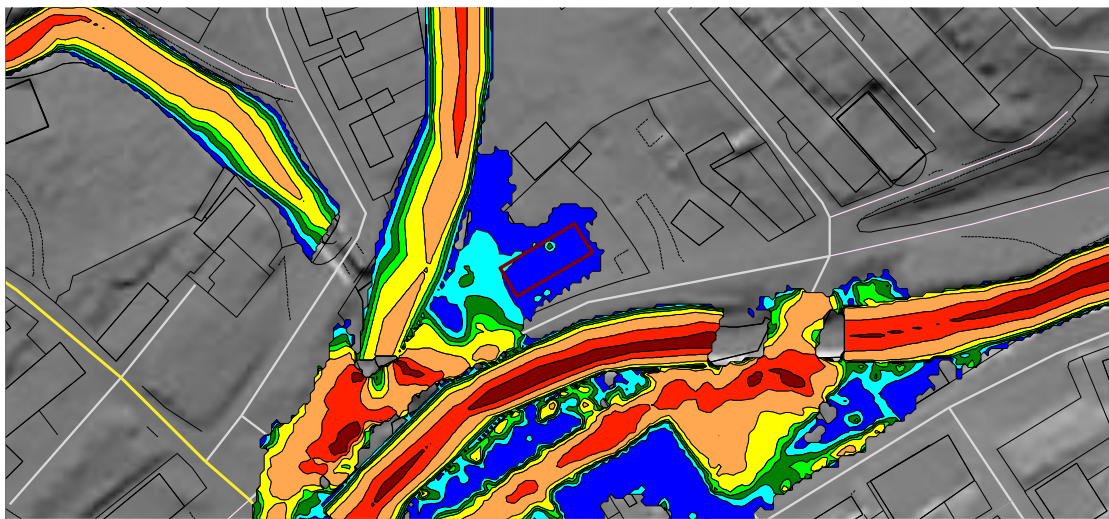


Figure 4.29 – Q100 + CC Flood Velocity - With 66% Blockage to the Downstream Bridge

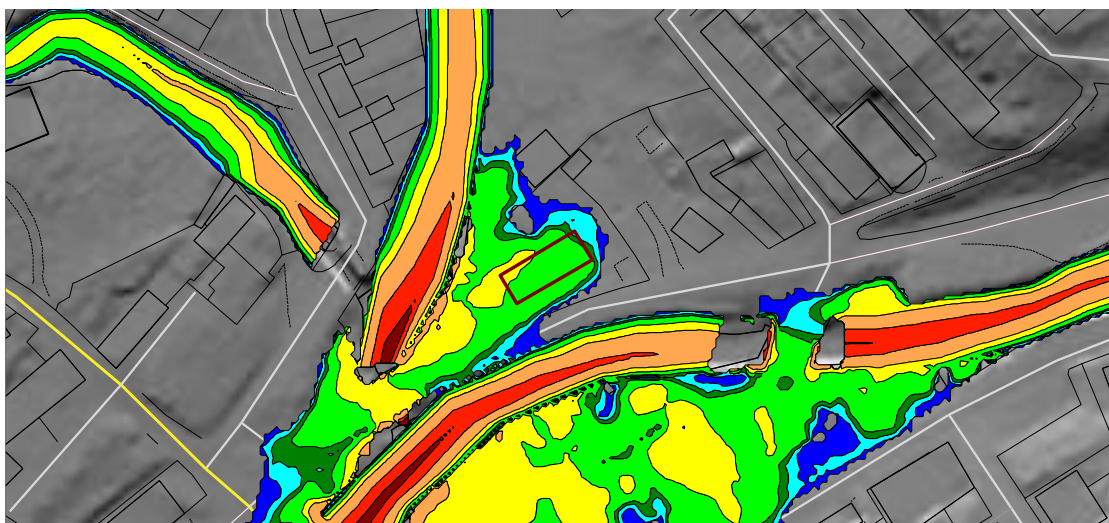


Figure 4.30 – Q1000 Flood Depth - With 66% Blockage to the Downstream Bridge

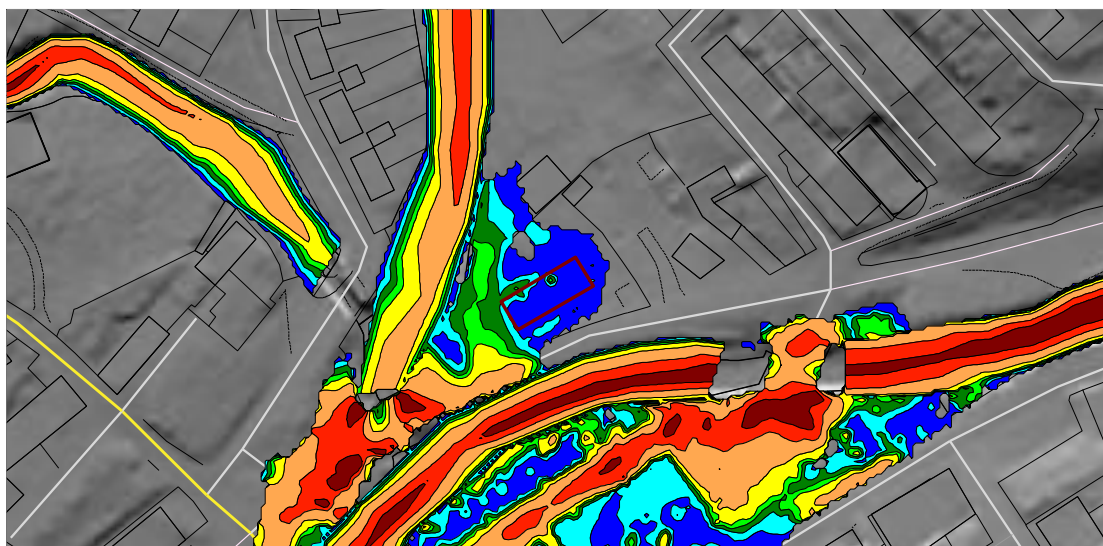


Figure 4.31 – Q1000 Flood Velocity - With 66% Blockage to the Downstream Bridge

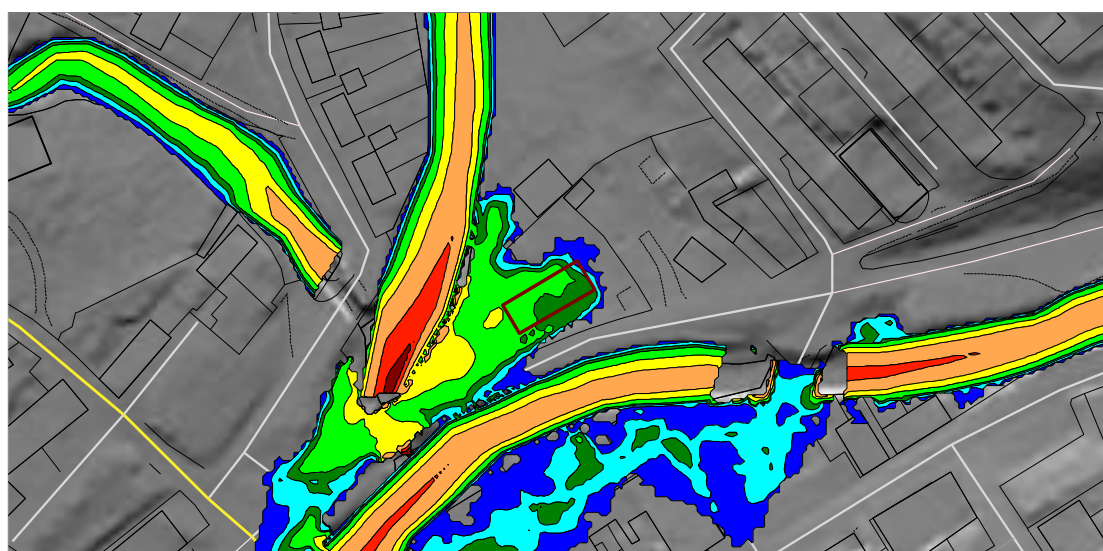


Figure 4.32 – Q100 Flood Depth - With 100% Blockage to the Downstream Bridge

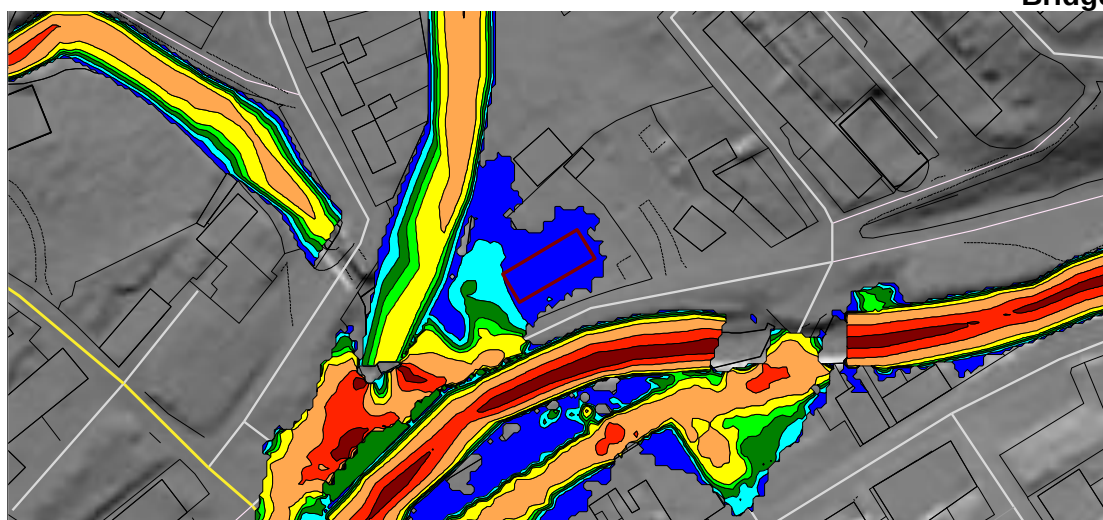


Figure 4.33 – Q100 Flood Velocity - With 100% Blockage to the Downstream Bridge

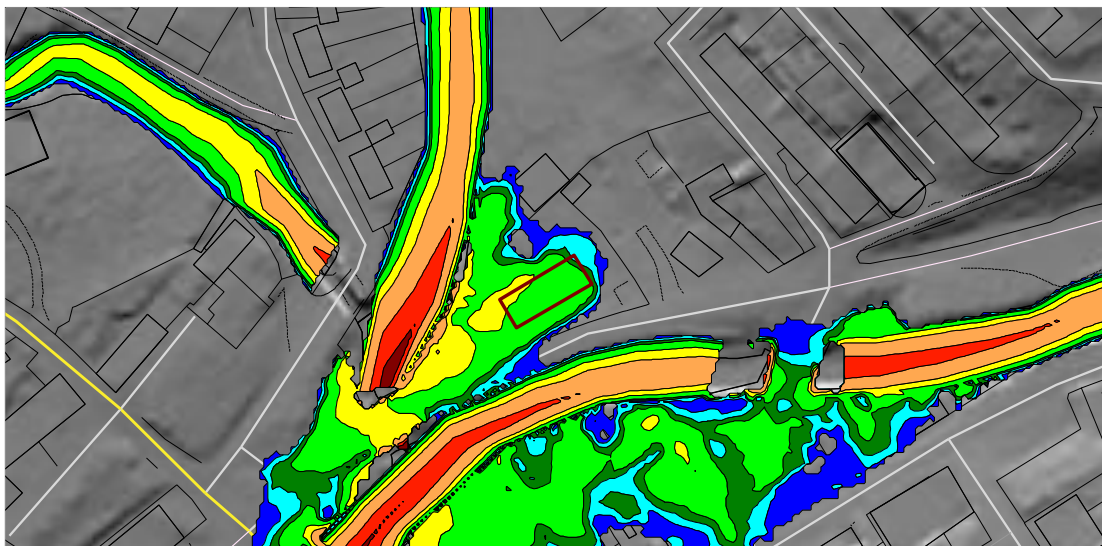


Figure 4.34 – Q100+CC Flood Depth - With 100% Blockage to the Downstream Bridge

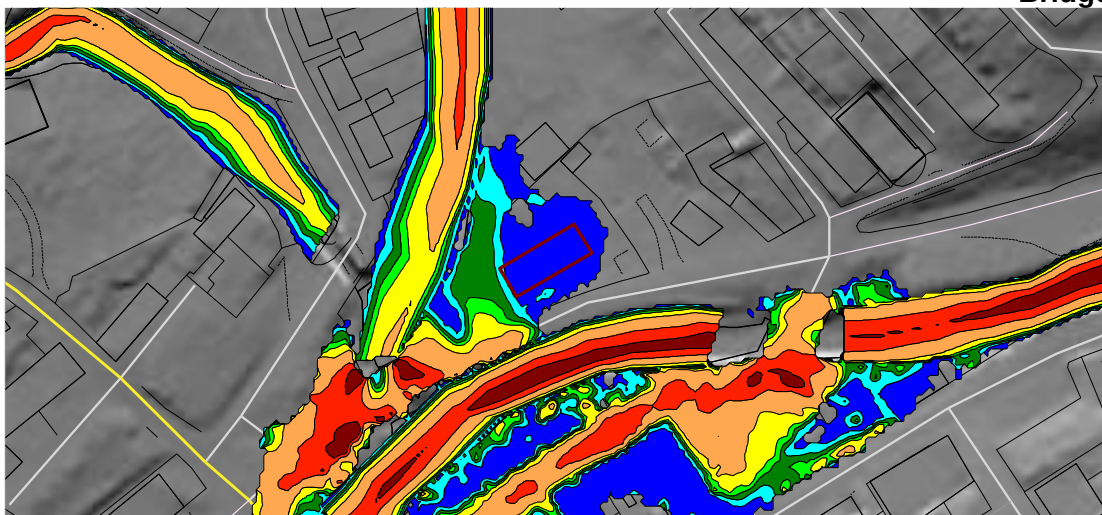


Figure 4.35 – Q100+CC Flood Velocity - With 100% Blockage to the Downstream Bridge

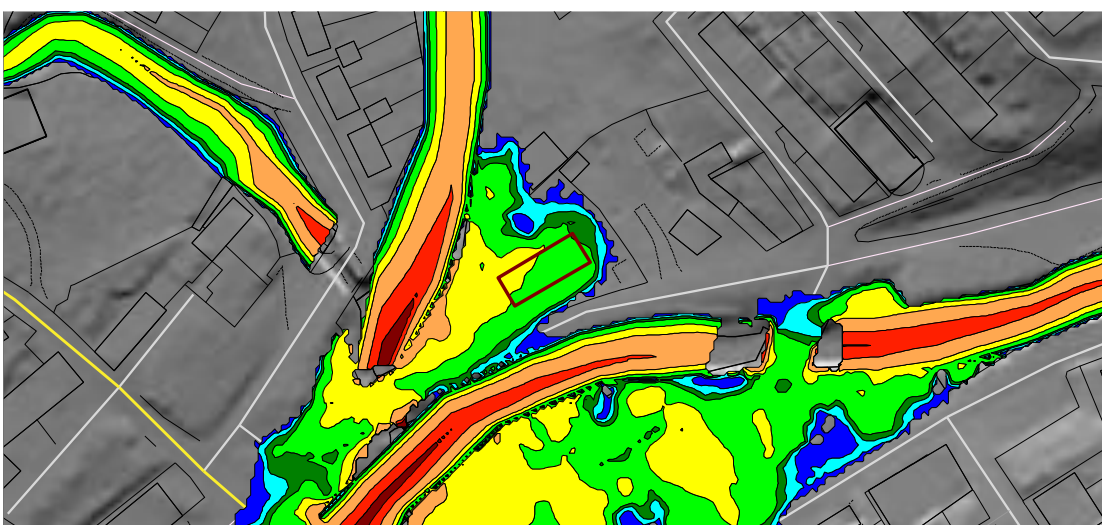


Figure 4.36 – Q1000 Flood Depth - With 100% Blockage to the Downstream Bridge

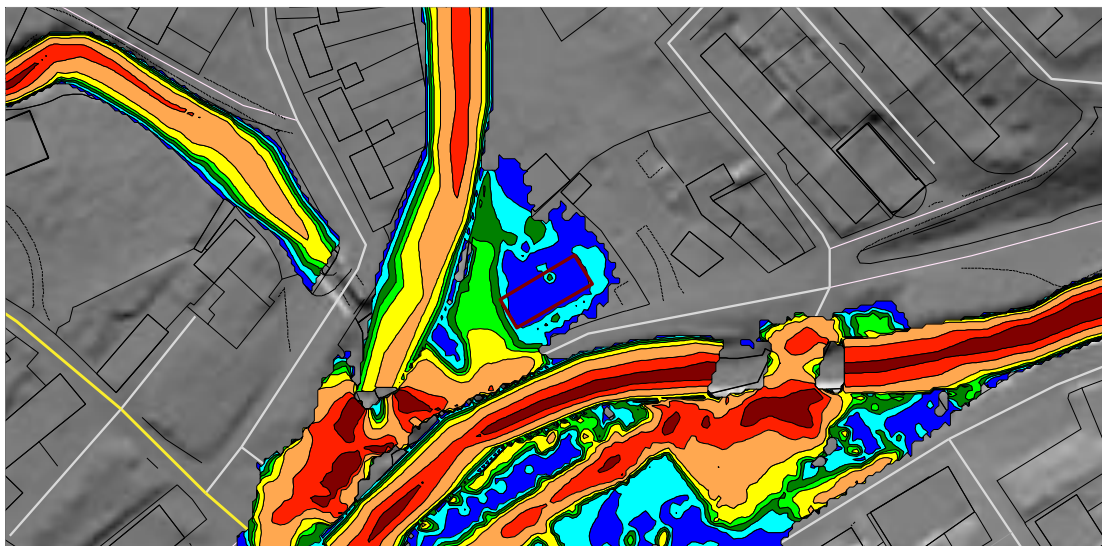


Figure 4.37 – Q1000 Flood Velocity - With 100% Blockage to the Downstream Bridge

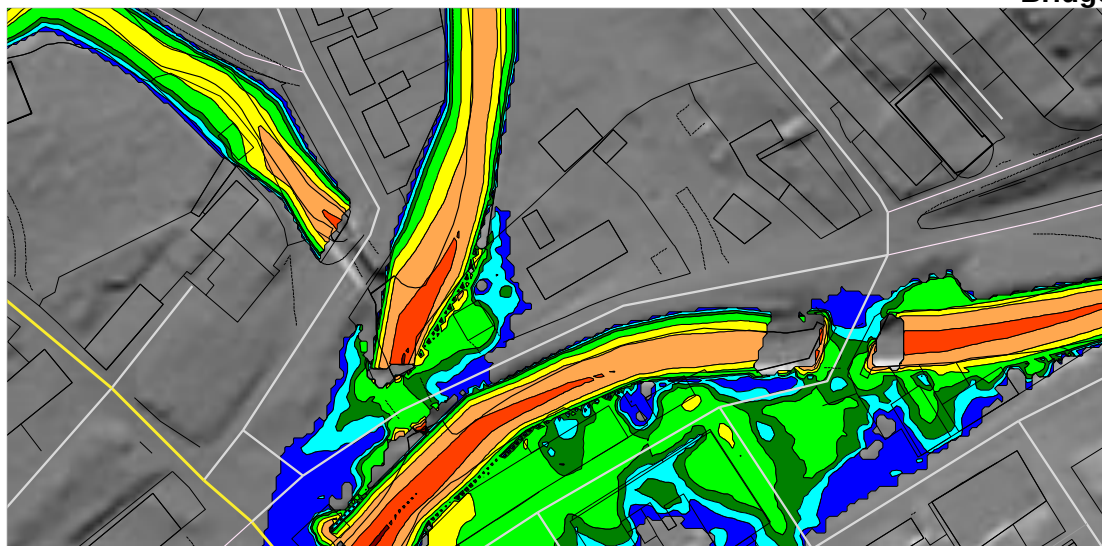


Figure 4.38 – Q100 + CC Flood Depths - Defended

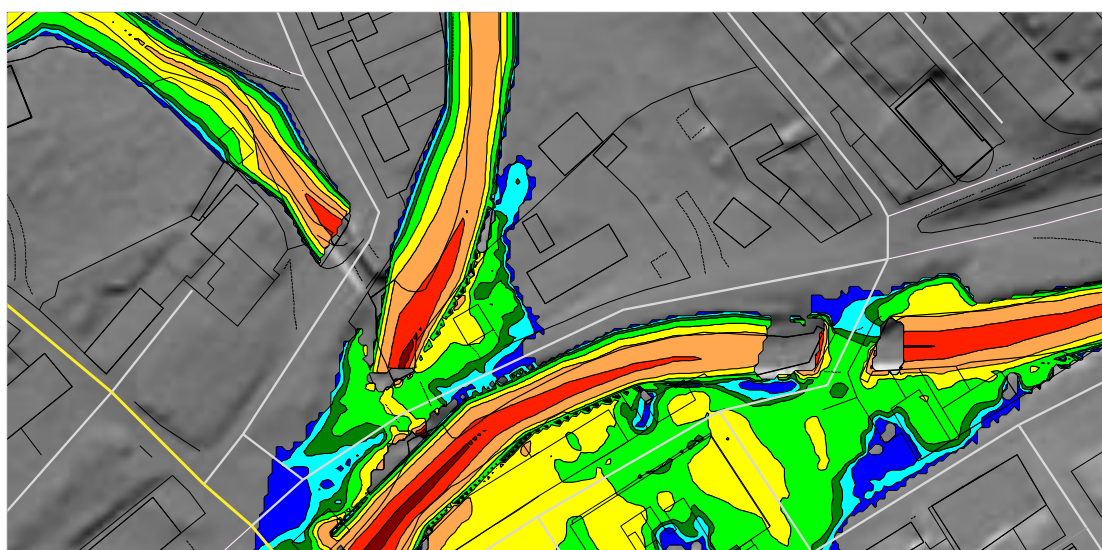


Figure 4.39 – Q1000 Flood Depths - Defended

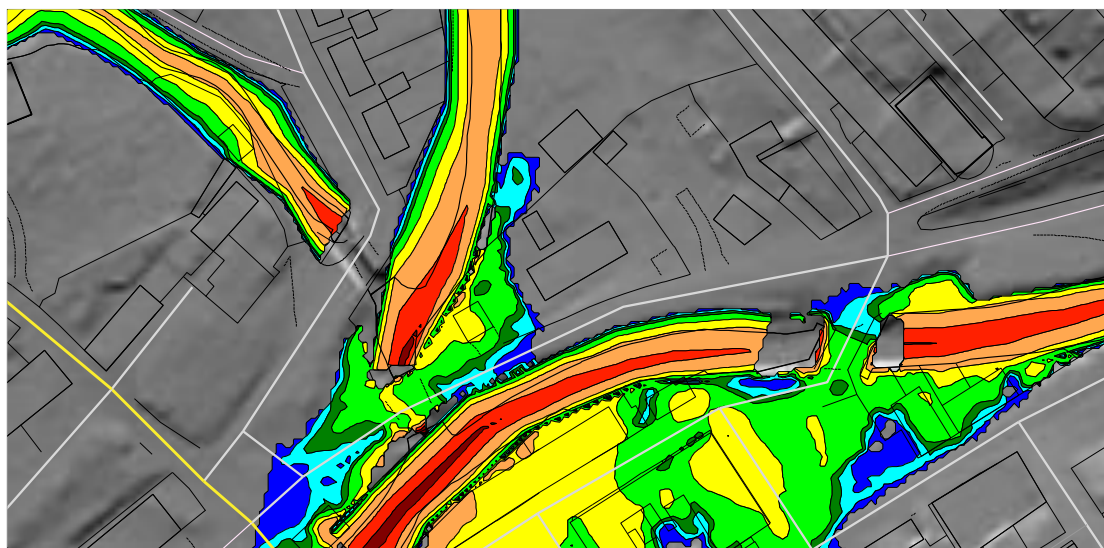


Figure 4.40 – Q1000 Flood Depths - With $n = 0.05$ - Defended

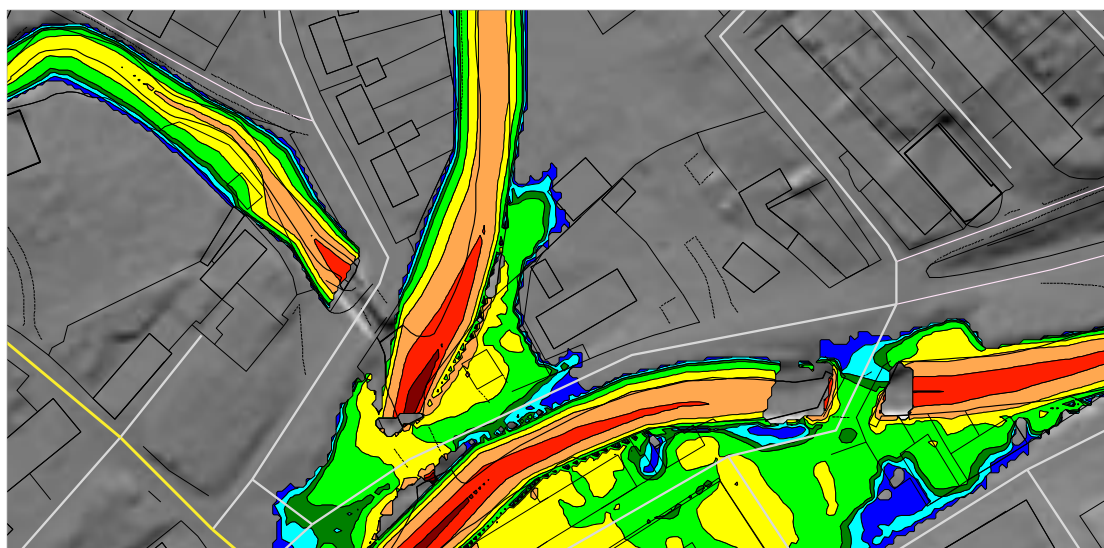


Figure 4.41 – Q1000 Flood Depth - With 66% Blockage to the Downstream Bridge - Defended

5 FLOOD RISK

Flooding can occur from various sources including fluvial and surface water. This section discusses the risk at the site from the various ways.

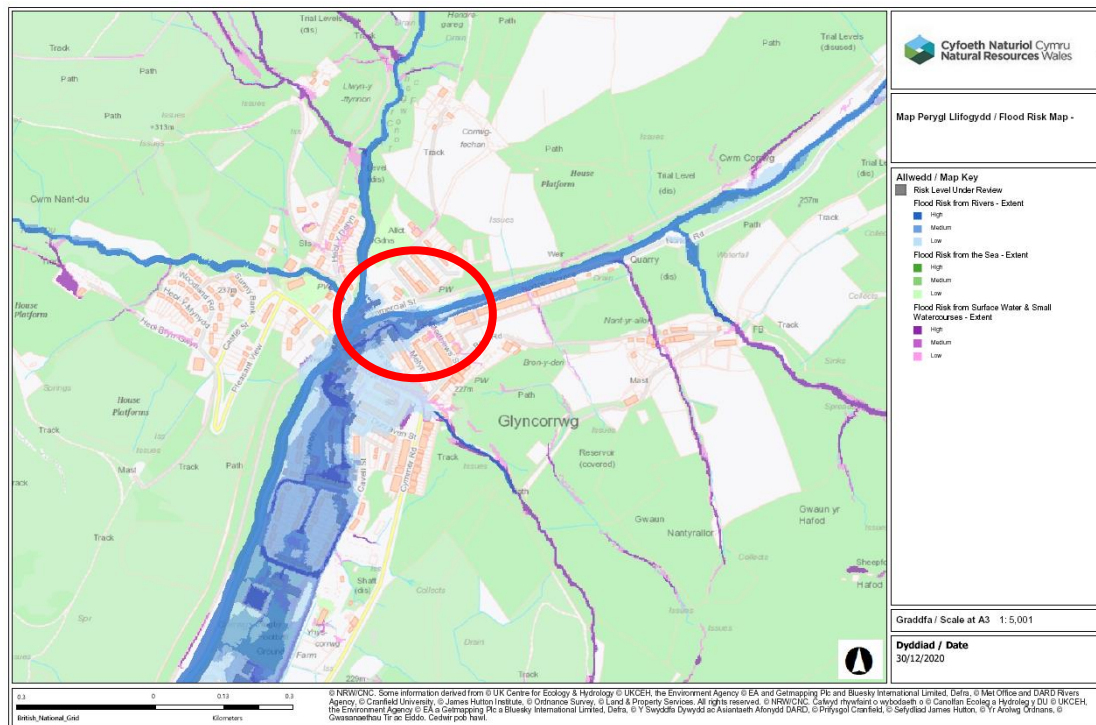


Figure 5.1 - NRW Flood Map

Fluvial Flooding

The Flood Map for Planning indicate that the western side of the site is at risk of flooding during the Q100+CC event and nearly all of the site is at risk during the Q1000 event.

To assess this risk in detail a hydraulic 2d model, using TUFLOW, was built and run for the Q100, Q100+CC and the Q1000 flows. The model showed that the site is expected to remain flood free during the Q100, and the risk is not overly sensitive to the friction of the stream bed. However, a blockage to the downstream culvert could result in the site being affected.

Part of the site could be at risk of flooding during the Q100+CC and the property could be at risk during the Q1000, however, the depth of flooding is not expected to exceed 600mm for all considered events. Even if the property becomes flooded the flow velocity is expected to be less than 0.15m/s.

As the existing building has a residential element on both floors it can be considered to be more vulnerable development which will not change as part of the proposals. To reduce the risk of flooding, however, it is proposed to build a flood wall between the building stream. This will ensure that the site remains flood free even during a Q1000 event for the considered scenarios. The model also found that the detrimental impact of the flood wall will generally be retained to land in the control of the client or permission has been given by the land owner for the minor impact (see Figure 5.3 5.4 and Table 5.1).

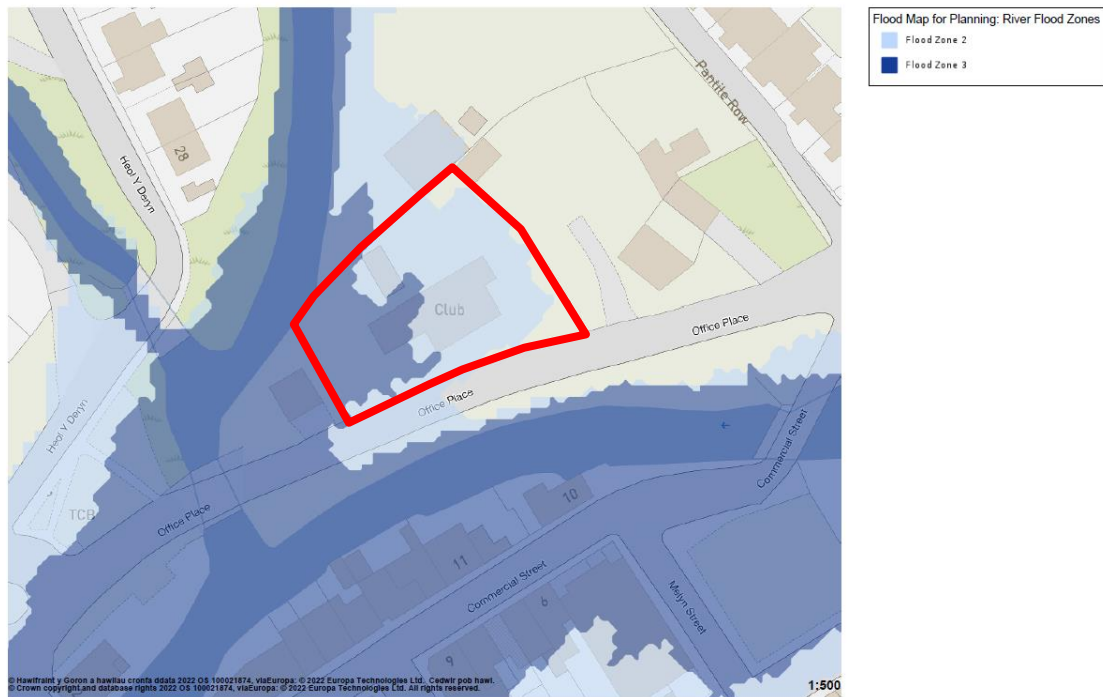


Figure 5.2 – Flood Maps For Planning - Fluvial

Table 5.1 Change in Depth Key	
Region	Depth
	< 0.050m
	-0.050m to -0.025m
	-0.025m to -0.005m
	-0.005m to 0.005m
	0.005m to 0.025m
	0.025m to 0.050m
	> 0.050m



Figure 5.3 - Q1000 Impact of Defended



Figure 5.4 - Q1000 Impact of Defended With 66% Blockage

Coastal Tide Levels.

The site is not expected to be at risk from a tidal source.

Surface Water

The Flood Maps for Planning shows that the site is not at risk from surface water flooding during the Q100 event but some water could collect on the northern side of the building during a Q1000 year event (see Figure 5.5). The water is from pooling rather than from discharge from a water course or other drainage system and measures can be put in place to remove this risk. The hazard level for the flooding is considered to be low (see Figure 5.6).

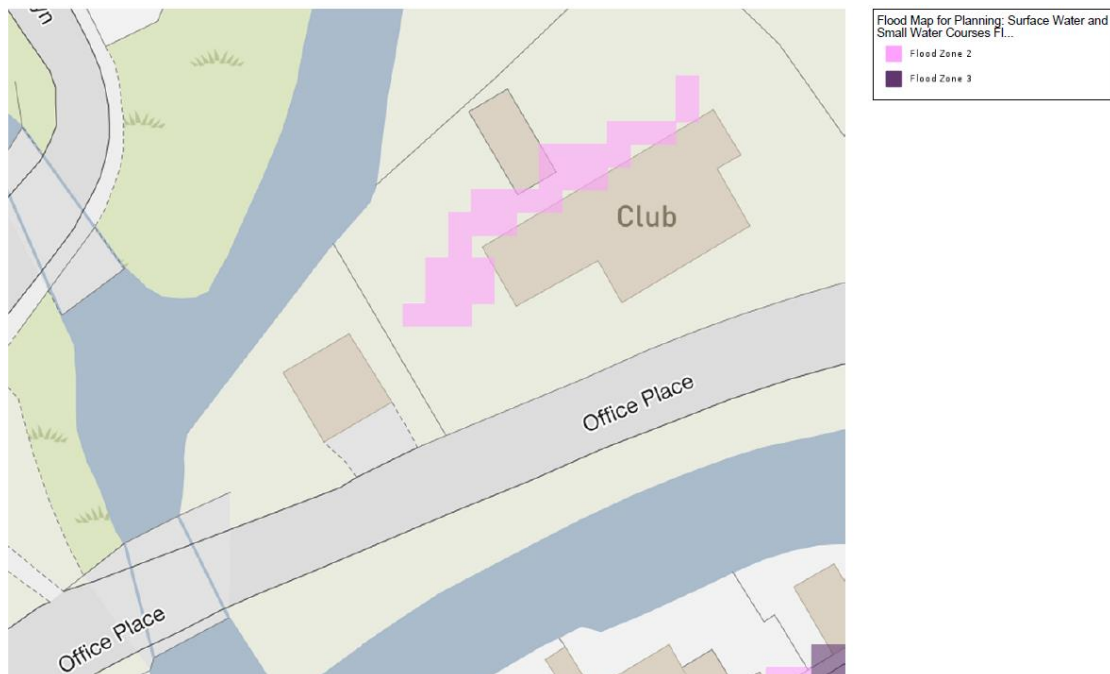


Figure 5.5 – Surface Water Flood Map For Planning

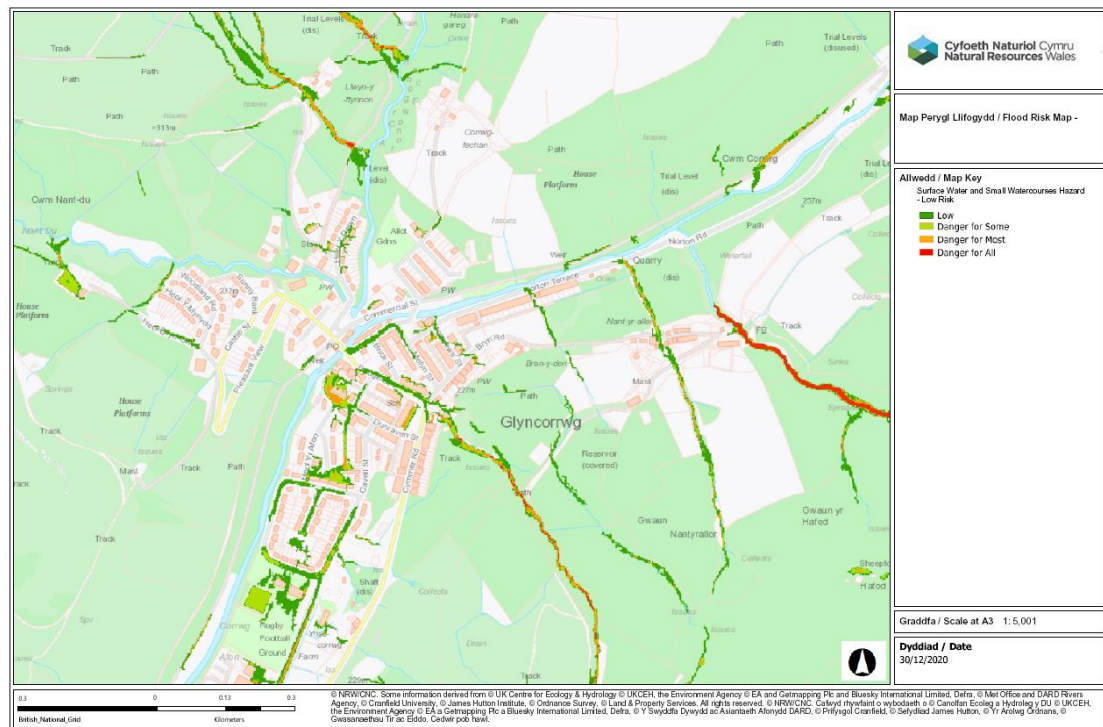


Figure 5.4 – Q1000 Surface Water Hazard Map

Sustainable Drainage

As the development is the refurbishment of an existing building, the installation of a sustainable drainage system is not strictly required. However, as a matter of good practice it is recommended that such a system is considered in accordance with new Welsh Government Standards and the SUDS manual.

Sewage Backflow.

The building is already connected to the main foul sewer system. Care should be taken to ensure that ground water can't enter, and safeguards should be put in place to prevent sewage from backing up into the development during flood conditions.

Flooding From a Reservoir Failure

The site is not considered at risk of flooding from a Reservoir Failure.

Ground Water

There could be some superficial geology of Clay, Silt, Sand, and Gravel from Alluvium on the western side of the site along with some Diamicton from Devensian Till on the eastern side of the site (see Figure 5.5). The superficial geology lies over a bedrock geology of Sandstone from the Brithdir Member (see Figure 5.6). When also taking the terrain into account the risk of groundwater flooding is considered to be low.

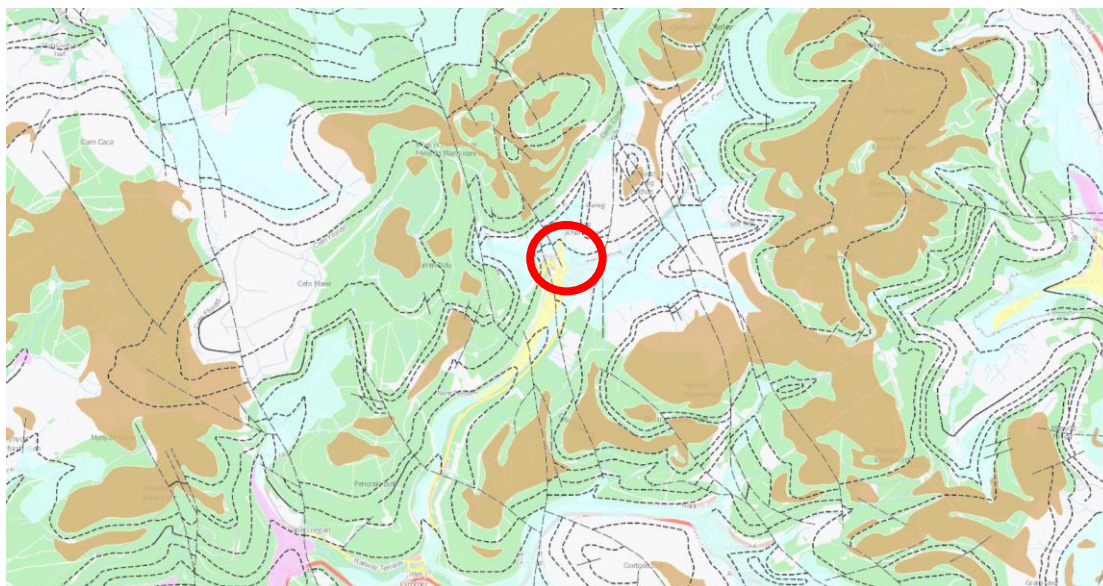


Figure 5.5 – Superficial Geology

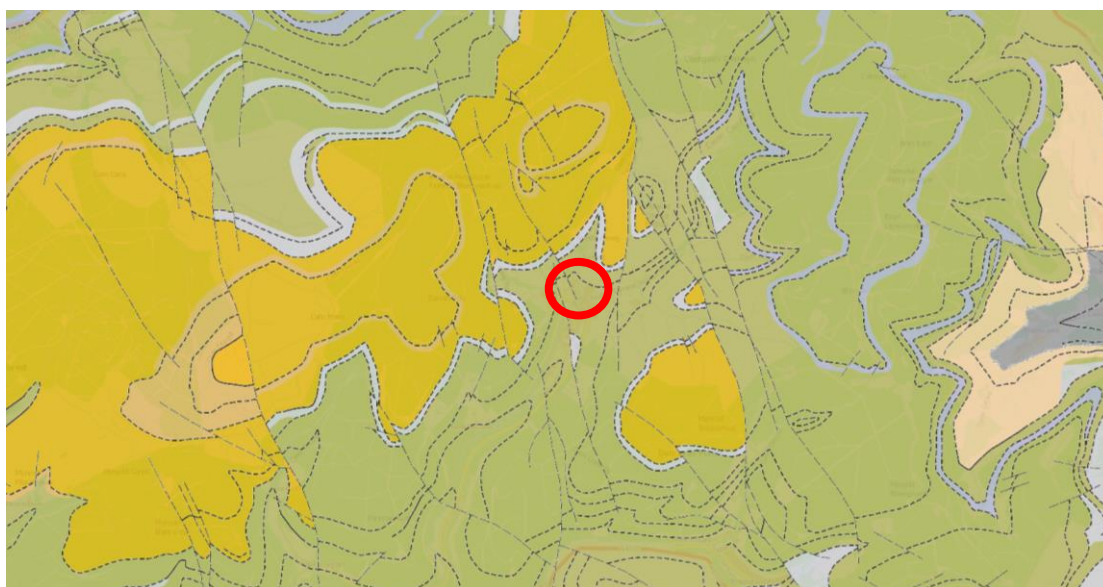


Figure 5.6 – Bedrock Geology

6 FLOOD PROOF MEASURES

Section 3 indicates that the existing building, and some of the surrounding land, on the site of consideration, potentially could be at risk of flooding from a tidal event, particularly when climate change is taken into consideration. Flooding can result in the need for expensive repairs. As well as the direct damage caused to the building, flooding can impact in many other, and possibly more stressful, ways. The inconvenience of cleaning up a home and the loss of sentimental valuables, can be immeasurable. There are methods, however, to limit and mitigate against the consequence of flood damage. Some of these are discussed in this section and should be considered as part of the development where applicable.

Water can enter a building:

- Around the edges of closed doors;
- Through airbricks;
- Backflow through overloaded sewers;
- Seepage through walls especially cracks;
- Seepage through the ground;
- Around cable / services entrance into the building.

Dryproofing - Preventing the water from entering the building.

In the first instance it is possible to take measures to prevent the ingress of water (dryproof).

- There are several propriety barriers available, however, these can be expensive. A boundary flood wall could however be constructed to provide protection against the adjacent stream.
- It would be appropriate to ensure that the walls of the building are able to act as a barrier themselves. Care should be taken to ensure that the pointing and any external plastering are kept in good order and that all cracks and gaps around cables and ducts entering the building are sealed.
- Providing temporary covers to any low air vents. These covers should be removed once the risk of flooding is over.
- Erecting a temporary barrier in front of any external doors or installing flood protection doors.
- Installing a valve allowing the sewer system to be shut preventing any back flow.

Wetproofing – Limiting the damage once water has entered a building.

It may not be feasible to completely eliminate the risk of flooding, however, it is possible to limit the damage that the water can cause once in the building (wetproof).

Where appropriate the following could be considered as part of the renovations:

- Move valuable items to a higher level;
- Have solid concrete floors. Suspended floors are more difficult to clean and dry underneath;
- Use water resistant render for walls;
- Use non water absorbing insulation;
- Use corrosion resistant fittings such as galvanised or stainless steel;
- Ensure that the ground floor electrics are on a separate circuit to the rest of the buildings and that the ground floor electric cables are fed from above with the sockets kept high;
- Use an appropriate damp proof course;
- Avoid timber frame construction on the ground floor including any internal partition walls;

- Consider freestanding movable equipment;
- Install any equipment with motors high up from the floor;
- Install solid internal and external doors effectively sealed;
- Avoid storage heaters on the ground floor;
- Ensure boilers are off the ground.

A flood response plan should be prepared and regularly maintained. All future occupiers should be made aware of the flood risk and what actions are to be undertaken during an event. It is important to also have as much warning as possible to allow the flood response plan to be followed safely. This can be achieved by registering on the flood warning scheme provided by NRW (see Figure 6.1).

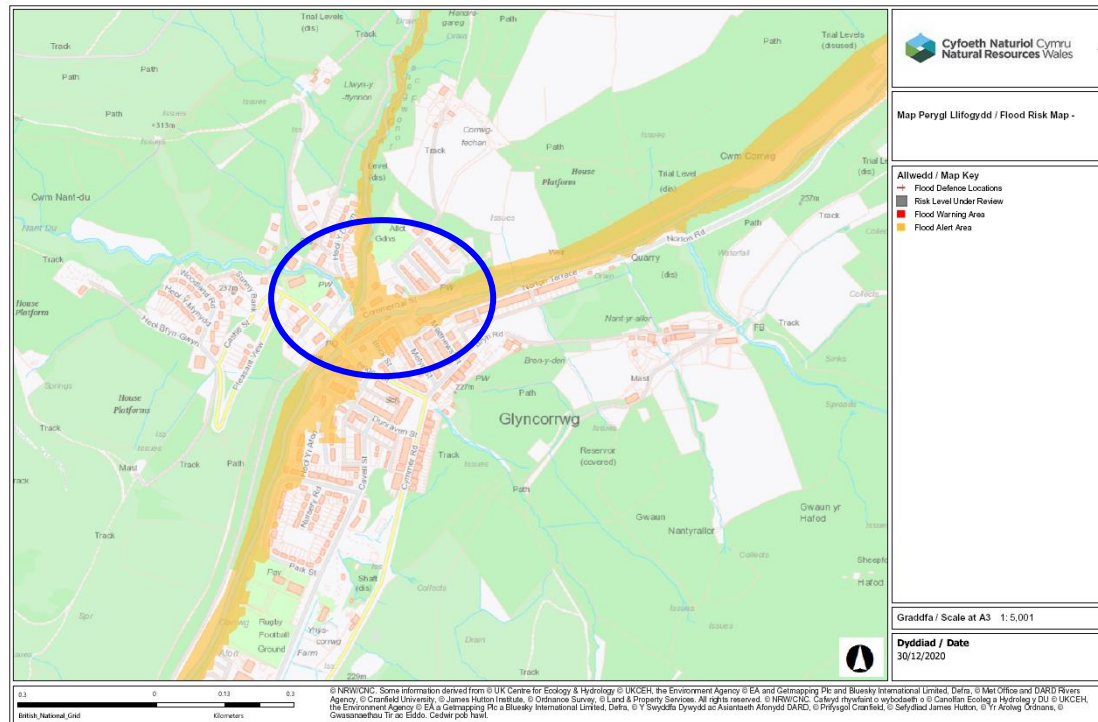


Figure 6.1 – NRW Flood Alert Area

7 CONCLUSION and RECOMMENDATIONS

Conclusion

It is proposed to redevelop a club in in Glyncoirwg, with residential accommodation, into a single house. Part of the plot, including the building, lies within Zone C2 as defined by TAN 15 and at risk of flooding during at least the 1 in 1000 year event. Detailed examination of a site can refine an areas risk of flooding. Francis Sant have undertaken, on behalf of the client, a Flood Consequence Assessment in accordance with the requirements of TAN 15.

As part of the study, the impact of flooding from the nearby stream was considered during the Q100, Q100 plus climate change, and Q1000 events. The flows were calculated for the stream using the procedures recommended in the Flood Estimation Handbook (FEH) and the Revitalised FSR/FEH rainfall runoff method, as amended (ReFH2). Hydrographs were produced using ReFH2 with the values adjusted so that the peak flows are the same as those estimated using FEH (see Table 7.1).

Table 7.1 – – Flows to be Used in the Steady State Model			
Return Period Years	Flow Rates for Afon Corrwg	Flow Rates for Corrwg Fechan	Flow Rates for Nant Du
100	50.631	23.948	10.163
100 + CC	65.820	31.132	13.212
1000	83.395	39.627	17.769

To evaluate the potential of flooding on the site a 2d TUFLOW model was built and run using the estimated flows. While the site was expected to remain flood free during the Q100 event it could be affected during the Q100+CC and the building could also be at risk during the Q1000 event, although the depth and velocity is considered manageable in accordance with TAN 15 (depth less than 600mm and velocity less than 0.15m/s).

The models sensitivity to channel friction was considered by increasing and reducing the Manning's number by 25%, however, this had a limited impact on the flood risk. Scenarios were also considered where the downstream culvert was blocked the downstream bridge by 33%, 66% and 100%. This increased the risk of flooding at the site with the building potentially being affected, however the flood depth in the property is expected to remain less than 600mm and the flow velocity remained low.

To reduce the risk of flooding at the property it is proposed to build boundary wall. Generally, this can be constructed without having a detrimental impact on third party land although the flood depth increased slightly adjacent to the plot when the downstream culvert became blocked. However, the owners of the land have no objection.

As the property already has a residential element on both the ground and first floors the building can be considered to be a more vulnerable development. As such the proposals will not change the vulnerability status of the building. By adopting the floodproofing measures suggested in Section 6, the proposals could deduce both the risk and consequence of flooding providing betterment.

As the development is limited to the refurbishment of an existing building a sustainable drainage system will not strictly be required. However, the

implementation of such a system should be considered and implemented in accordance with the Welsh Government Standards.

Some water could pool on the northern side of the property during a 1 in 1000 year event, however, measure can be put in place to remove this risk.

The site is not considered to be at risk from tidal flooding or from reservoir failure and the risk from ground water flooding is considered to be low.

Recommendations

In developing the site we would recommend the following be adhered to:

- Consideration is given to installing an appropriate sustainable drainage system, in accordance with the Welsh Government Standards.
- A boundary flood wall is built on the western side of the site.
- Wet proofing measures, as identified in Section 6, are incorporate in the development as part of the refurbishment.
- A Flood Response Plan is prepared, implemented and maintained.
- The property is registered with NRW's Flood Warning service if available.

APPENDIX A – FLOW ESTIMATION

In evaluating the risk of flooding at the site we should consider flows in the adjacent streams for various return periods especially the 1 in 100, 1 in 100 + CC and the 1 in 1000 events. The streams of concern are listed in Table A.1.

Table A.1 – Streams of Interest				
Name	POI	Centroid	Area	SPRHOST
Afon Corrwg	287550 199200	289413 200725	9.9625	51.94
Nant Corrwg Fechan	287500 199300	287975 201150	4.365	50.84
Nant Du	287400 199300	286550 199732	1.5025	49.83

The Flood Estimation Handbook describes numerous methods of estimating river flows, for various return periods, at ungauged sites; however, where possible the FEH recommends the use of a donor site to adjust flows calculated using catchment descriptors. In this instance there are a number of potential donor sites for the streams at the point of interest which are considered in table A.2. Three stations were chosen as potential donor sites, namely the Afan at Macroft Weir, Rhondda Fawr at Tynewydd and the Dulais at Cilfrew

Table A.2 - Potential Donor Sites				
Station Number	Name	Area	Distant	Comment
58004	Afan @ Cwmafan	81.5		Limited data, affected by abstraction and minewater - Dismissed
58012	Afan @ Marcroft Weir	87.8	3.6 – 6.4	Area greater than POI
57017	Rhondda Fawr @ Tynewydd	16.6	2.6 – 5.4	Catchment descriptors similar to POI Use
58002	Neath @ Resolven	190.9	9.3 – 11.1	Area significantly greater than POI Dismissed
58008	Dulais @ Cilfrew	43	10.6 – 9.2	Not considered appropriate for Pooling but ok for QMED
58006	Mellte @ Pontneddfechan	65.8	15.2 – 17.3	FARL lower than POI Dismissed

An adjustment factor using the data transfer scheme, was estimated using the stations.

$$\text{QMED adjusted at the point of interest} = \text{QMED}_{s,cd} \times (\text{QMED}_{d,obs} / \text{QMED}_{d,cd})^a$$

Where s = site

cd = catchment descriptors

d = donor site

obs = observed

a = adjusting factor (generally based on the distance between the sites)

Table A.3 - Donor Site Adjustment			
	Afan @ Marcroft Weir	Rhondda Fawr @ Tynnewydd	Dulais @ Cilfrew
Donor QMED cd	79.52449244	30.96242123	46.49679393
Donor QMED obs	98.7	24.3	57.6
Afon Corrwg			
Distance between centroids	6.389km	2.632km	10.604km
a	0.43004696	0.589542	0.375312
Site QMED cd	19.60445	19.60445	19.60445
Adjustment multiple	1.097	0.867	1.084
Average Adjustment	1.016		
Adjusted QMED	19.918		
Nant Corrwg Fechan			
Distance between centroids	5.642km	4.131km	9.172
a	0.447051806	0.498171069	0.38944526
Site QMED cd	9.10617997	9.10617997	9.10617997
Adjustment multiple	1.101	0.886	1.087
Average Adjustment	1.025		
Adjusted QMED	9.333		
Nant Du			
Distance between centroids	3.644km	5.427km	9.043km
a	0.521952051	0.452756755	0.390861038
Site QMED cd	3.527111364	3.527111364	3.527111364
Adjustment multiple	1.119	0.896	1.087
Average Adjustment	1.034		
Adjusted QMED	3.648		

Catchment Descriptors

An estimate of the flow using pooled data from sites with similar catchment descriptors to the streams at the POI has been made, using the WINFAP – FEH software. The initial pooling groups was reviewed and a number of stations were removed and others added to ensure sufficient record length. The list of stations considered and used in the final pooling group for the Afon Corrwg is given in Table A.4 below. A similar list is provided for the Nant Corrwg Fechan and Nant Du in tables A.5 and A.6 respectively.

The final pooling group for Afon Corrwg gave a standardised test value H2 of 0.835 with 536 years of data while the Corrwg Fechan gave a H2 of 1.541 with 522 years of data and the Nant Du gave H2 of 0.94 with 508 years of data. Based on the information obtained, a statistical distribution (generalised logistic) is fitted to the data to create a flood growth curve. The growth curve is then applied to the adjusted QMED flow, derived from the catchment descriptors, to obtain extreme flows such as the 1 in 100 year return. This method provided the flow rates given in Table A.7.

Table A.4 - Final Pooling Group for Corrwg

Station	Dist	Area	SAAR	FARL	BFIHOST	Urbext	Comment
Severn @ Plynlimon Flume	0.188	8.75	2481	1	0.323	0.0	Accepted
Croasdale Beck @ Croasdale	0.527	10.710	1882	1	0.276	0.0	Accepted
Allt Leachdach @ Intake	0.596	6.540	2554	0.992	0.397	0.0	Accepted
Trout Beck @ Moor House	0.648	11.4	1905	1	0.227	0.0	Accepted
Rhondda Fawr @ Tynewydd	0.72	16.640	2458	0.999	0.317	0.016	Accepted
Laxdale @ Laxdale	0.839	10.64	1993	0.888		0	Rejected - low FARL
Annalong @ Recorder	0.895	14.440	1704	0.981	0.336	0.0	Accepted with caution
Langdon Beck @ Langdon	1.047	12.79	1463	1	0.237	0.001	Accepted
Dove @ Hollinsclough	1.188	7.92	1346	1	0.403	0	Accepted
Tory Brook @ Newnham Park	1.217	13.430	1403	0.942	0.431	0.014	Rejected - low FARL
East Dart @ Believer	1.322	22.27	2095	1	0.363	0	Accepted
Haddeo @ Upton	1.450	6.81	1210	1	0.590	0.005	Accepted
De Lank @ de Lank	1.483	21.610	1628	0.998	0.379	0	Accepted
St Neot @ Craigshill Wood	1.505	22.970	1511	0.982	0.463	0.002	Rejected - low FARL
Harwood Beck @ Harwood	1527	24.580	1577	1	0.261	0	Accepted
Hebden Beck @ Hebden	1.529	22.25	1433	0.997	0.252	0.0	Accepted

Table A.5 - Final Pooling Group for Corrwg Fechan

Station	Dist	Area	SAAR	FARL	BFIHOST	Urbext	Comment
Allt Leachdach @ Intake	0.596	6.540	2554	0.992	0.397	0.0	Accepted
Severn @ Plynlimon Flume	0.188	8.75	2481	1	0.323	0.0	Accepted
Croasdale Beck @ Croasdale	0.527	10.710	1882	1	0.276	0.0	Accepted
Dove @ Hollinsclough	1.188	7.92	1346	1	0.403	0	Accepted
Haddeo @ Upton	1.450	6.81	1210	1	0.590	0.005	Accepted
Trout Beck @ Moor House	0.648	11.4	1905	1	0.227	0.0	Accepted
Laxdale @ Laxdale	0.839	10.64	1993	0.888		0	Rejected - low FARL
Langdon Beck	1.047	12.79	1463	1	0.237	0.001	Accepted

@ Langdon							
Annalong @ Recorder	0.895	14.440	1704	0.981	0.336	0.0	Accepted with caution
Rhondda Fawr @ Tynewydd	0.72	16.640	2458	0.999	0.317	0.016	Accepted
Tory Brook @ Newnham Park	1.217	13.430	1403	0.942	0.431	0.014	Rejected - low FARL
Coal Burn @ Coalburn	1.081	1.630	1096	1	0.196	0	Accepted
Crimple @ Burn Bridge	2.942	8.170	855	1.0	0.309	0.006	Accepted
East Dart @ Believer	1.322	22.27	2095	1	0.363	0	Accepted
Bollingey Stream @ Bolingey	3.881	16.08	1044	0.991	0.627	0.006	Rejected - Insufficient years
De Lank @ de Lank	1.483	21.610	1628	0.998	0.379	0	Accepted

Table A.6 - Final Pooling Group for Nant Du

Station	Dist	Area	SAAR	FARL	BFIHOST	Urbext	Comment
Coal Burn @ Coalburn	1.081	1.630	1096	1	0.196	0	Accepted
Allt Leachdach @ Intake	0.596	6.540	2554	0.992	0.397	0.0	Accepted
Haddeo @ Upton	1.450	6.81	1210	1	0.590	0.005	Accepted
Severn @ Plynlimon Flume	0.188	8.75	2481	1	0.323	0.0	Accepted
Dove @ Hollinsclough	1.188	7.92	1346	1	0.403	0	Accepted
Croasdale Beck @ Croasdale	0.527	10.710	1882	1	0.276	0.0	Accepted
Laxdale @ Laxdale	0.839	10.64	1993	0.888		0	Rejected - low FARL
Trout Beck @ Moor House	0.648	11.4	1905	1	0.227	0.0	Accepted
Crimple @ Burn Bridge	2.942	8.170	855	1.0	0.309	0.006	Accepted
Langdon Beck @ Langdon	1.047	12.79	1463	1	0.237	0.001	Accepted
Annalong @ Recorder	0.895	14.440	1704	0.981	0.336	0.0	Accepted with caution
Tory Brook @ Newnham Park	1.217	13.430	1403	0.942	0.431	0.014	Rejected - low FARL
Rhondda Fawr @ Tynewydd	0.72	16.640	2458	0.999	0.317	0.016	Accepted
Bollingey Stream @ Bolingey	3.881	16.08	1044	0.991	0.627	0.006	Rejected - Insufficient years
Leven @ Easby	3.853	15.090	830	0.981	0.524	0.004	Low SAAR
De Lank @ de Lank	1.483	21.610	1628	0.998	0.379	0	Accepted

Table A.7 – Calculated Flow Rates Based on Catchment Descriptors						
	Afon Corrwg		Corrwg Fechan		Nant Du	
Return Period (years)	Growth Fitting	Q	Growth Fitting	Q	Growth Fitting	Q
2	1	19.918	1	9.333	1	3.648
5	1.31	26.092	1.314	12.263	1.339	4.885
10	1.542	30.713	1.549	14.456	1.601	5.840
25	1.886	37.565	1.899	17.723	2	7.296
50	2.19	43.620	2.208	20.607	2.361	8.613
75	2.389	47.583	2.411	22.501	2.601	9.488
100	2.542	50.631	2.566	23.948	2.786	10.163
200	2.951	58.777	2.983	27.840	3.292	12.009
500	3.599	71.684	3.645	34.018	4.111	14.997
1000	4.187	83.395	4.246	39.627	4.871	17.769

Climate Change

Adding 30% to the values given in Table A.7, to account for climate change, gives us the flows noted in table A.8.

Table A.8 – Calculated Flow Rates Based on Catchment Descriptors Increased by 30% to Account for Climate Change			
Return Period Years	Flow Rates for Afon Corrwg	Flow Rates for Corrwg Fechan	Flow Rates for Nant Du
2	25.893	12.133	4.742
5	33.920	15.942	6.350
10	39.927	18.793	7.592
25	48.834	23.040	9.485
50	56.706	26.789	11.197
75	61.858	29.252	12.335
100	65.820	31.132	13.212
200	76.410	36.192	15.612
500	93.189	44.223	19.496
1000	108.414	51.515	23.100

A Hydrograph was also constructed for the Q100 and Q1000 flows using the Revitalised FEH / FSR method as recommended by Centre of Ecology and Hydrology. The results are provided in Table A.9 with the peak flows provided in Table A.10

Table A.9 – Q100 and Q1000 Hydrograph For Stream

	Afon Corrwg		Corrwg Fechan		Nant Du	
Time Step	Q100	Q1000	Q100	Q1000	Q100	Q1000
00:00:00	1.419	1.419	0.588	0.588	0.199	0.199
00:15:00	1.470	1.499	0.628	0.649	0.216	0.225
00:30:00	1.672	1.802	0.780	0.879	0.280	0.323
00:45:00	2.084	2.410	1.101	1.359	0.424	0.543
01:00:00	2.780	3.439	1.672	2.215	0.684	0.940
01:15:00	3.867	5.049	2.585	3.594	1.112	1.599
01:30:00	5.445	7.399	3.906	5.612	1.751	2.602
01:45:00	7.554	10.567	5.830	8.600	2.740	4.186
02:00:00	10.388	14.873	8.583	12.961	4.043	6.318
02:15:00	14.225	20.790	12.079	18.606	0.452	0.449
02:30:00	19.353	28.829	15.854	24.814	6.708	10.820
02:45:00	25.681	38.915	19.290	30.582	7.443	12.137
03:00:00	32.683	50.243	21.689	34.743	7.567	12.439
03:15:00	39.652	61.695	22.565	36.438	7.202	11.904
03:30:00	45.775	71.946	22.125	35.942	6.555	10.874
03:45:00	50.161	79.506	20.783	33.905	5.758	9.568
04:00:00	52.211	83.313	18.883	30.891	4.938	8.207
04:15:00	52.146	83.629	16.738	27.418	4.125	6.850
04:30:00	50.456	81.208	14.531	23.810	3.354	5.558
04:45:00	47.636	76.839	12.330	20.191	2.673	4.416
05:00:00	44.081	71.174	10.207	16.685	2.084	3.424
05:15:00	40.149	64.824	8.304	13.539	1.620	2.637
05:30:00	36.072	58.206	6.649	10.792	1.291	2.074
05:45:00	31.948	51.504	5.292	8.526	1.077	1.706
06:00:00	27.841	44.828	4.289	6.839	0.938	1.465
06:15:00	23.858	38.353	3.586	5.650	0.854	1.320
06:30:00	20.221	32.435	3.105	4.833	0.804	1.235
06:45:00	16.964	27.120	2.785	4.288	0.779	1.193
07:00:00	14.143	22.495	2.579	3.939	0.768	1.175
07:15:00	11.841	18.700	2.453	3.728	0.760	1.163
07:30:00	10.090	15.798	2.384	3.614	0.752	1.150
07:45:00	8.776	13.615	2.352	3.564	0.743	1.138
08:00:00	7.800	11.994	2.329	3.528	0.735	1.125
08:15:00	7.086	10.812	2.306	3.493	0.727	1.113
08:30:00	6.573	9.970	2.283	3.458	0.720	1.101
08:45:00	6.213	9.385	2.260	3.424	0.712	1.089
09:00:00	5.969	8.992	2.237	3.389	0.704	1.077

Table A.10 – Calculated Peak Flow Rates Based on ReFH 2

Return Period Years	Flow Rates for Afon Corrwg	Flow Rates for Corrwg Fechan	Flow Rates for Nant Du
100	52.211	22.565	7.567
1000	83.629	36.438	12.439

Consideration was given to estimating the Q1000 value by multiplying the statistical FEH Q100 value by ReFH2 ($Q1000 / Q100$), however, in this instance using the statistical Q1000 was deemed more appropriate. The values provided in Table A.11 should, therefore, be used in any steady state modelling.

Table A.11 – – Flows to be Used in the Steady State Model			
Return Period Years	Flow Rates for Afon Corrwg	Flow Rates for Corrwg Fechan	Flow Rates for Nant Du
100	50.631	23.948	10.163
100 + CC	65.820	31.132	13.212
1000	83.395	39.627	17.769