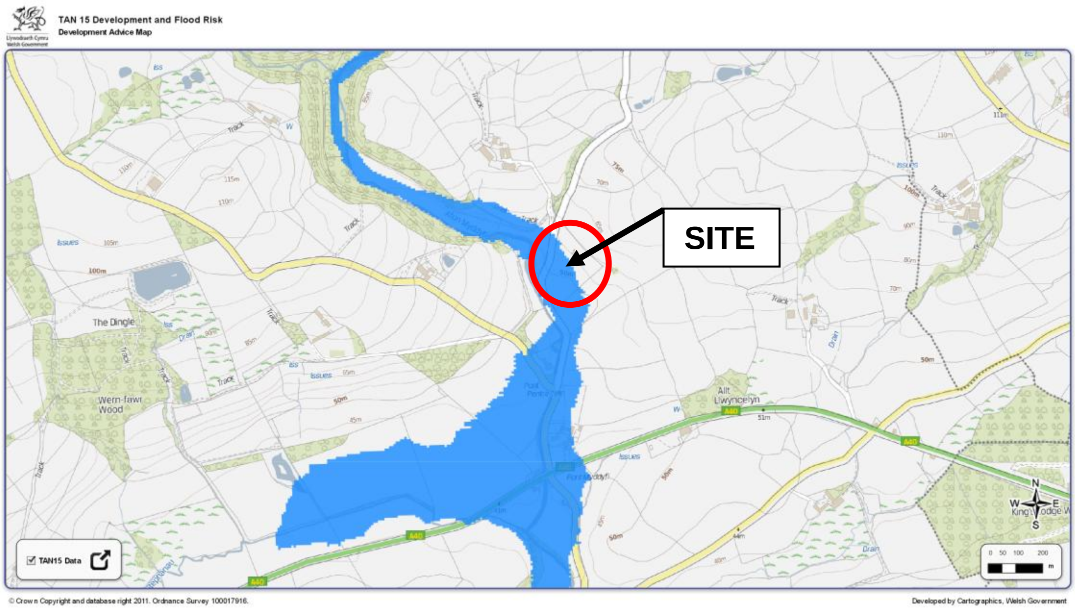
Francis Sant

Proposed Free Range Poultry Unit, Pentrefelin, Llandeilo
Flood Consequence Assessment



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Signed ……………………………………………………………………

Date ……………………………………………………………………

CONTENTS

1 Introduction

It is proposed to build a free range poultry unit on land north of Glanmyddyfi, Pentrfelin, Llandeilo. However, the client has been advised that part of the land lies within Zone C2 as defined by the development advice maps (see Figure 1.1) referred to in Technical Advise Note 15, Development and Flood Risk (TAN 15). This means that part of the site is considered to be at risk of flooding during at least the 1 in 1000 year event and is not afforded protection from recognised flood defences.

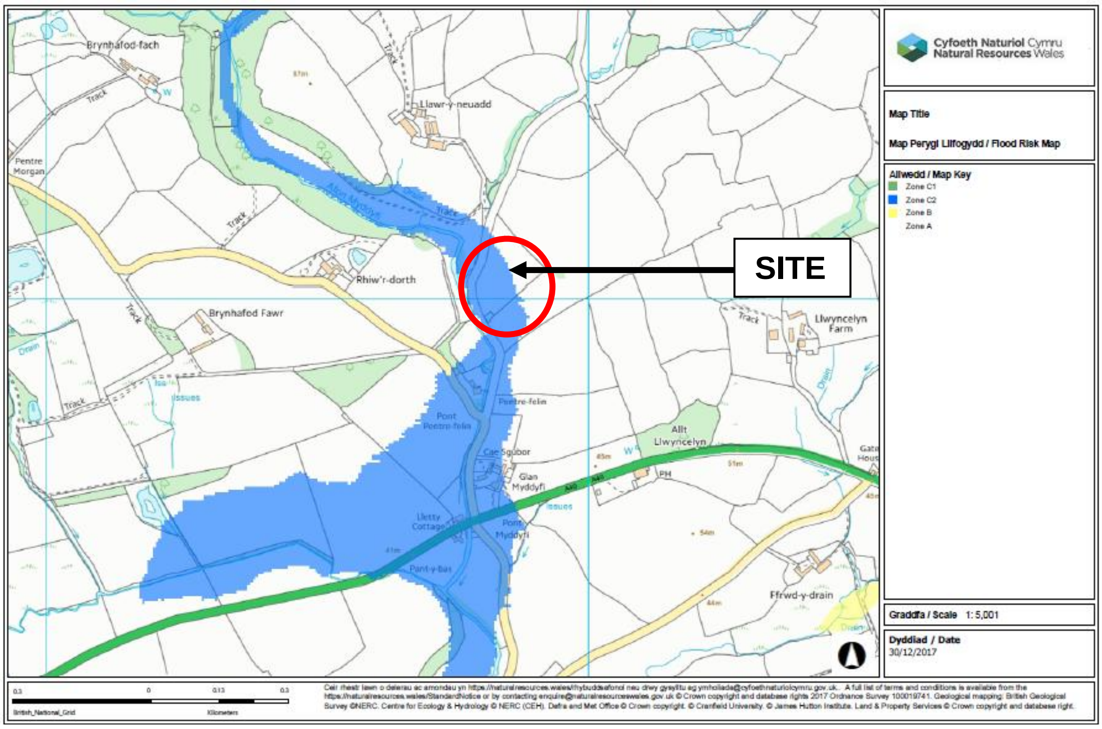

Figure 1.1 - Development Advice Flood Map

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

It is possible that the proposed development could be at risk of fluvial inundation from the adjacent stream. With this in mind the client recognises the need for a Flood Consequence Assessment to be prepared to evaluate the implication of any flooding on the site and how this affects any proposed development. The assessment should be in accordance with the requirements of Section 7 and Appendix 1 of TAN 15. Francis Sant have been employed to undertake this task.

An assessment of the risk was evaluated in 2015, however, since then the size of the proposed sheds have reduced and the client wants the risk to be reassessed but with the 1 in 100year fluvial flow in the nearby stream increased by 30% to account for climate change. The 1 in 100 year and the 1 in 1000 year flows will not be recalculated.

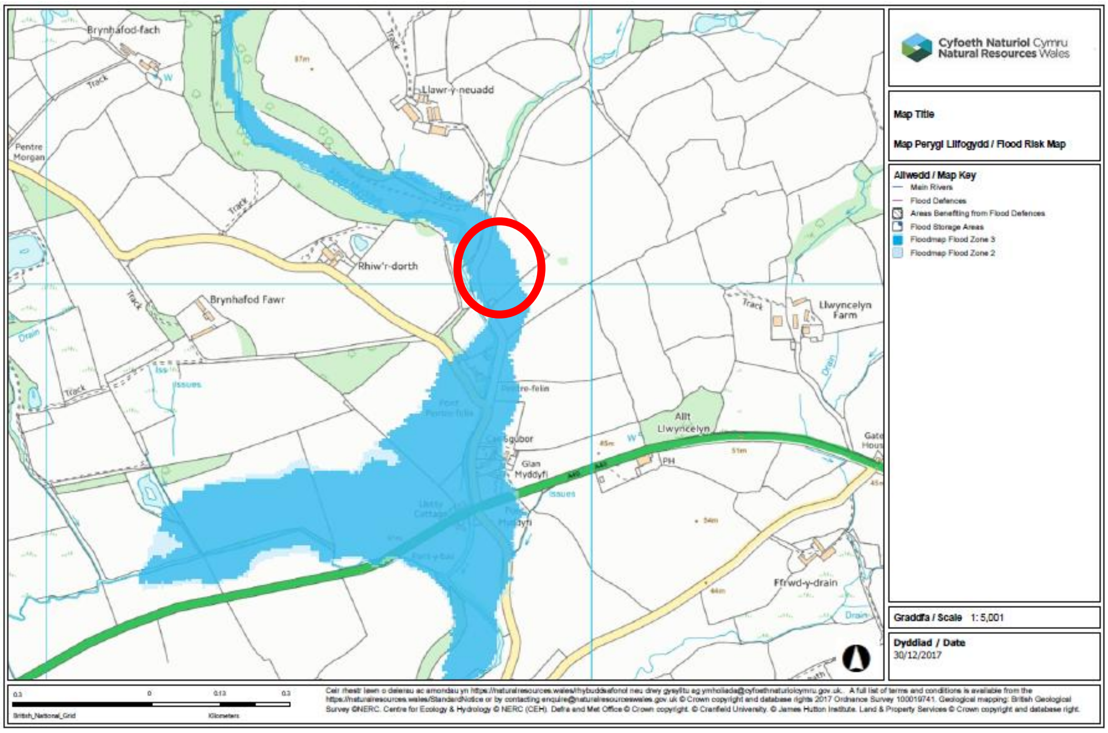

Figure 1.2 - NRW Flood Map

This report assesses the risk of flooding at the site, especially from the adjacent stream. The location of the development is described in Section 2 while the procedure followed in estimating the 1 in 100 and the 1 in 1000 year flow, in the adjacent watercourse, is summarised in Section 3 and described in Appendix A. The estimate was undertaken using the procedures recommended in the Flood Estimation Handbook (FEH) and the Revitalised FSR/FEH rainfall runoff method, as amended. Flows in the stream were mathematically modelled and the flood levels calculated for the 1 in 100 and 1 in 1000 year events, the results of which are summarised in Section 4. The risk of flooding is discussed generally in Section 5 while flood proofing measures are discussed in Section 6. The conclusions and recommendations of the Flood Consequence Assessment are provided in Section 7.

2 Background

It is proposed to develop a free range poultry unit on an open field at Pentrefelin, some 3km west of Llandeilo (coordinates E259850 N224020). The site is accessed from a minor road 400m north of the main A40(T) between Llandelio and Carmarthen (see Figure 2.1 to 2.3). The site is in a rural location with the minor road forming the western boundary of the site and the Myddyfi stream located west of the road.

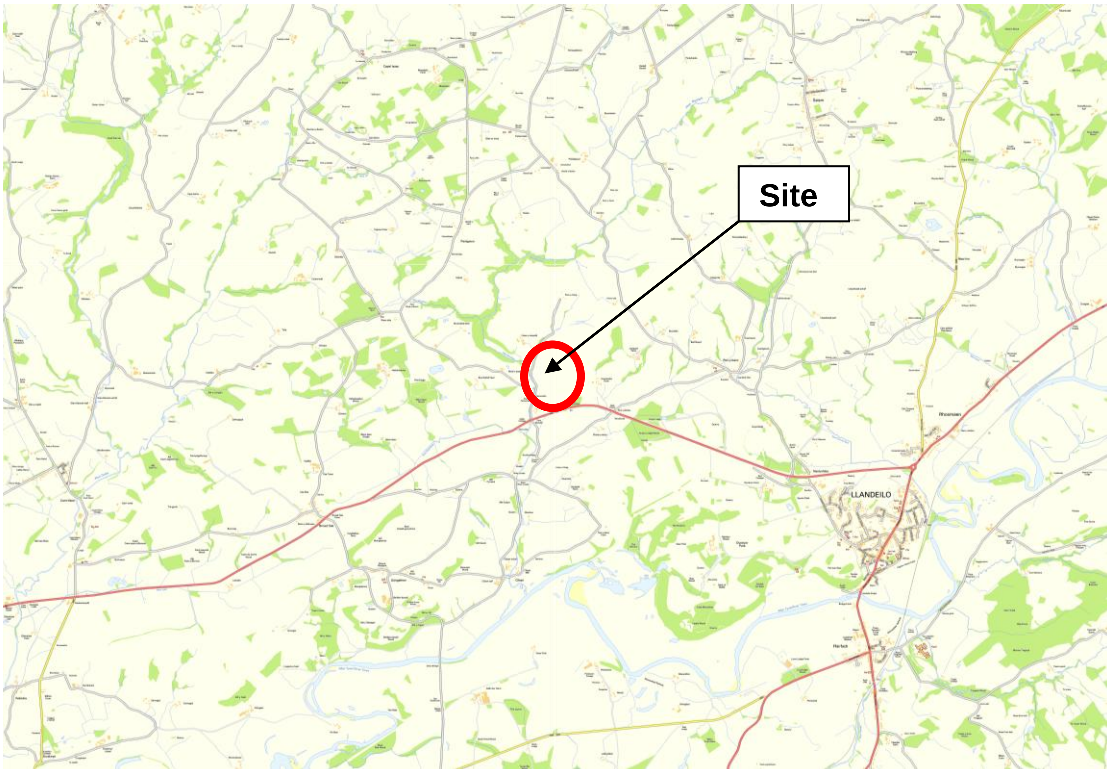

Figure 2.1 – Location Plan

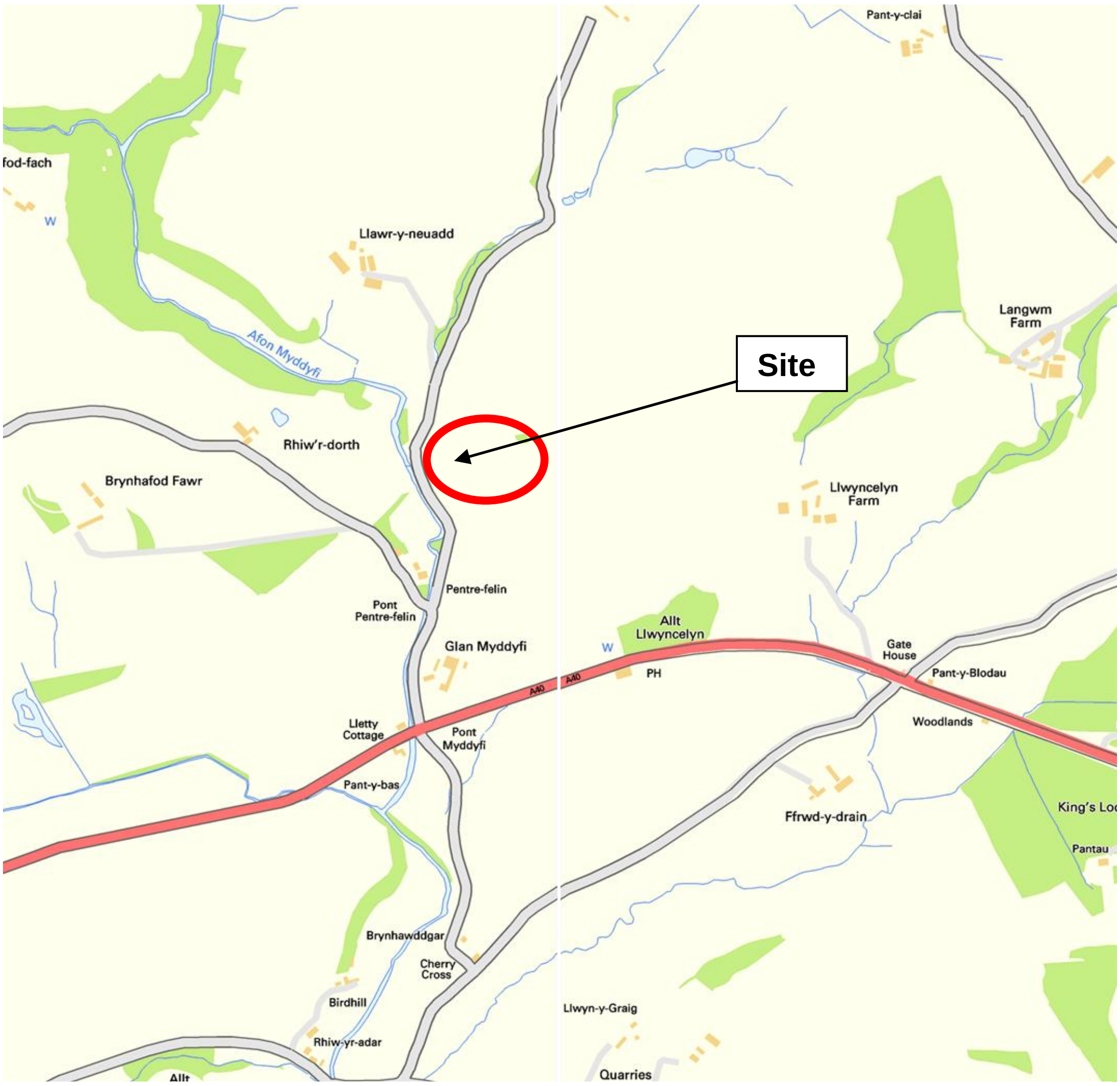

Figure 2.2 – Location of Site

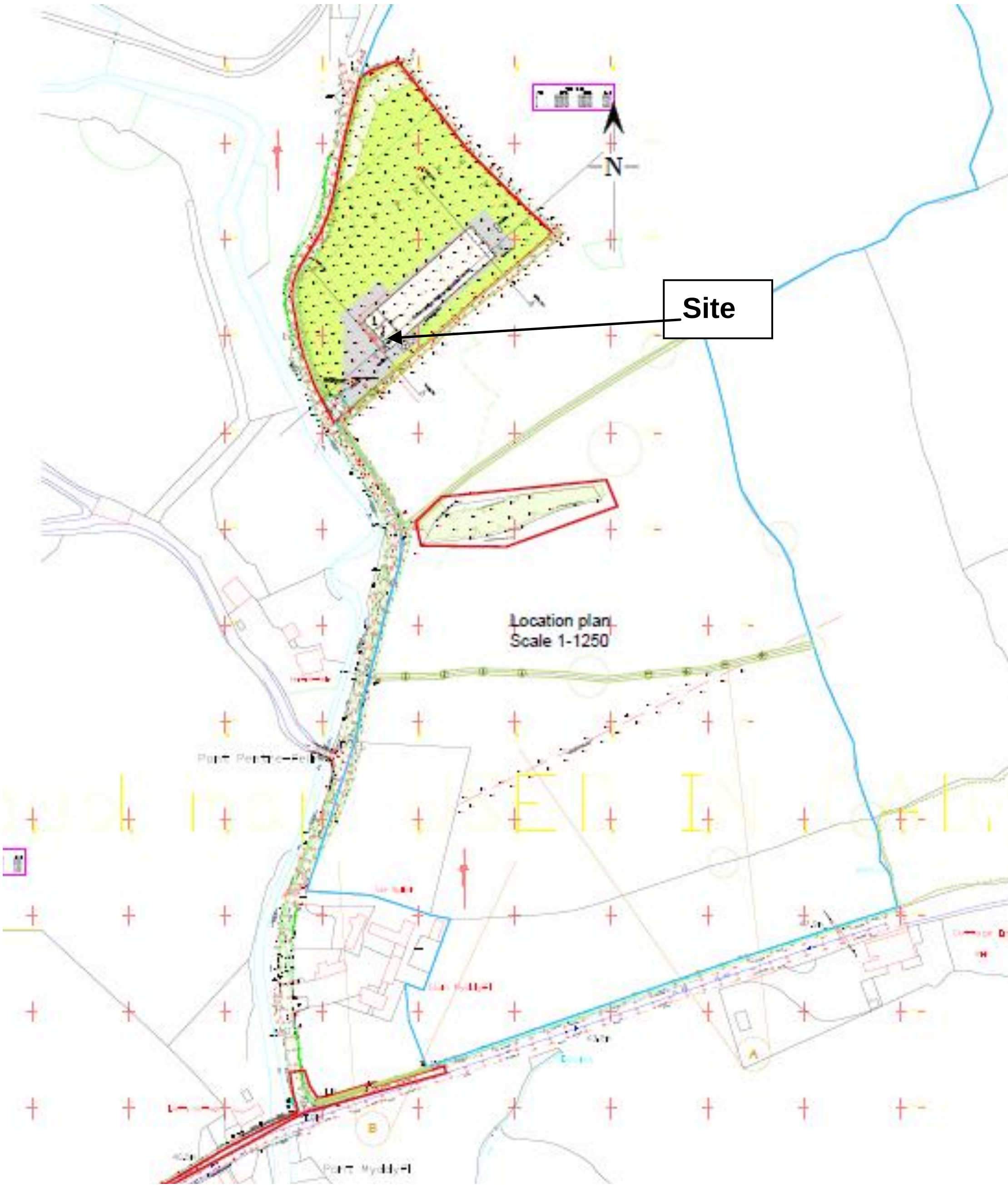

Figure 2.3 – Site Plan

Afon Myddyfi has its source in the hills 1.5km north of the site at a height of around 135m AOD. The river flows towards the site mainly through pasture land and a tree lined valley. Some 200m downstream of the site the stream flows beneath Pont Pentrefelin before continuing its way towards the Tywi some 1.8km to the south.

Details of the catchment for the Myddyfi 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 is provided in Table 2.1. The catchment areas were checked using OS 1:25000 Explorer Maps and generally found to have a close correlation with the values provided in the FEH CD-ROM (see Figure 2.4).

Table 2.1 – Catchment Descriptors for the Stream	
Descriptor	**Myddyfi**
AREA	11.77
ALTBAR	146
ASPBAR	178
ASPVAR	0.41
BFIHOST	0.362
DPLBAR	4.03
DPSBAR	83.4
FARL	1
FPEXT	0.0278
FPDBAR	0.237
FPLOC	0.88
LDP	7.21
PROPWET	0.57
RMED-1H	11.1
RMED-1D	46.6
RMED-2D	61.6
SAAR	1436
SAAR4170	1512
SPRHOST	41.37

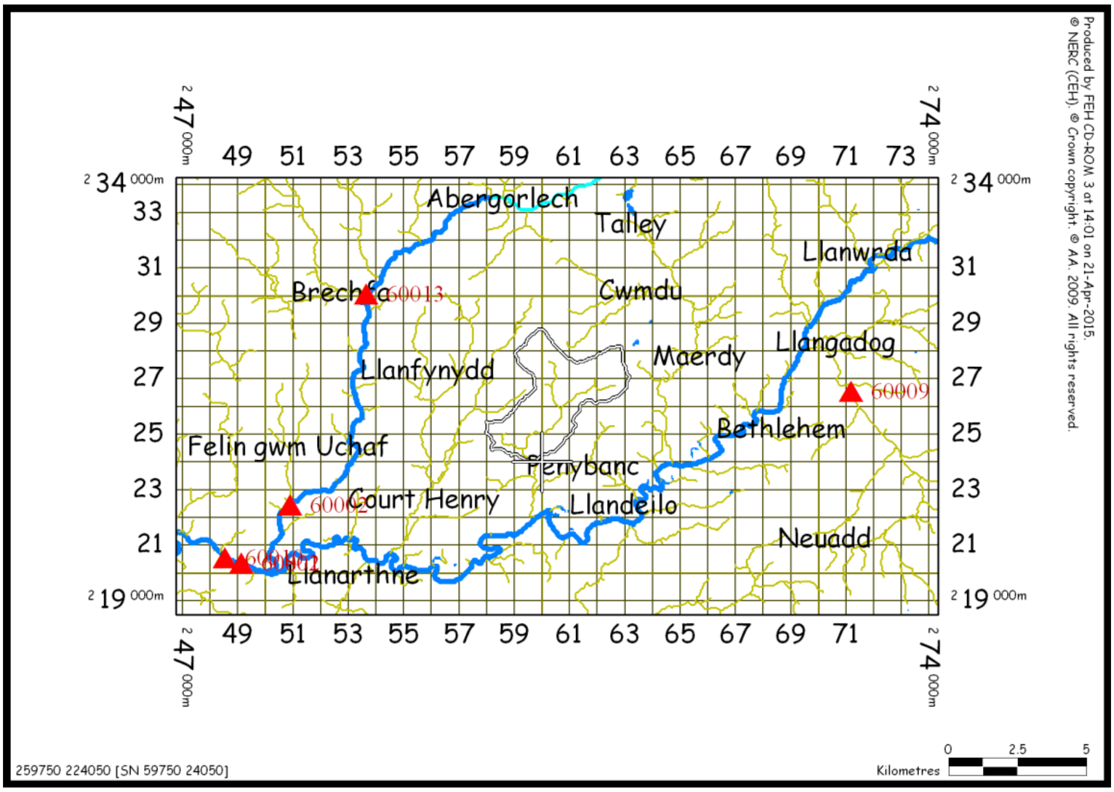

Figure 2.4 - Catchment Area for the Myddyfi

Topographic Information

A topographic survey of the site, along with the surrounding land, and the road was obtained (see Figure 2.5). This showed that the ground level on the site ranged between 45.8m AOD and 57.74m AOD with the building itself located on land ranging between 47.95m AOD and 55.4m AOD.

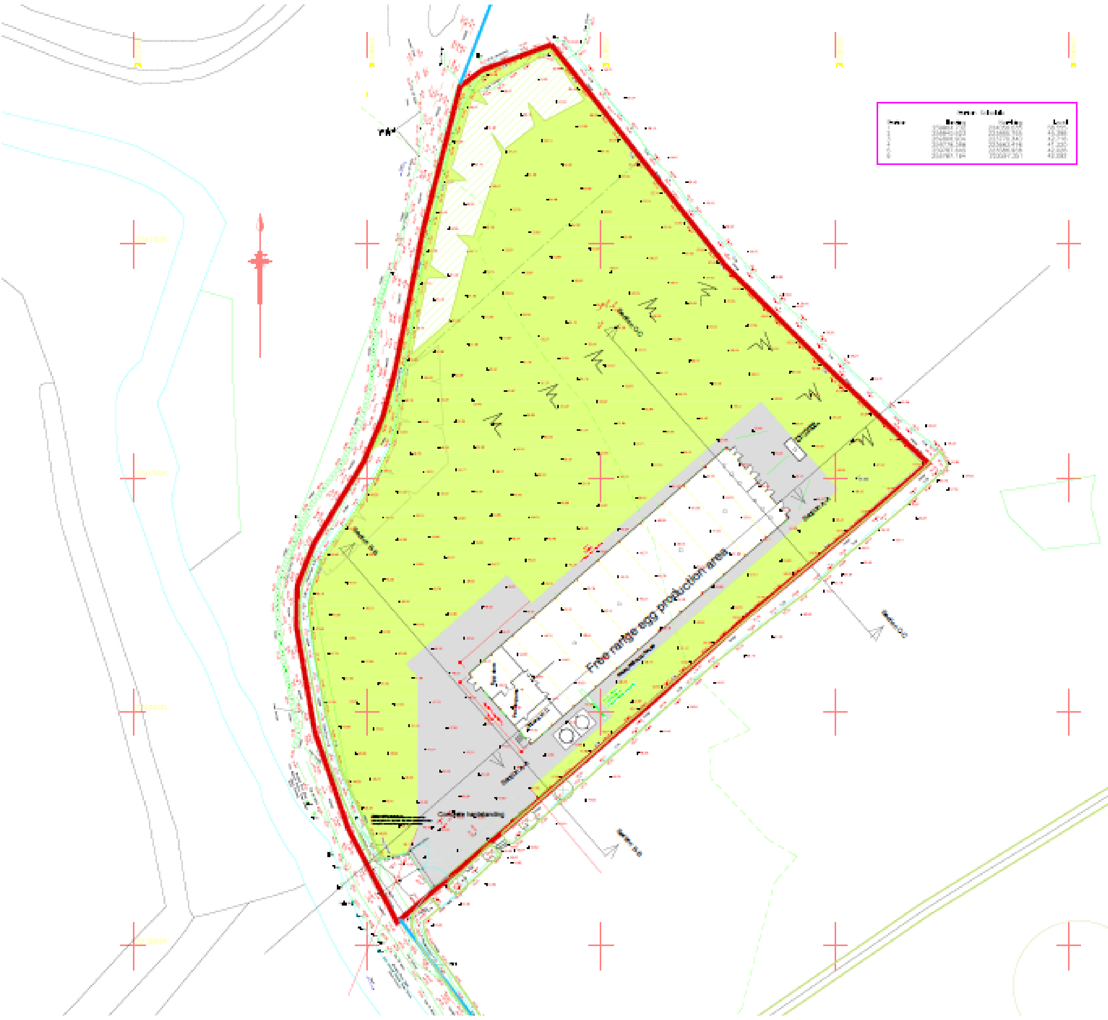

Figure 2.5 – Topographic Survey of the Site

Proposed Development

The proposed development consists of a 73 m x 19.75m steel framed barn which will contain the free range egg production area, packing area, egg store, and office (see Figure 2.6). In addition two food silos are to be constructed on the south eastern side of the building. As mentioned the finished floor level of the building will be set at 47.75m AOD.

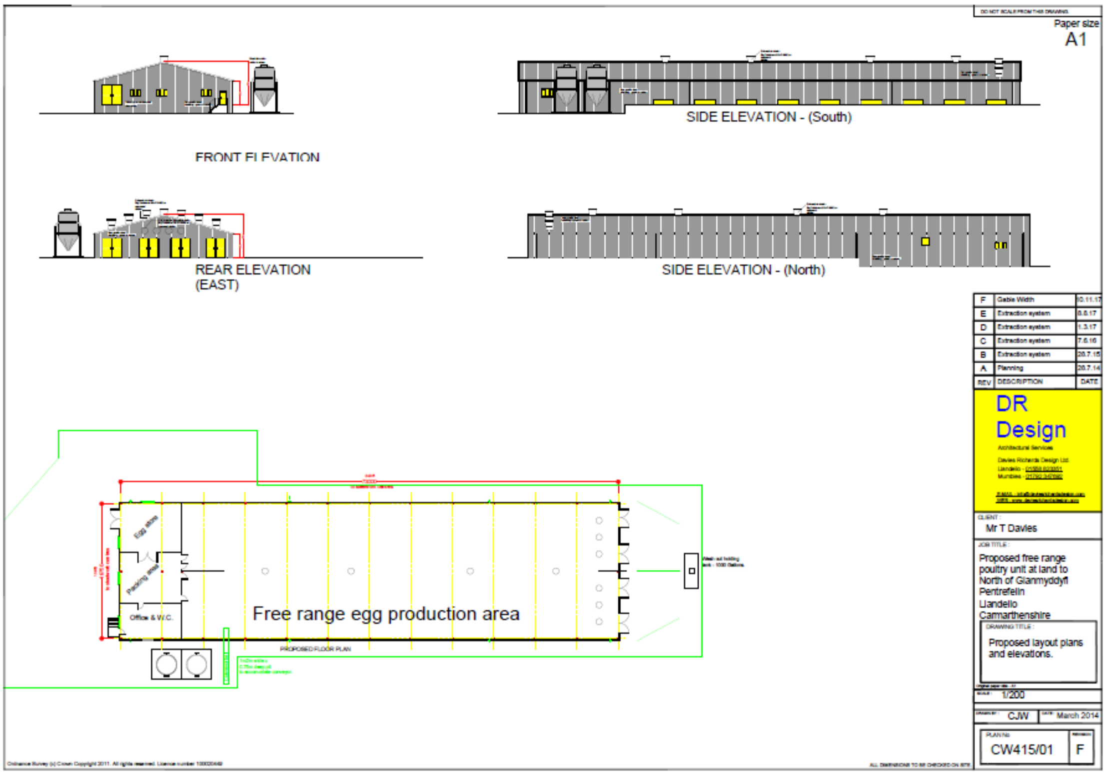

Figure 2.6 – Proposed Development

3 FLOW AND TIDE LEVEL ESTIMATION

Flow Estimation

The site is potentially at risk of flooding from various sources, including surface water, and fluvial flows. This section considers the estimated flow in the adjacent stream.

Afon Myddyfi is 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 preferably located either upstream or downstream of the point of interest. In this instance there are two potential donor sites one on the Cothi at Felin Mynachdi and the other on the Sawdde at Felin-y-Cwm. An adjustment factor will, therefore, be taken as the mean from each individual station. The calculations are described and the results provided in Appendix A. An estimate was also made by taking peak flows from a hydrograph, estimated using the revitalised FSR/FEH rainfall runoff method.

The obtained values were taken and increased by 30% to account for climate change. By this method we obtain the estimated flows indicated in Table 3.1.

Table 3.1 – Calculated Flow Rates Based on Catchment Descriptors and Increased by 20% to Account for Climate Change	
Return Period Years	**Flow Rates for Myddyfi**
Q100	41.474
Q100 + 30%	53.916
Q1000	74.086
Q1000 + 20%	96.312

Hydrographs were also constructed for the stream using the Revitalised FEH / FSR rainfall runoff method, as recommended by the 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	
Return Period Years	**Myddyfi**
100	28.5
1000	51.8

Advice from NRW recommends that the Q1000 values are obtained using FEH Q100 + CC value multiplied by ReFH (Q1000 / Q100). This was done and the results are provided in Table 3.3 which should be used in any steady state modelling.

Table 3.3 – Flows to be Used in the Steady State Model	
Return Period Years	**Flow Rates for Myddyfi**
100	41.474
Q100 + 30%	53.916
1000	74.631

These flows are estimated adjacent to the entrance to the site and downstream of the confluence with a minor tributary. The flows above the confluence were, therefore, taken as proportionate to the catchment areas (see Table 3.4).

Table 3.4 – Flows to be Used in the Steady State Model Above Confluence		
Return Period Years	**Flow Rates for the Myddyfi**	**Flow Rates for the Tributary**
100	39.747	1.727
Q100 + 30%	51.671	2.245
1000	71.524	3.107

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, with climate change, and to estimate the potential for flooding at the site, a HEC-RAS mathematical model was built. HEC-RAS, as developed by the U.S. Army Corps of Engineers', is a water surface profile model used for modelling both steady and unsteady, one-dimensional, gradually varied flow in both natural and man-made river channels. The model can incorporate bridges, culverts, channel modifications, split flow and subcritical & supercritical flow. HEC-RAS can perform mixed flow regime (subcritical to supercritical, as well as hydraulic jumps) calculations during an unsteady flow run.

The model extends some 100m upstream on the Myddyfi and some 250m downstream. A normal gradient of 0.0245 was used as a boundary condition on the upstream side of the model on the Myddyfi while a normal gradient of 0.0234 was used on the lower end. A small tributary to the Myddyfi was also included in the model and given an upstream boundary normal gradient of 0.0388. The bridge and culverts along the modelled reach was included.

The Q100, Q100+CC and Q1000 steady flows, as identified in Section 3, were considered.

Water levels were calculated within the model at a number of sections along the stream. The approximate locations of the profiles are indicated on Figure 4.1. The Manning's number for the river channel was taken as 0.035 with the banks on either side taken as 0.05.

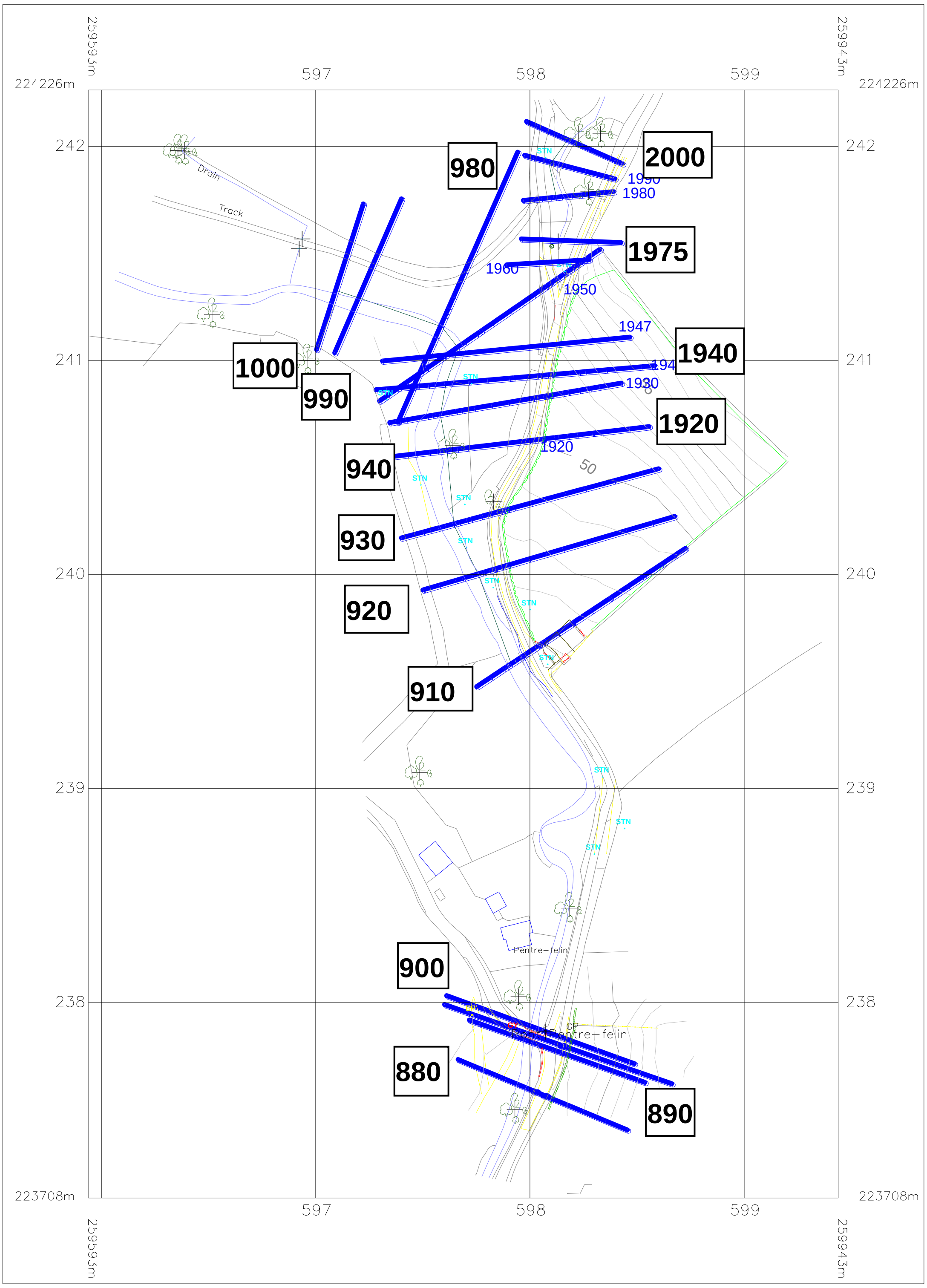

Figure 4.1 - Approximate Locations of HEC RAS Profiles

Upstream of the site the Myddyfi flows within a small ravine and while it is expected to exceed its natural channel it is unlikely to overflow the left bank of the ravine (see Figure 4.2). Adjacent to the site the model showed that the stream could possible overflow onto the road (see Figure 4.3) with the flood levels at the entrance into the site reaching 45.67m AOD, 45.97m AOD and 46.35m AOD during the Q100, Q100+CC and Q1000 events respectively (see Figure 4.4).

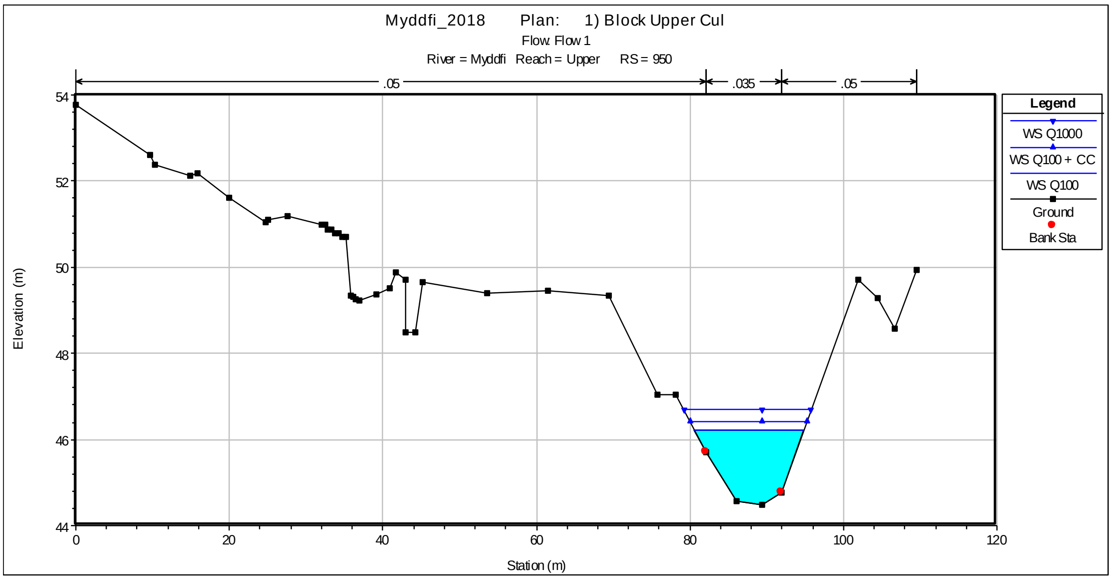

Figure 4.2 - Cross Section Upstream of the Site

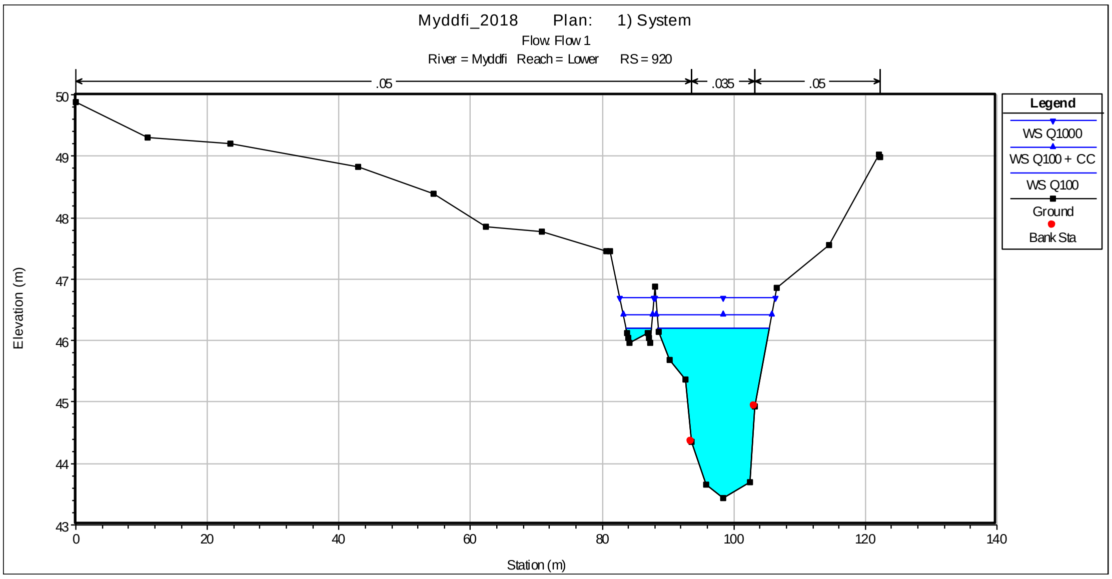

Figure 4.3 - Cross Section Adjacent to the Proposed Development

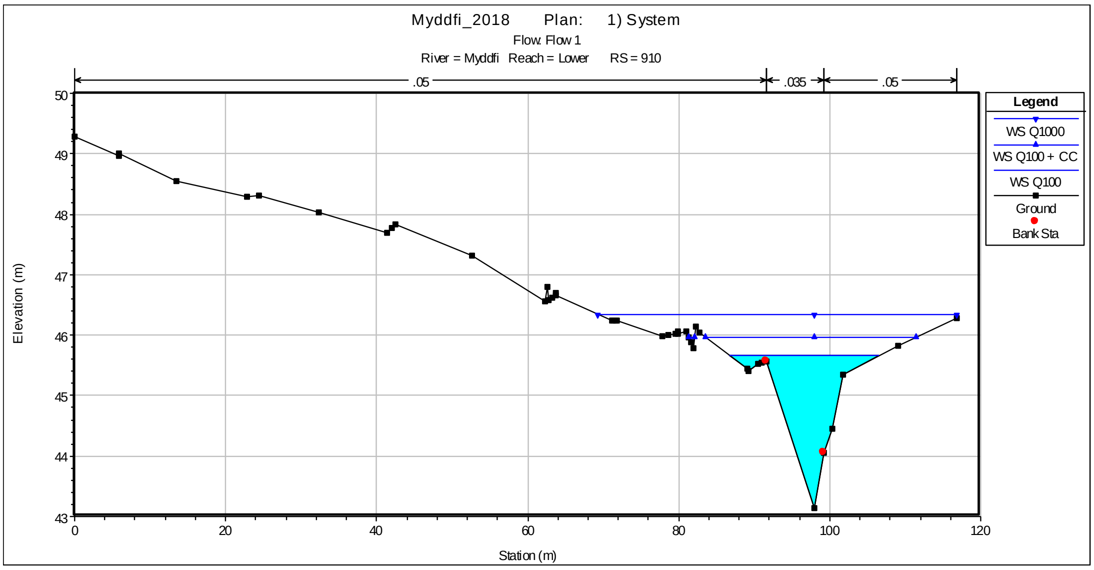

Figure 4.4 - Cross Section Adjacent to the Site Entrance

Beyond the site the Myddyfi flows down towards a masonry arched bridge, located some 170m downstream (see Figure 4.5). While the bridge is able to accommodate the Q100 and possibly the Q100+CC flows the and Q1000 flow is expected to overflow over the bridge.

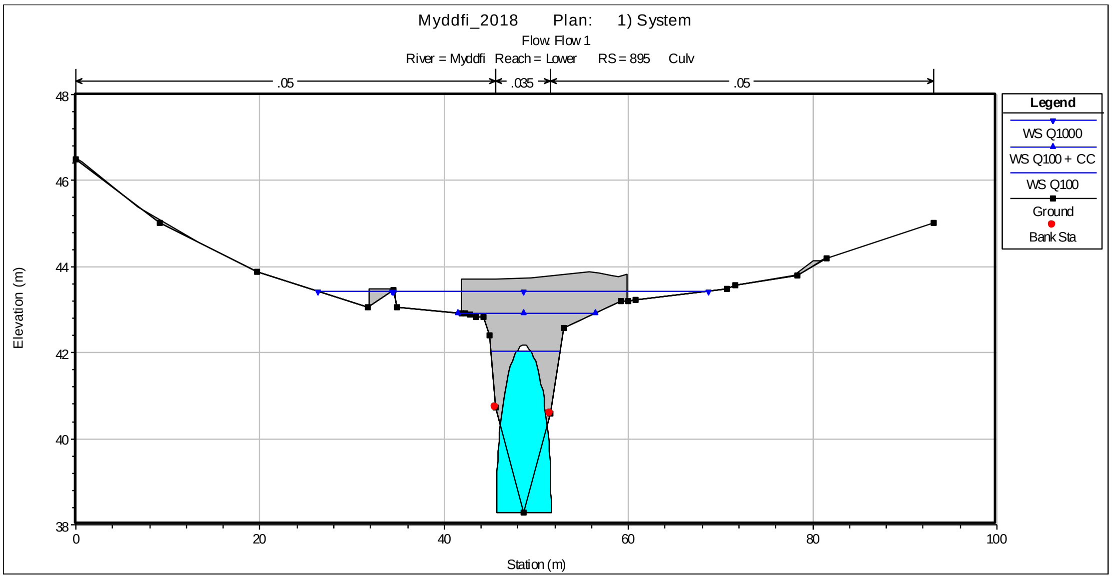

Figure 4.5 - Cross Section at the Downstream Bridge

Potentially the bridge could become partially blocked. To evaluate the impact this might have on the flood levels adjacent to the site a scenario was considered with a 1.6m blockage to the structure. While this did have an impact on the flood levels locally near the bridge (see Figure 4.6) it did not affect the flood levels adjacent to the site (see Figure 4.7).

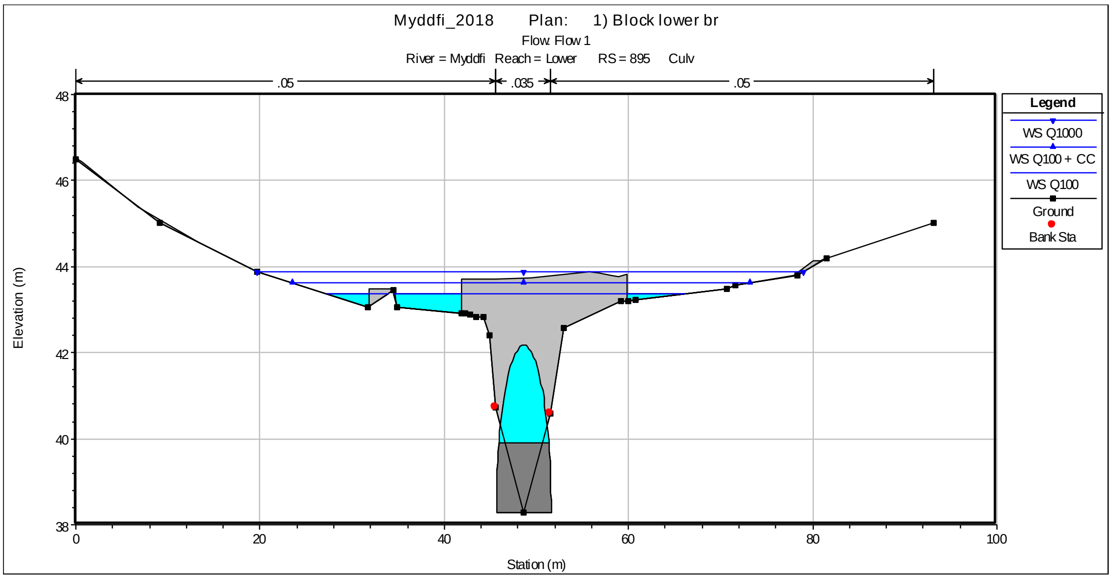

Figure 4.6 - Cross Section at the Downstream Bridge With a 1.6m Block

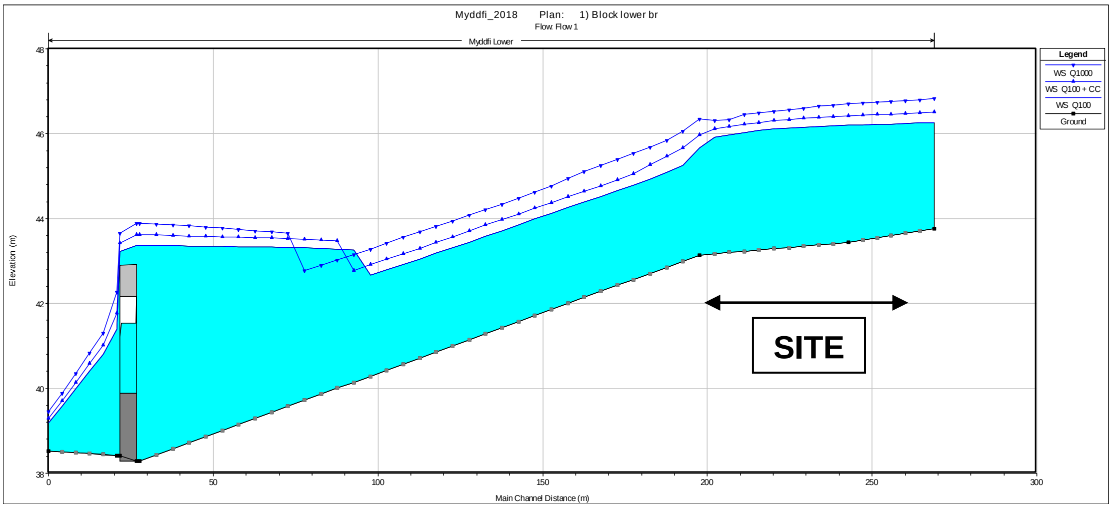

Figure 4.7 - Longitudinal Section of Stream Covering Bridge and Site With and Without Blockage

A sensitivity analysis of the model's bed friction was examined by increasing Manning's number for the channel by 20% from 0.035 to 0.042. It was found that this had only a marginal impact of flood levels with the levels adjacent to the site effectively remaining the same (see Figure 4.8). At the site entrance the Q100 reduced slightly to 45.60m AOD, the Q100+CC reduced to45.95n AOD and the Q1000 reduced to 46.31m AOD.

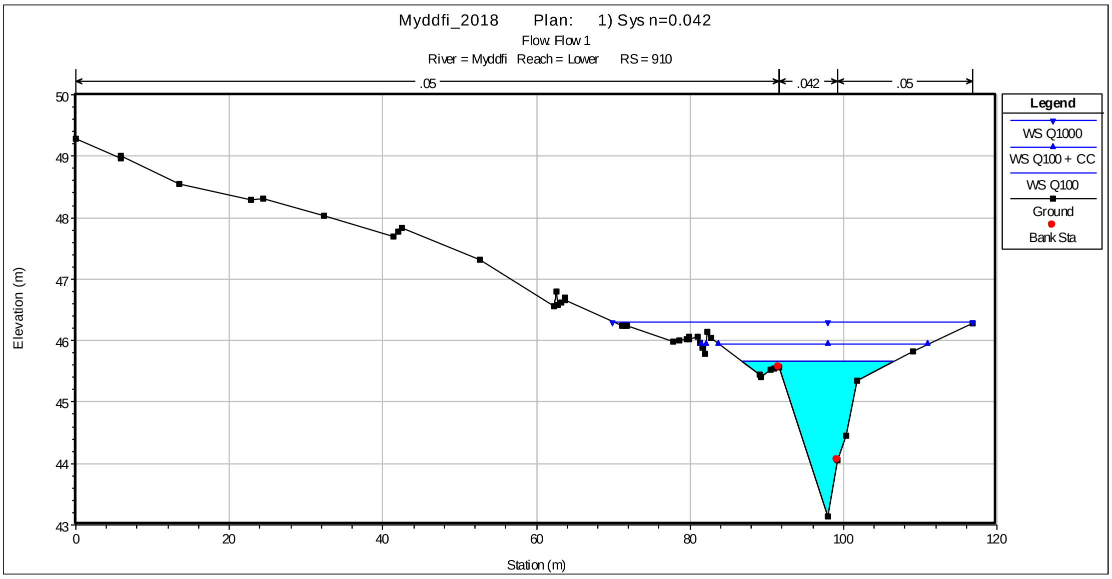

Figure 4.8 - Cross Section Adjacent to the Site Entrance With n = 0.042

A small tributary channel outfalls into the Myddyfi upstream of the development. For most of the modelled length the tributary runs parallel with the lane which goes past the site. Generally the flood water remains in channel during the considered events (see Figure 4.9). However, the stream is culverted in a couple of places and it is possible that the watercourse could overtop onto the road at the culvert nearest the site (see Figure 4.10). This would be exacerbated should the culvert become blocked, particularly during the Q100, as can be seen on Figure 4.11 where around 80% of the channel is blocked.

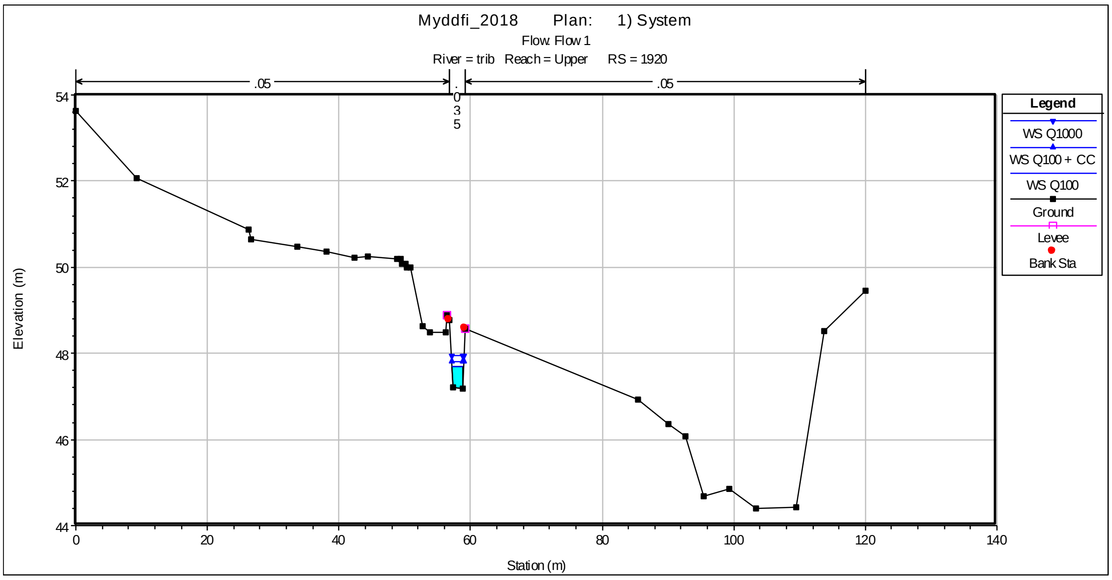

Figure 4.9 - Cross Section of Tributary Near the Site

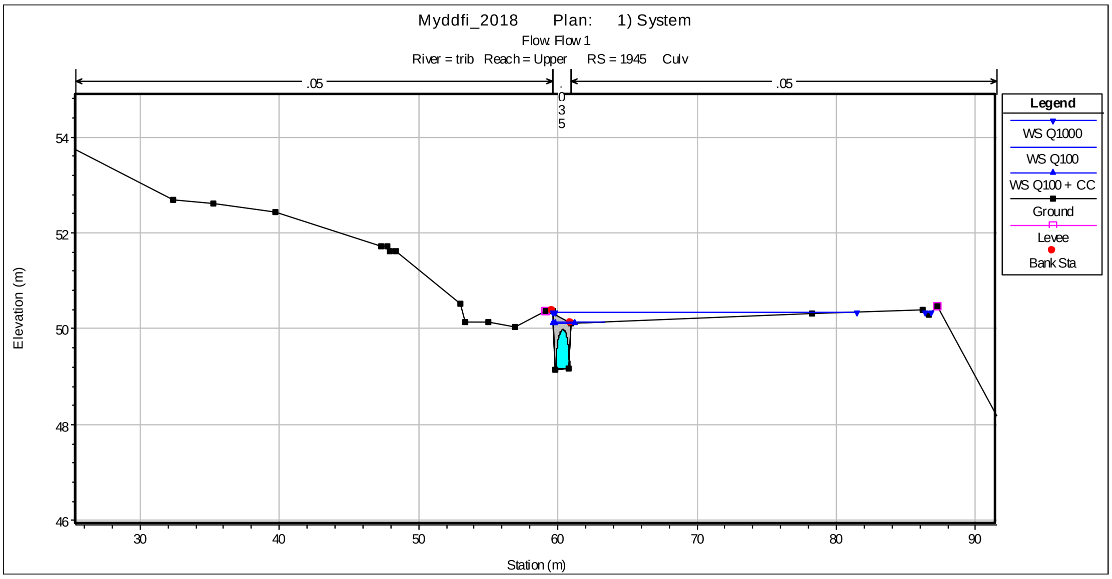

Figure 4.10 - Cross Section of Tributary Upstream of Culvert

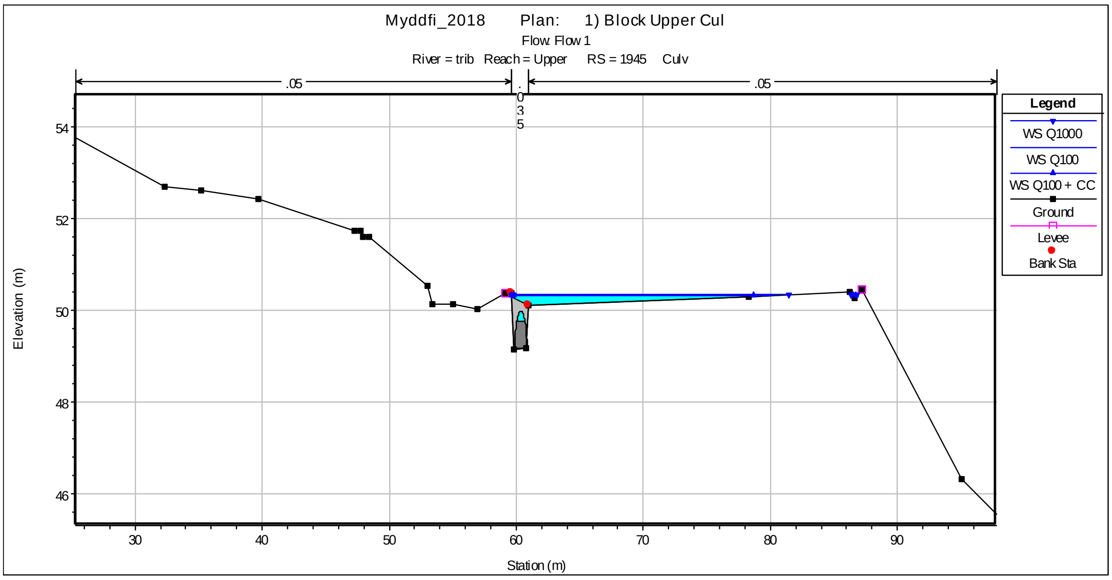

Figure 4.11 - Cross Section of Tributary Upstream of Culvert With 80% Blockage

5 FLOOD RISK

Flooding can occur from various sources including fluvial and surface water. This section discusses the risk of flooding at the site by various means and the impact of developing the site on the risk of flooding elsewhere.

Fluvial Flooding

NRW flood maps (see Figure 5.1) would indicate that the site is within the C2 flood zone. However, the maps are not considered to be accurate at this location with part of the stream and ravine shown to be flood free while the adjacent higher land is shown to be at risk.

Figure 5.1 – NRW Flood Map

As part of the study the Q100, Q100+CC and the Q1000 flows have been estimated for the adjacent stream using a combination of statistical and the revitalised rainfall runoff method. The flows were then run in a 1d mathematical model which estimated the potential flood levels.

The model showed that the flood levels adjacent to the site entrance were expected to be 45.67m AOD during the Q100 event, 45.97m AOD during the Q100+CC and 46.35m AOD during the Q1000 event. These levels did not increase when the downstream bridge was partially blocked or when the Manning's number was increased by 20% to 0.042.

The proposed development is to be constructed on ground of over 47.75m AOD and will have a slab level of 47.5m AOD. Clearly, therefore, the development itself is expected to be flood free during the considered events year event. However, the land at the entrance into the site, along with the adjacent road, could be at risk of flooding with flood depths of up to a meter during a Q1000 event with corresponding maximum velocity of around 1m/s.

Water is also expected to flood across the lane adjacent to the bridge downstream of the site, however, an alternative flood free access route (see Figure 5.2) is available to the A40 trunk road across adjacent fields, which is in the ownership of the developer and can be maintained in perpetuity. This route would also be acceptable for emergency vehicles.

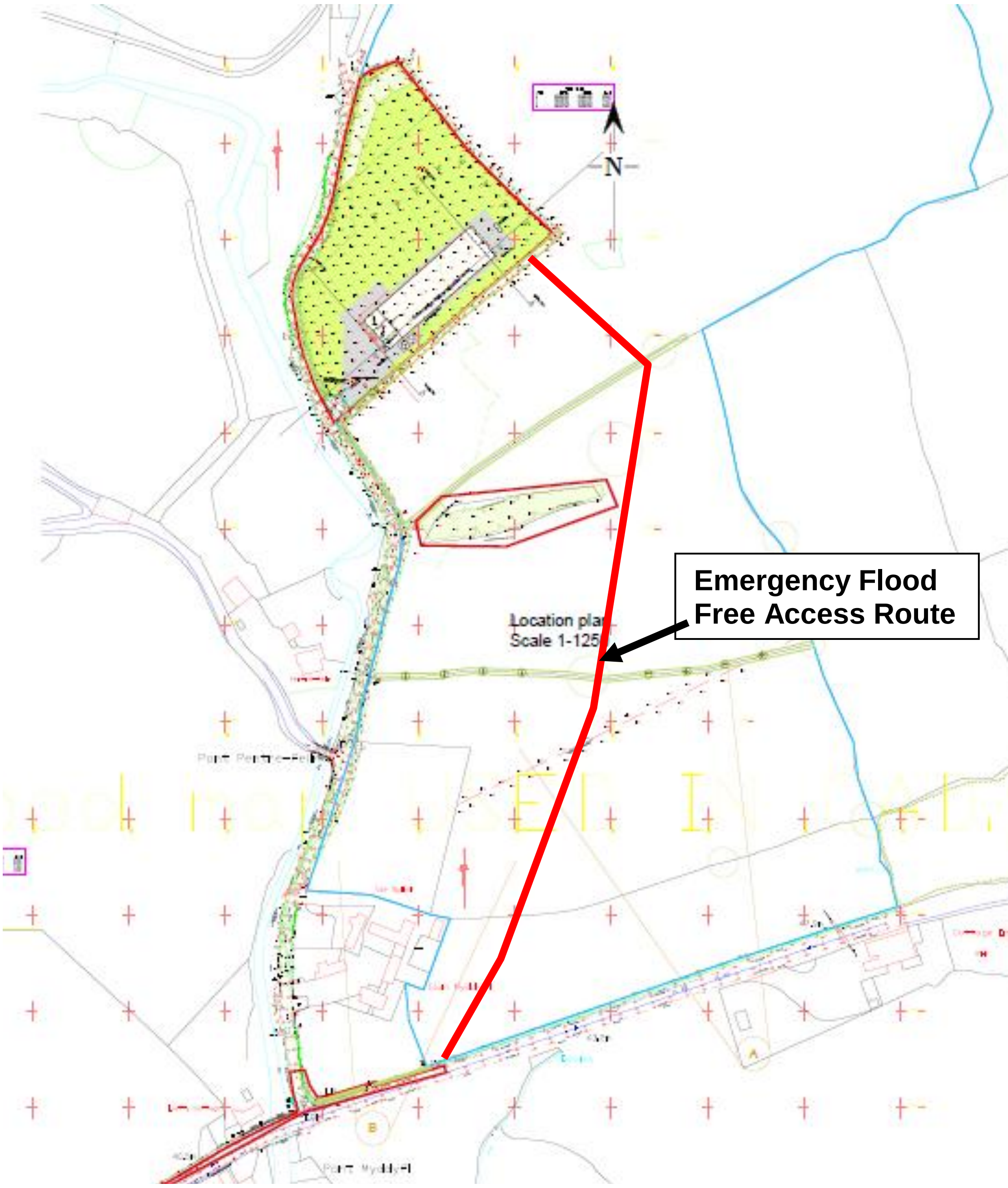

Figure 5.2 – Alternative Access Route

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

Surface water
The site could be at risk of flooding from surface water flowing from the adjacent fields although there is no obvious route and any water would be expected to

continue to flow towards the lane. Therefore, standard precautions are expected to be sufficient to prevent flooding from this source.

The NRW surface water flood map also shows the site as being flood free although the lane could be affected (see Figure 5.3)

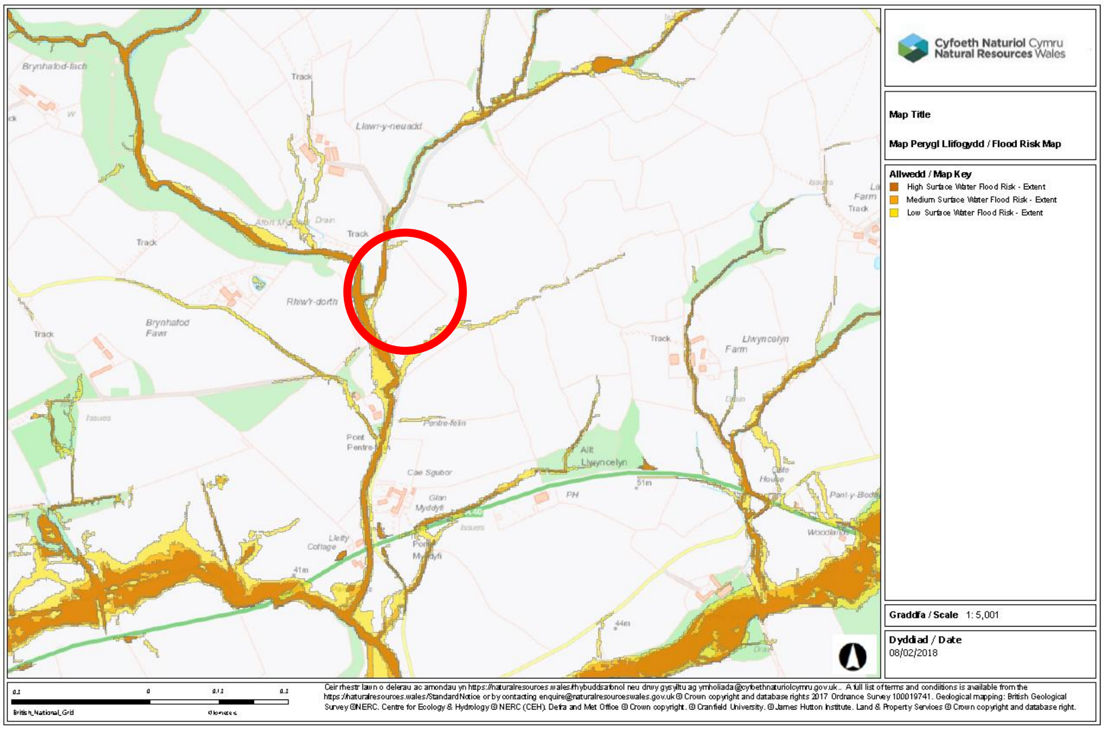

Figure 5.3 – NRW Surface Water Flood Map

Sustainable Drainage

As the proposed building is on a greenfield site there will be an increase in the impermeable surface area. Therefore, a sustainable drainage system, designed in accordance with Welsh Government Standards and the SUDS manual, will be required to ensure that the rainfall runoff rate from the site is not increased.

Reservoir Failure

The site is not considered at risk of flooding from reservoir failure.

Ground Water

The superficial geology for the area consist of Diamicton of Devensian Till overlying a bedrock geology of Mudstone from the Nantmel Mudstone Formation (see Figure 5.4 and 5.5). Water could seep through the sand, however, considering the river defences and the topography, the risk of groundwater flooding as opposed to direct flooding is considered to be low.

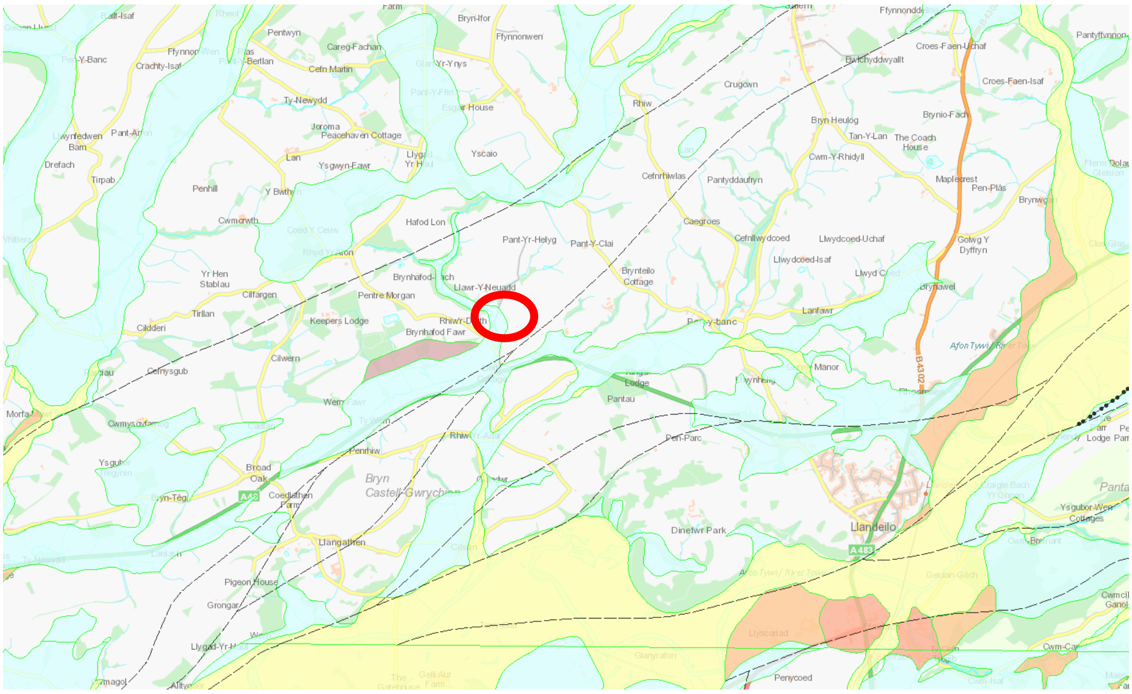

Figure 5.4 – Superficial Geology

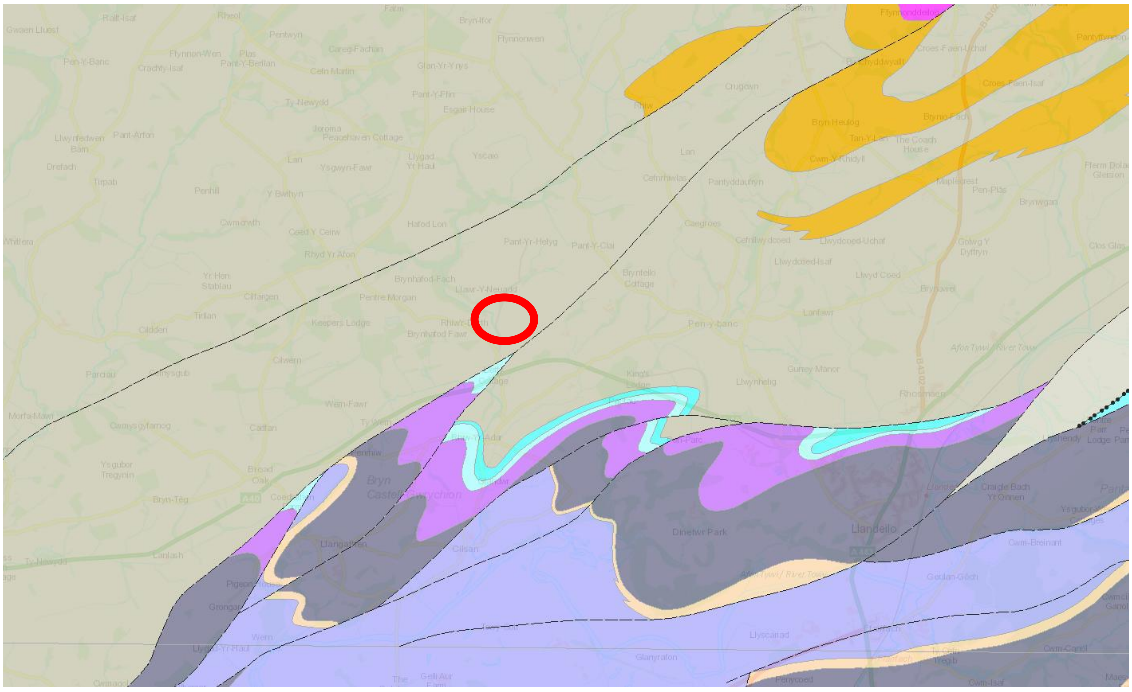

Figure 5.5 – Bedrock Geology

6 FLOOD PROOFING

As the proposed building is not expected to be at risk of flooding dryproofing flood protection measures are not considered necessary. Nevertheless, some wetproofing measures might be beneficial to improve the resilience of the building against, for instance, a burst pipe. Some of these measures are identified below:

- Locating vulnerable items at a higher level;
- Having solid concrete floors. Suspended floors are more difficult to clean and dry underneath;
- Using water resistant render for walls;
- Avoiding timber frame partition walls. These are expensive to repair and dry;
- Using non water absorbing insulation;
- Using corrosion resistant fittings such as galvanised or stainless steel in place of mild steel;
- Ensuring that electric cables are fed from above and keeping sockets away from the floor level;
- Applying an appropriate damp proof course;
- Installing appropriate water resilient doors;
- Avoiding placing storage heaters on the ground floor;
- Ensuring boilers are off the ground.

In order to prepare for a potential flood event it is recommended that the site is registered on NRW's flood warning system. However, the warning time afforded by such a system is likely to be limited in this instance.

All future occupiers of the building should be made aware of the flood risk and a flood response plan should be prepared and disseminated effectively.

7 CONCLUSION and RECOMMENDATIONS

Conclusion

It is proposed to build a free range poultry unit on land north of Glanmyddyfi, Pentrfelin, Llandeilo. However, the client has been advised that the land lies within Zone C2 as defined by the development advice maps. This means that part of the site is considered to be at risk of flooding during at least the 1 in 1000 year event and is not afforded protection from recognised flood defences. Francis Sant were, therefore, requested in 2015 to evaluate the site's risk of flooding and assess the consequence of an event. The size of the unit has now been reduced and the FCA has been updated accordingly. The originally estimated Q100 and Q1000 flows have been retained although the Q100 flow has now been increased by 30% to account for climate change (20% used in original report).

As part of the study, the impact of flooding from the nearby Afon Myddyfi and a small tributary was considered during the Q100, Q100+CC and Q1000 events (see Table 7.1). The flows were estimated using the procedures recommended in the Flood Estimation Handbook (FEH) and the Revitalised FSR/FEH rainfall runoff method, as amended.

Table 7.1 – Flows to be Used in the Steady State Model		
Return Period Years	**Flow Rates for the Myddyfi**	**Flow Rates for the Tributary**
100	39.747	1.727
Q100 + 30%	51.671	2.245
1000	71.524	3.107

To determine the water levels in the stream, and to evaluate the risk of flooding at the site, a 1D model was built using HEC RAS 4.1. The model was run using the estimated Q100 and Q1000 flows. This identified that the proposed development itself is expected to remain flood free during both the Q100 and Q1000 year event, however, the entrance to the site could potentially experience flood depths of up to 1m during the Q1000 event with potentially a corresponding velocity of 1m/s. In addition the lane leading to the main road (A40 trunk road) is also expected to be affected during the considered events. As such, an alternative flood free access route is proposed from the site to the A40 highway which can be used by emergency vehicles.

As the development will be constructed on a greenfield site a sustainable drainage system, following the trquirements of the Welsh Government Standards, will be required to ensure that the rainfall runoff rate is not increased.

The site should be registered on Natural Resources Wales flood warning scheme.

Recommendations

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

- The finished floor level is maintained as shown;
- A sustainable drainage system is included in the proposals;
- Standard precautions are adopted to prevent flooding from surface water;
- Consideration is given for the incorporation of flood proofing measures, as identified in Section 6, to improve the resilience of the building against incidental flooding (eg a burst pipe);
- The site is registered on Natural Resources Wales flood warning scheme;
- An emergency access route is provided to the A40 trunk road.

APPENDIX A – FLOW ESTIMATION

In evaluating the risk of flooding at the site we should consider flows in the adjacent stream for various return periods especially the 1 in 100 and the 1 in 1000.

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 two potential donor sites one on the Cothi at Felin Mynachdi and the other on the Sawdde at Felin-y-Cwm. An adjustment factor will, therefore, be taken as the mean from each individual station.

An estimate of the flow will also be made by taking peak flows from a hydrograph, estimated using the revitalised FSR/FEH rainfall runoff method.

QMED for the Myddyfi is estimated, using catchment descriptors at the point of interest. An adjustment factor using the data transfer scheme, based on the Cothi at Felin Mynachdy gauge as a donor station, is estimated below.

Table A.1 – QMED At Point Of Interest And At Cothi Donor Site		
QMED Calculated Using Catchment Descriptors		QMED Observed
Myfddyfi@ POI	Donor Site	Donor Site
12.269	145.375	171.368

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

Where s = site
cd = catchment descriptors
d = donor site
obs = observed
a = adjusting factor (generally based on the distance between the sites)

a is calculated to be 0.391 for the Myddyfi, therefore, the adjusting factor for QMED is 1.066 which gives the **adjusted QMED as 13.084m3/s**.

An adjustment factor based on the Sawdde at Felin-y-Cwm gauging station, as a donor site, is estimated below.

Table A.2 – QMED At Point Of Interest And At Sawdde Donor Site		
QMED Calculated Using Catchment Descriptors		QMED Observed
Myfddyfi@ POI	Donor Site	Donor Site
12.269	63.712	124.708

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

Where s = site
cd = catchment descriptors
d = donor site
obs = observed
a = adjusting factor (generally based on the distance between the sites)

a is calculated to be 0.366 for the Tyweli, therefore, the adjusting factor for QMED is 1.279 which gives the **adjusted QMED as 15.686m3/s**.

The mean adjusted QMED is therefore (13.084 + 15.686)/ 2 = **14.385m3/s**

Catchment Descriptors
An estimate of the flow using pooled data from sites with similar catchment descriptors to the Myddyfi at the POI, has been made using the WINFAP – FEH software. The initial pooling group was reviewed and a number of stations were removed and others added to ensure sufficient record length. The list of stations used in the final pooling group is given in Table A.3 below.

The final pooling group for the Myddyfi gave a standardised test value H2 of -0.65 with 504 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 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.4.

Table A.3 - Final Pooling Group for Afon Myddyfi
Station
Langdon Beck @ Langdon
Trout Beck @ Moor House
Haddeo @ Upton
Hebden Beck @ Hebden
Hodge Beck @ Bransdale Weir
Harwood Beck @ Harwood
Leven @ Easby
Severn @ Plynlimon Flume
Brock @ U/S a6
Keer @ High Keer Weir
Kensey @ Launceston Newport
Tiddy @ Tideford
Hamps @ Waterhouses
Sprint @ Sprint Mill
Ettrick Water @ Brockhoperig

Table A.4 – Calculated Flow Rates Based on Catchment Descriptors		
Return Period (years)	**Growth Fitting**	**Myddyfi**
2	1.000	14.386
5	1.351	19.435
10	1.624	23.362
25	2.045	29.419
50	2.428	34.928
75	2.684	38.611
100	**2.883**	**41.474**
200	3.428	49.314
500	4.318	62.117
1000	**5.150**	**74.086**

Climate Change
Adding 30% to the values given in Table A.4, to account for climate change, gives us the flows noted in table A.5.

Table A.5 – Calculated Flow Rates Based on Catchment Descriptors Increased by 30% to Account for Climate Change	
Return Period Years	**Flow Rates for Myddyfi**
2	18.701
5	25.266
10	30.371
25	38.244
50	45.407
75	50.195
100	**53.916**
200	64.108
500	80.753
1000	**96.312**

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.6 with the peak flows provided in Table A.7

Table A.6 – Q100 and Q1000 Hydrograph For Myddyfi		
Time Step	**Q100**	**Q1000**
0.00	1.1	1.1
0.25	1.1	1.1
0.50	1.1	1.2
0.75	1.3	1.4
1.00	1.5	1.7
1.25	1.8	2.3
1.50	2.4	3.1
1.75	3.1	4.3
2.00	4.2	6.1
2.25	5.7	8.6
2.50	7.7	12.0
2.75	10.2	16.4
3.00	13.1	21.6
3.25	16.2	27.2
3.50	19.3	33.1
3.75	22.3	38.8
4.00	24.9	43.9
4.25	26.9	48.0
4.50	28.1	50.7
4.75	28.5	51.8
5.00	28.2	51.5
5.25	27.3	50.2
5.50	26.0	48.1
5.75	24.5	45.3
6.00	22.8	42.3
6.25	21.1	39.1
6.50	19.4	35.9
6.75	17.8	32.9
7.00	16.3	30.0
7.25	14.8	27.4
7.50	13.5	24.9
7.75	12.3	22.5
8.00	11.1	20.3
8.25	9.9	18.2
8.50	8.9	16.2

8.75	7.9	14.3
9.00	7.0	12.6
9.25	6.2	11.1
9.50	5.5	9.8
9.75	5.0	8.8
10.00	4.7	8.1
10.25	4.4	7.6
10.50	4.2	7.1
10.75	4.0	6.8
11.00	3.9	6.6
11.25	3.8	6.5
11.50	3.8	6.4

Table A.7 – Calculated Peak Flow Rates Based on ReFH	
Return Period Years	**Myddyfi**
100	28.5
1000	51.8

Advice from NRW recommends that the Q1000 values are obtained using FEH Q100 + CC value multiplied by ReFH (Q1000 / Q100). This was done and the results are provided in Table A.8 which should be used in any steady state modelling.

Table A.8 – Flows to be Used in the Steady State Model	
Return Period Years	**Flow Rates for Myddyfi**
100	41.474
Q100 + 30%	53.916
1000	74.631

These flows are estimated adjacent to the entrance to the site and downstream of the minor tributary. The flows above the confluence were, therefore, taken as proportionate to the catchment areas (see Table A.9).

Table A.9 – Flows to be Used in the Steady State Model Above Confluence		
Return Period Years	**Flow Rates for the Myddyfi**	**Flow Rates for the Tributary**
100	39.747	1.727
Q100 + 30%	51.671	2.245
1000	71.524	3.107

APPENDIX B – CALCULATED WATER LEVELS

Table B.1 – Water Level For Q100+CC and Q1000 Flows

River	River Station	Min Ch El(m)	Flow (m3/s)	Water Level(m)	Flow (m3/s)	Water Level(m)
			Q100		Q1000	
trib	2000	55.49	2.25	56.02	3.11	56.11
trib	1990	54.96	2.25	55.5	3.11	55.58
trib	1980	54.38	2.25	55.28	3.11	55.36
trib	1975	54.38	2.25	55.24	3.11	55.31
trib	1970		Culvert		Culvert	
trib	1960	53.25	2.25	53.87	3.11	53.96
trib	1950	51.6	2.25	52.26	3.11	52.39
trib	1947	49.15	2.25	49.96	3.11	50.35
trib	1945		Culvert		Culvert	
trib	1940	48.65	2.25	49.46	3.11	49.85
trib	1930	48.49	2.25	49.08	3.11	49.29
trib	1920	47.18	2.25	47.8	3.11	47.94
Myddfi	1000	46.39	51.67	47.75	71.52	48.01
Myddfi	990	46	51.67	47.32	71.52	47.59
Myddfi	980	45.11	51.67	47.39	71.52	47.8
Myddfi	970	44.9	51.67	46.89	71.52	47.52
Myddfi	960	44.84	51.67	46.1	71.52	46.35
Myddfi	950	44.48	51.67	46.43	71.52	46.69
Myddfi	940	44.41	51.67	46.56	71.52	46.88
Myddfi	930	43.77	53.92	46.51	74.63	46.84
Myddfi	920	43.44	53.92	46.43	74.63	46.7
Myddfi	910	43.14	53.92	45.97	74.63	46.35
Myddfi	900	38.29	53.92	42.66	74.63	43.44
Myddfi	895		Culvert		Culvert	
Myddfi	890	38.42	53.92	41.76	74.63	42.27
Myddfi	880	38.52	53.92	39.29	74.63	39.45

Table B.2 – Water Level For Q100 and Q1000 Flows With Blockage to Bridge						
River	**River Station**	**Min Ch El(m)**	**Flow (m3/s)**	**Water level(m)**	**Flow (m3/s)**	**Water Level(m)**
			Q100		**Q1000**	
trib	2000	55.49	2.25	56.02	3.11	56.11
trib	1990	54.96	2.25	55.5	3.11	55.58
trib	1980	54.38	2.25	55.28	3.11	55.36
trib	1975	54.38	2.25	55.24	3.11	55.31
trib	1970		Culvert		Culvert	
trib	1960	53.25	2.25	53.87	3.11	53.96
trib	1950	51.6	2.25	52.26	3.11	52.39
trib	1947	49.15	2.25	49.96	3.11	50.35
trib	1945		Culvert		Culvert	
trib	1940	48.65	2.25	49.46	3.11	49.85
trib	1930	48.49	2.25	49.08	3.11	49.29
trib	1920	47.18	2.25	47.8	3.11	47.94
Myddfi	1000	46.39	51.67	47.75	71.52	48.01
Myddfi	990	46	51.67	47.32	71.52	47.59
Myddfi	980	45.11	51.67	47.39	71.52	47.8
Myddfi	970	44.9	51.67	46.89	71.52	47.52
Myddfi	960	44.84	51.67	46.1	71.52	46.35
Myddfi	950	44.48	51.67	46.43	71.52	46.69
Myddfi	940	44.41	51.67	46.56	71.52	46.88
Myddfi	930	43.77	53.92	46.51	74.63	46.84
Myddfi	920	43.44	53.92	46.43	74.63	46.7
Myddfi	910	43.14	53.92	45.97	74.63	46.35
Myddfi	900	38.29	53.92	43.62	74.63	43.89
Myddfi	895		Culvert		Culvert	
Myddfi	890	38.42	53.92	41.76	74.63	42.27
Myddfi	880	38.52	53.92	39.29	74.63	39.45

Table B.3 – Water Level For Q100 and Q1000 Flows With n = 0.042						
River	**River Station**	**Min Ch El(m)**	**Flow (m3/s)**	**Water level(m)**	**Flow (m3/s)**	**Water Level(m)**
			Q100		**Q1000**	
trib	2000	55.49	2.25	56.07	3.11	56.17
trib	1990	54.96	2.25	55.54	3.11	55.61
trib	1980	54.38	2.25	55.3	3.11	55.38
trib	1975	54.38	2.25	55.24	3.11	55.31
trib	1970		Culvert		Culvert	
trib	1960	53.25	2.25	53.87	3.11	53.96
trib	1950	51.6	2.25	52.26	3.11	52.39
trib	1947	49.15	2.25	49.96	3.11	50.34
trib	1945		Culvert		Culvert	
trib	1940	48.65	2.25	49.53	3.11	49.84
trib	1930	48.49	2.25	49.14	3.11	49.29
trib	1920	47.18	2.25	47.8	3.11	47.94
Myddfi	1000	46.39	51.67	48.22	71.52	48.7
Myddfi	990	46	51.67	47.37	71.52	47.65
Myddfi	980	45.11	51.67	47.43	71.52	47.83
Myddfi	970	44.9	51.67	46.91	71.52	47.56
Myddfi	960	44.84	51.67	46.15	71.52	46.4
Myddfi	950	44.48	51.67	46.52	71.52	46.79
Myddfi	940	44.41	51.67	46.6	71.52	46.93
Myddfi	930	43.77	53.92	46.55	74.63	46.86
Myddfi	920	43.44	53.92	46.44	74.63	46.71
Myddfi	910	43.14	53.92	45.95	74.63	46.31
Myddfi	900	38.29	53.92	42.66	74.63	43.47
Myddfi	895		Culvert		Culvert	
Myddfi	890	38.42	53.92	41.76	74.63	42.27
Myddfi	880	38.52	53.92	39.35	74.63	39.5

Table B.4 – Water Level For Q100 and Q1000 Flows With Blockage to Tributary Culverts						
River	**River Station**	**Min Ch El(m)**	**Flow (m3/s)**	**Water level(m)**	**Flow (m3/s)**	**Water Level(m)**
			Q100		**Q1000**	
trib	2000	55.49	2.25	56.02	3.11	56.11
trib	1990	54.96	2.25	55.5	3.11	55.58
trib	1980	54.38	2.25	55.28	3.11	55.36
trib	1975	54.38	2.25	55.24	3.11	55.31
trib	1970		Culvert		Culvert	
trib	1960	53.25	2.25	53.87	3.11	53.96
trib	1950	51.6	2.25	52.26	3.11	52.39
trib	1947	49.15	2.25	50.31	3.11	50.35
trib	1945		Culvert		Culvert	
trib	1940	48.65	2.25	49.46	3.11	49.85
trib	1930	48.49	2.25	49.08	3.11	49.29
trib	1920	47.18	2.25	47.8	3.11	47.94
Myddfi	1000	46.39	51.67	47.75	71.52	48.01
Myddfi	990	46	51.67	47.32	71.52	47.59
Myddfi	980	45.11	51.67	47.39	71.52	47.8
Myddfi	970	44.9	51.67	46.89	71.52	47.52
Myddfi	960	44.84	51.67	46.1	71.52	46.35
Myddfi	950	44.48	51.67	46.43	71.52	46.69
Myddfi	940	44.41	51.67	46.56	71.52	46.88
Myddfi	930	43.77	53.92	46.51	74.63	46.84
Myddfi	920	43.44	53.92	46.43	74.63	46.7
Myddfi	910	43.14	53.92	45.97	74.63	46.35
Myddfi	900	38.29	53.92	42.66	74.63	43.44
Myddfi	895		Culvert		Culvert	
Myddfi	890	38.42	53.92	41.76	74.63	42.27
Myddfi	880	38.52	53.92	39.29	74.63	39.45