

Housing Development Croesnewydd Road, WREXHAM 15223

Flood Model Report
April 2016



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Control Copy No. V2

Date: April 2016

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1.0 INTRODUCTION

Datrys have been instructed to prepare an FCA and a supporting planning application for a residential development on a site off Croesnewydd Road, Wrexham. Following a consultation the NRW have requested assessment by modelling of the risk associated with flooding of a small water course running through the site from the south, this also includes any flooding that may arise from the pond to the west of the site.

The proposed development is to build 2 blocks flats at Croesnewydd Road, Wrexham. The site is located on the western outskirts of the town of Wrexham at National Grid Reference SH 31936 50274. The purpose of the investigation was to model the effect that flooding of the small ditch that runs from through the edge of the site from the south would have on the site. A site location plan can be seen in Appendix A.

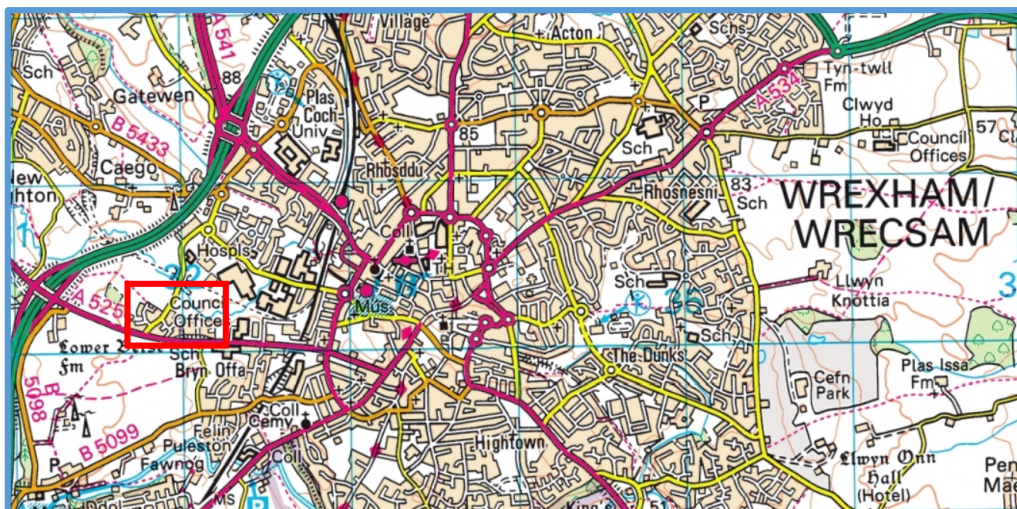


Figure 1. Location of development site (Red outline)

Following the Welsh governments planning policy TAN15 the proposed development in question is currently situated within 3 zones.

- Zone A: Considered to be at little or no risk of fluvial or coastal/tidal flooding.
- Zone B: Areas known to have flooded in the past.
- Zone C2: Without significant flood defence infrastructure.

Zone C2: without significant flood defence infrastructure is also located within the proposed developments site, however no dwellings are to be built on this zone.

Flood modelling of the small watercourse was undertaken on the CH2M Flood Modeller programme using a 1D-2D linked model.

The purpose of this model was to ascertain the extent of area that floods during various severities and scenarios of fluvial flooding. Floods of a 1 in 100 year occurrence, 1 in 100 (+30% climate change) year occurrence and 1 in 1000 year occurrence were modelled both with and without culvert blockages of varying degrees. The threshold event is the 1 in 100 + 30% climate change and the extreme event is the 1 in 1000 year event.

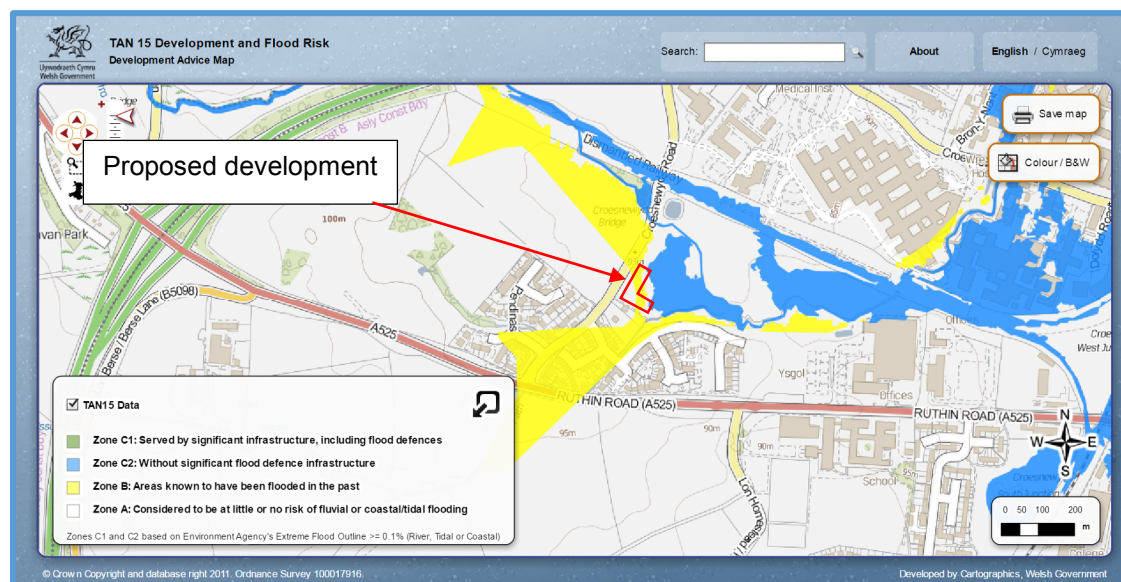


Figure 2. Development Advice map (DAM) of local area and development site (Red outline)

2.0 SITE DESCRIPTION

Location and Proposals

The Croesnewydd site is located near Afon Gwenfro to the west of Wrexham. The planned area of development occupies roughly 0.0139Km² and the proposed development consists of 2 blocks of flats, car parking and a large landscaped area. An aerial photograph of the current site area is shown below with the site boundary shown in red.



Figure 3. Google Earth view of the site and surrounding area

The general topography of the area slopes from west to east. LiDAR data shows the topography of the site itself varies considerably, it shows pockets of higher ground surrounded by lower ground that slopes down towards Afon Gwenfro. A pond towards the north of the site is also shown to with an invert level of 90.5m A.O.D. A topographical survey undertaken in November 2015 shows the site to slope from west to east with no significant localised changes.

FEH data for Afon Gwenfro estimates the catchment for the river up to the Croesnewydd site to be 9.92Km². According to the FEH data the ditch to the south does not flow into Afon Gwenfro but is shown as flowing into Afon Clywedog to the south. For the purpose of this model the southern watercourse has been modelled as flowing into Afon Gwenfro in agreement with topographic survey. The catchment area

of for the small southern watercourse is estimated to be 1.84Km². No data is given on the FEH CD-ROM 3 for the western watercourse emanating from a pond feature, which was therefore described by using the same descriptors as the southern watercourse with a smaller catchment of 0.233Km².

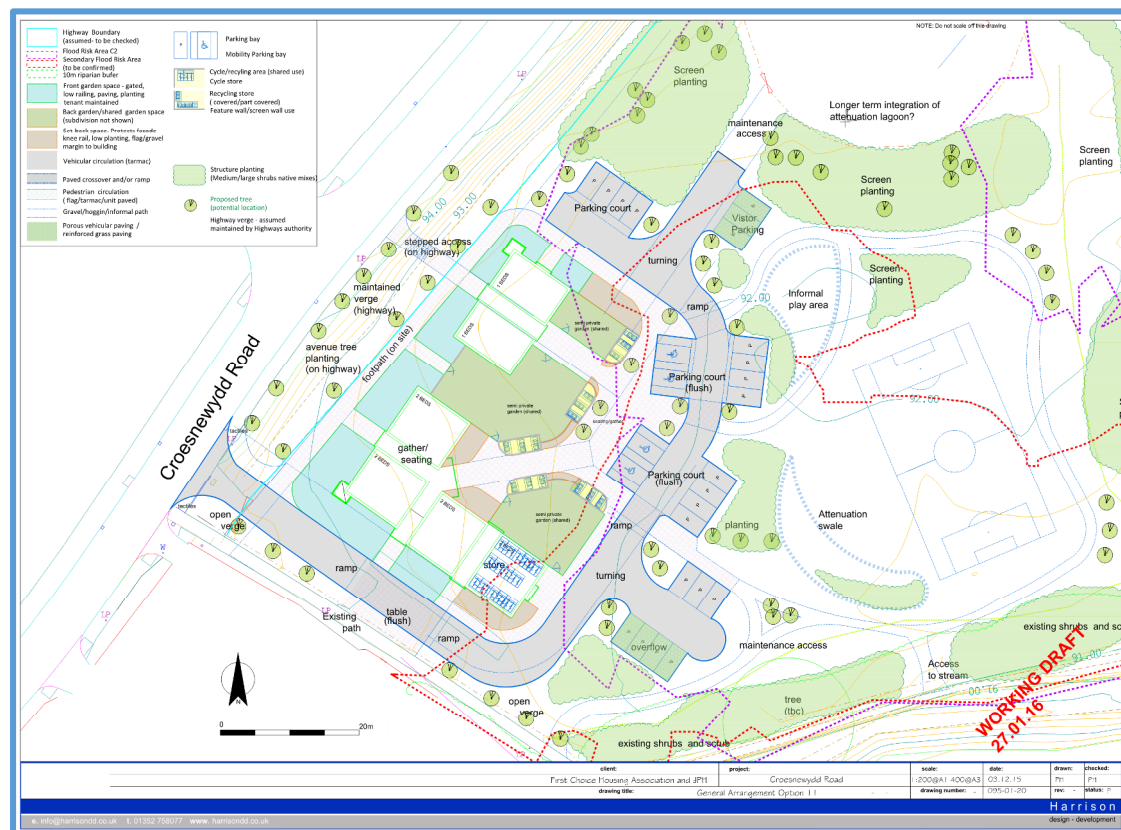


Figure 4. Site plan of the development.

Natural Resources Wales's Flood Risk map (Figure 5) shows the area to have risk of both surface water flooding and also risk of flooding from rivers and the sea. The maps shows a low risk of surface water flooding along Croesnewydd Road from the western watercourse. The map also shows the site to be at a low risk of flooding from Afon Gwenfro.



Figure 5. NRW Flood Risk Map of the site and surrounding area

3.0 FLOOD MODEL

The site in question lies within the red boundary of figure 6 below. Part of the site itself lies within a C2 boundary outlined on the Development Advice Map provided by the Welsh Government. As described earlier, buildings of the development are to be built outside of this C2 zone.

The DAM's however do not outline any potential flooding from smaller watercourses, and hence the need to model the watercourses from the west and south of the site for various storm intensities and scenarios.

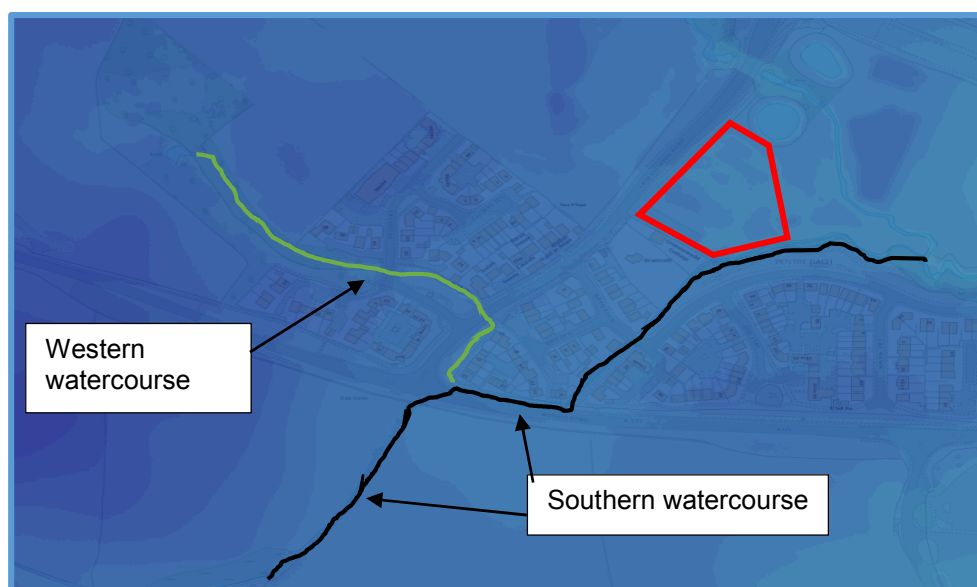


Figure 6. Site plan of the development of CTS showing the proposed building outlined in red.

The programme used to model the flood was Flood Modeller Pro by CH2M Hill. A 1D-2D linked model was prepared in order to simulate the interaction of flow within the 1D channel and then the extent of flooding on the floodplain.

Due to instabilities with using the culvert simulation tool, orifices were used at three of the four culverts of the 1D model in order to best represent the flow, this practice has been deemed a suitable method by Flood Modeller Pro support. USPBR bridges were also placed at the two locations where a bridge was present along the channel. Cross

section data for the river channels were originally obtained via the LiDAR data, and subsequently changed to a trapezoidal shape in order to further stabilise the model. Left and right bank levels, along with the bed level was taken from the LiDAR.

Flow data for the model was derived using the FEH function within Flood Modeller. Data had been extracted for the area using the Centre for Ecology and Hydrology FEH CD-ROM 3 and after inputting the catchment descriptors into Flood Modeller Pro a hydrograph was generated for various rainfall intensities. A hydrograph was produced for both the western watercourse (at river source) and the southern watercourse from Lower Berse Farm.

The 1D model downstream boundary was at the confluence with Afon Gwenfro. A head time boundary was used in order to represent a 1 in 100 year water level at Afon Gwenfro (see below for results). Initial conditions were obtained by running both hydrograph base flows for a period of 50 hours and extracting resulting water levels at the end of the run. These initial conditions were then used at the start of the full hydrograph which was ran for 8 hours in an unsteady run. Once the 1D unsteady model was running correctly, it was linked to the floodplain via a level link in a 2D simulation. The 2D simulation included the topographical information, manning grid, and the unsteady in channel data for each event.

10 points were chosen at random within the site, and the flood depths at those 10 points were recorded for various flood events and scenarios.

3.1 PRIMARY INPUT DATA

Natural Resources Wales Digital Terrain LiDAR data was obtained online via 'Y Lle' website for the site at a resolution of 1m in DTM format, which was the smallest cell size available.

The area files were downloaded for the site were:

- SJ3149_dtm_1m_w
- SJ3150_dtm_1m_w
- SJ3249_dtm_1m_w
- SJ3250_dtm_1m_w.

Once the 4 files were added into the flood modeller programme they were superimposed into one large map. No overlapping of the files occurred.

Digital maps in .TIF format were also used in the map for reference.



Figure 7. Full extent of the Lidar data and digital maps on the same grid.

Whilst reviewing the Lidar data, it was revealed that the elevations of the sites field did not agree with the topographic survey that was undertaken by Angle Surveys, nor the site visit conducted by Datrys. Elevation data from the topographic survey were therefore converted into an asci grid with the use of Civils 3D and OS GEO. The asci grid was then superimposed on top of the Lidar in order to create the most accurate surface in order to model the flood. The topographic survey can be viewed in Appendix B.

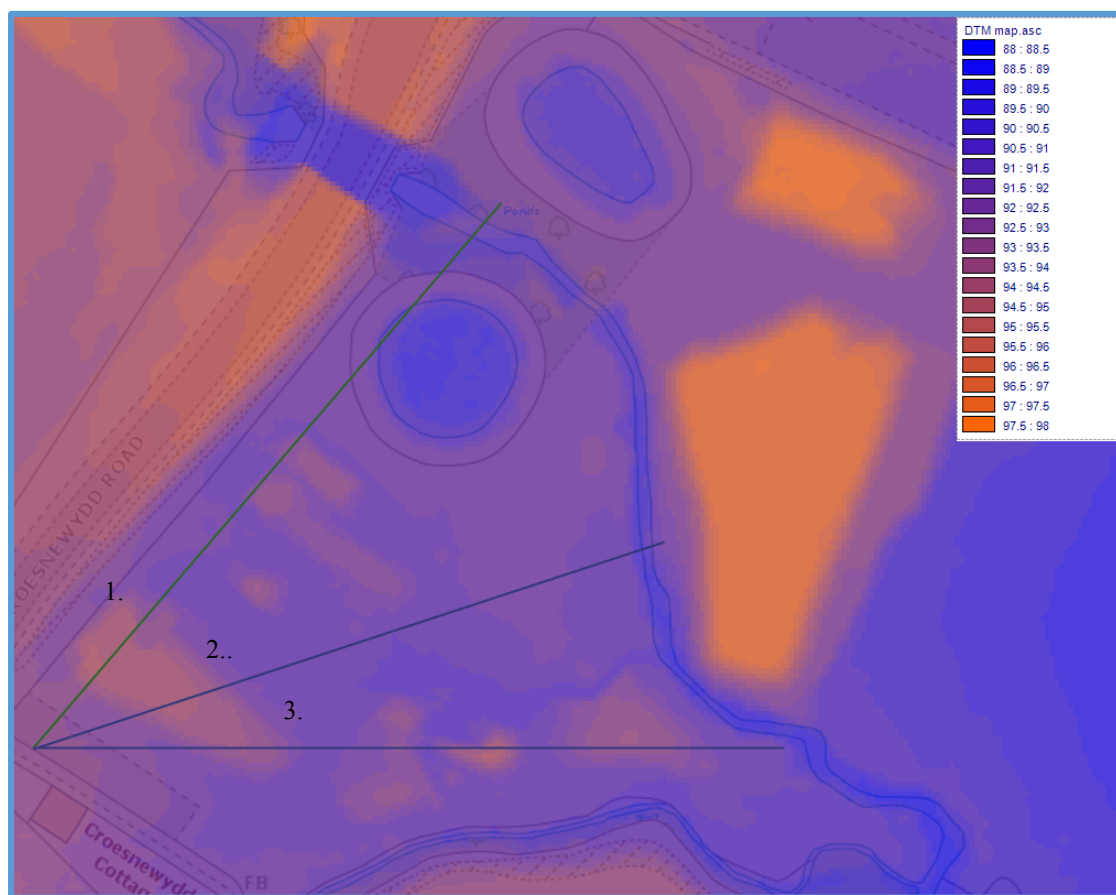


Figure 8. Ground elevation as shown in the flood modeller programme.

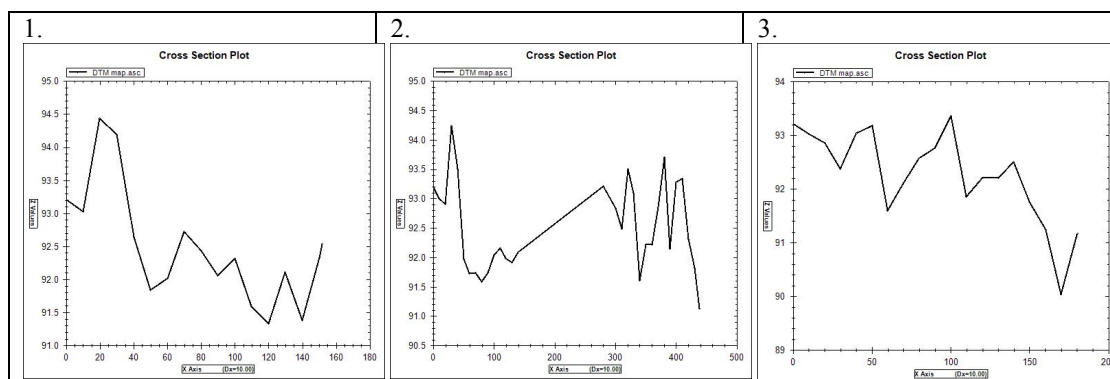


Figure 9. Cross section data of the ground elevation for various sections along the site.

3.2 SECONDARY INPUT DATA

FEH CD ROM 3 was used in order to determine the characteristics for the southern watercourse, this could then be used in order to determine flow rates using the FEH function within Flood Modeller. Figure 10 below shows the catchment described by the FEH program, the window also gives values for various catchment descriptors. These values were then used to input into the FEH node within Flood Modeller Pro, which created a hydrograph representative of the return period and the catchment. As the western watercourse had a catchment of less than 0.5Km² it was not displayed within the FEH program and consequently the same descriptors were used as the southern watercourse however with a much smaller catchment area in order to represent the smaller catchment more accurately.

A value of 1.84 Km² was used to describe the catchment. The FEH CD ROM-3 also showed the watercourse does not flow through the site or join Afon Gwenfro, it is shown to flow into Afon Clywedog to the south. For the purpose of modelling however it was assumed that this catchment did in fact run through the site in agreement with the site surveys.

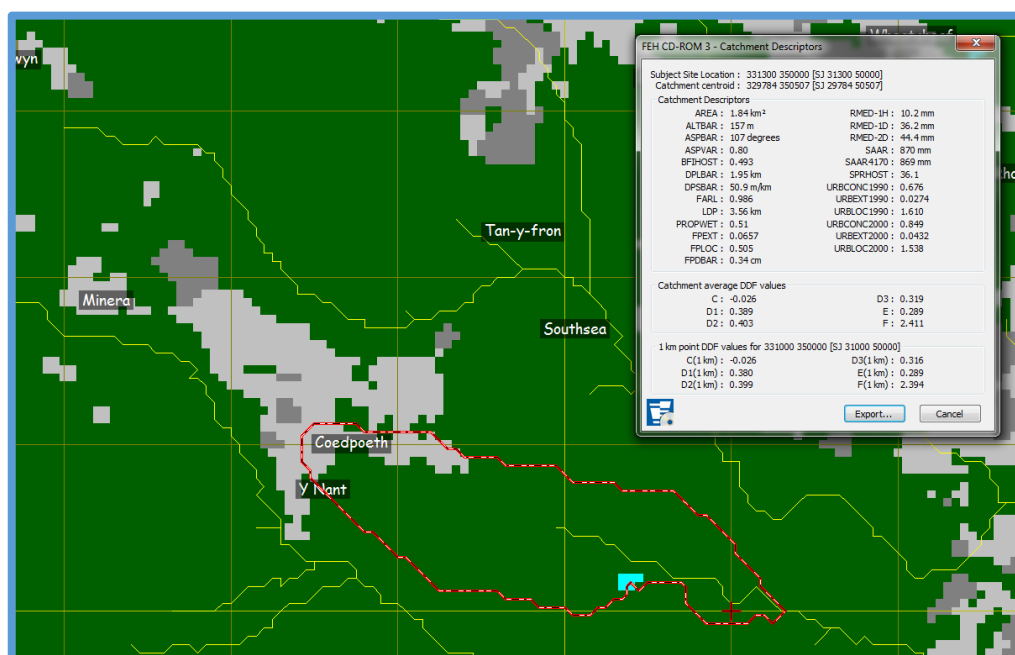


Figure 10. Screen shot of the catchment area for the southern watercourse on the FEH CD-ROM3 programme.

As the catchments were located close together the assumption was made that a flood event at one of the catchments would also represent the flood event in the other catchment.

Catchment descriptors obtained from FEH CD ROM-3 were input into the FEHBDY tool in flood modeller and subsequently scaled to provide a hydrograph representative of the catchment. The hydrographs were scaled down as previous correspondence with NRW described the maximum flow rates as being too high. Total flow was obtained for the southern ditch and the western ditch for 1 in 100 year occurrence and 1 in 1000 year occurrence.

To apply the allowance for climate change to the 1 in 100 year flood, the values for Total Flow were multiplied by 1.3 to allow for a 30% increase as per DEFRA guidance for rainfall intensities in small catchments. The 1 in 100 + CC event is considered to be TAN15 threshold event and the 1 in 1000 year as the extreme event.

Maximum flow rates for different fluvial events are given in the table below for the southern watercourse.

	Q100	Q100 + CC	Q1000
Max Flow rate (m³/s)	3.02	3.926	5.336

Table 1: Maximum flow rate for various flood events within southern watercourse

As the western watercourse was less than 0.5Km² it was not recognised as a river on the FEH CD – ROM 3. Within the FEH function in Flood Modeller an area of less than 0.5Km² was suitable for a hydrograph. Therefore using the same catchment descriptors as the southern watercourse, and a catchment area of 0.233Km² obtained using an OS map it was possible to generate a hydrograph for input into the 1D model. Maximum flow rates for the western watercourse are shown in the table below.

	Q100	Q100 + CC	Q1000
Max Flow rate (m³/s)	0.260	0.338	0.430

Table 2: Maximum flow rate for various flood events within western watercourse

Refer to Appendix C for all full hydrographs.

At the final node of the 1D model, a head-time boundary was used to represent the water level of Afon Gwenfro. A previous study on the site was undertaken by JBA titled FCA for the WAST development at Wrexham Maelor Hospital. Predicted water levels in Afon Gwenfro were described within the report, which showed that when the bed level of the river was at an elevation of 89.47mAOD that the 1 in 100 year river level was 1.03m higher than the bed level at that point. As no data was available to show the increase and decrease of this flood level against time, the head-time boundary was set at 90.50mAOD for the entire simulation length (See figure 11 below for the extract on the sites previous study written by JBA). A sensitivity analysis regarding the effect the head-time boundary had on the site was undertaken with levels of 90.0m, 90.5m and 91.0m used as the water head on the final node and can be seen in results section.

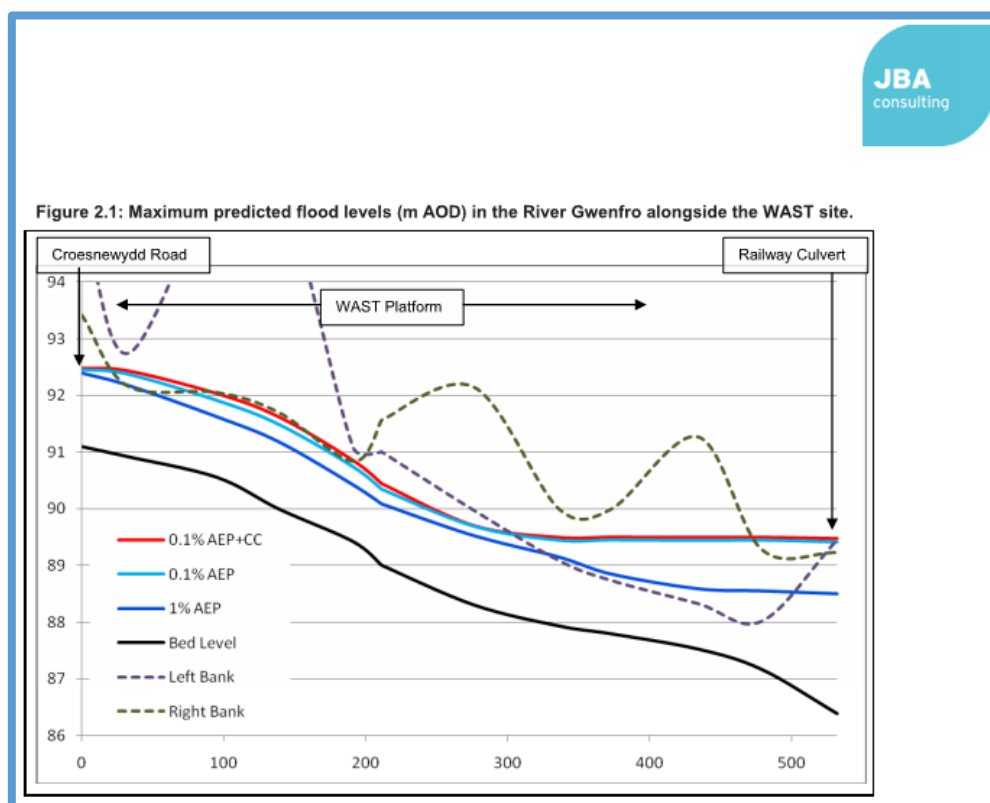


Figure 11. Extract from JBA report describing river levels during various storm intensities.

Surface roughness was described via Manning's Roughness scale and was input into the file via the use of shapefiles representing the various surfaces within the flood modeller program. Manning roughness values for various surfaces is given in the table below.

Surface	Manning Value
Roads	0.011
Built up area	0.08
Global roughness value	0.04
1D channel roughness	0.03

Table 3: Table describing the manning roughness values for various land use.

Due to the short steep channels and very low flows, the instabilities within the model were minimized. Within the model a few minor adjustments were required in order for the model to run smoothly, see below:

- As discussed earlier the three of the four culverts were replaced with orifices.
- All channel sections were modified to represent a trapezoidal section with bank levels and bed levels taken from the LIDAR DSM to represent the section.
- Interpolations were necessary in most river sections to help stabilise the 1D simulation.
- Link lines were manually drawn to follow the interaction between the 1D model and the 2D model, interpolates were included within the link line.
- The Head-Time boundary at the end of the reach was set at 89.5m for the first 30 minutes and was increased in 0.25m increments up to 90.5m in order to stabilise the model. As the peak flow within the model was at approximately 4.5 hours this would not alter the extent of flooding.
- The models initial conditions were derived using a base flow of $0.05\text{m}^3/\text{s}$ for the Western watercourse and a base flow of $0.065\text{m}^3/\text{s}$ for the Southern watercourse.

Blockages to the culverts were requested by NRW. Information on the four culverts included within the flood model has been taken from the topographic survey undertaken by Angle Surverys.

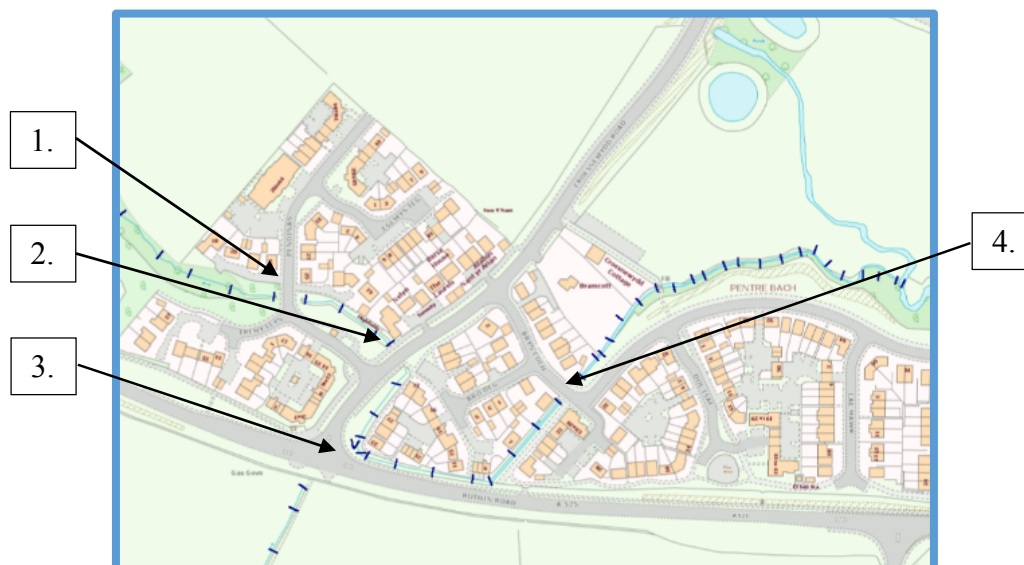


Figure 12. Culvert locations.

Culverts 1-3 were modelled as orifices within the flood modeller programme. Whereas culvert 4 was modelled as a culvert.

Culvert	Diameter	Unblocked bore area (m ²)		
		0%	33%	80%
1	0.5m	0.196	0.131	0.039
2	0.5m	0.196	0.131	0.039
3	2x0.3m	0.141	0.094	0.029
4	1.0m	0.785	0.523	0.157

Table 4: Area of culvert able to transfer flow.

4.0 RESULTS

A sensitivity analysis of the head-time boundary showed that increasing and decreasing the starting water level on the head-time boundary in the junction to Afon Gwenfro had little effect on the extent of flooding within the proposed development. Storage volume required for any additional flood water due to the increase in head-time boundary level was downstream of the site and hence had no effect on the proposed site.

The starting water level of 90.5m was chosen as the JBA report demonstrated that this was the water level at Afon Gwenfro when the bed level was at an elevation of 89.47mAOD as shown in figure 11. The 1 in 1000 year plus climate change water level at this same bed elevation is shown to be 91.0mAOD. And the level of 90.0m was to demonstrate the effect of flooding with a shallower starting water level at Gwenfro.

Therefore the head-time boundary at the final node (the junction into Afon Gwenfro) for each flood event and scenario was set as 90.5m.

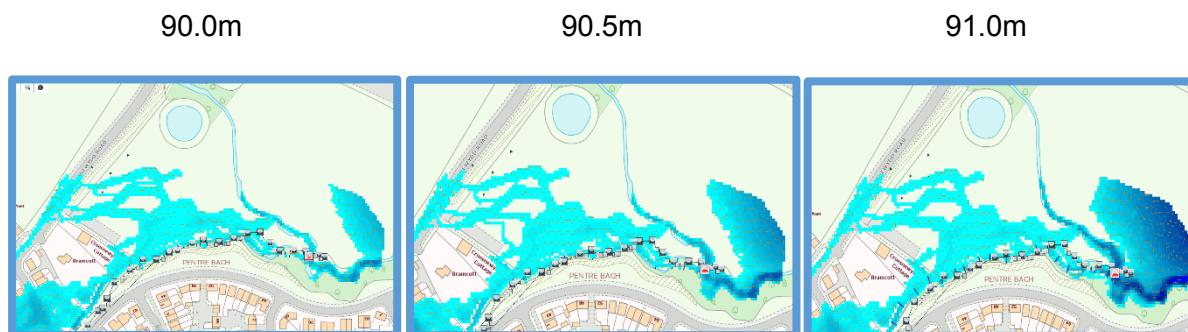
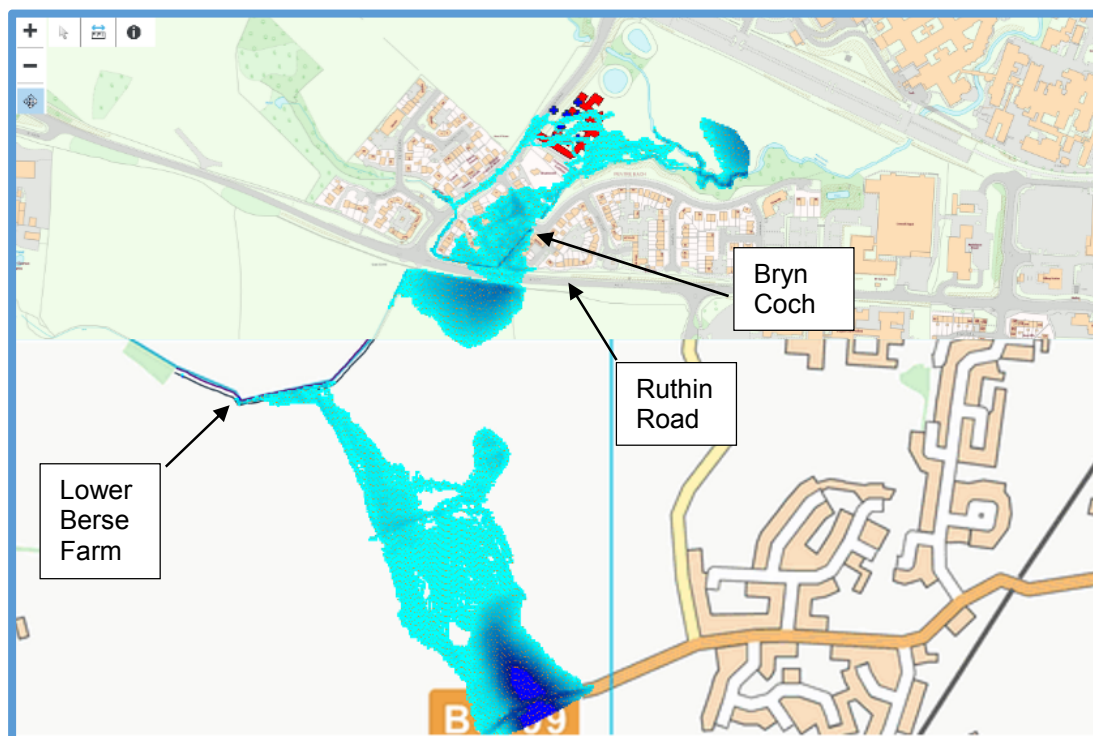


Figure 13: Iterations showing variance of flooding during the threshold event with various starting water levels at Afon Gwenfro.

Although the extent of flooding increases with an increase in volume of flow and also blockage proportion, each flood event and scenario followed the same pattern. The full extent of 1D-2D linked flooding for the threshold event can be seen below in figure 12 and also trends explained below.



. Figure 14: Full extent of flooding of model during the threshold flood event with a 0% blockage

One finding whilst running the models is that down near Lower Berse Farm, the southern watercourse changes direction from flowing to the east to flowing north (grid reference SJ 31641 49939). Multiple sources suggest that at larger flows the southern watercourse may divert away from the channel heading north towards Ruthin Road and flow to the south to join Afon Clywedog. FEH CD-ROM 3 show the river to flow south at this part rather than north which may suggest that the watercourse has been diverted north to follow the field boundary. NRW flood maps show considerable surface water flooding flowing from the southern watercourse to the south. All of our 2D runs also suggest that at high flows, part of the discharge does indeed flow south and away from Ruthin Road. All of this information and data indicate that the southern watercourse may have been diverted along field boundaries north to Afon Gwenfro rather than south to Afon Clywedog.

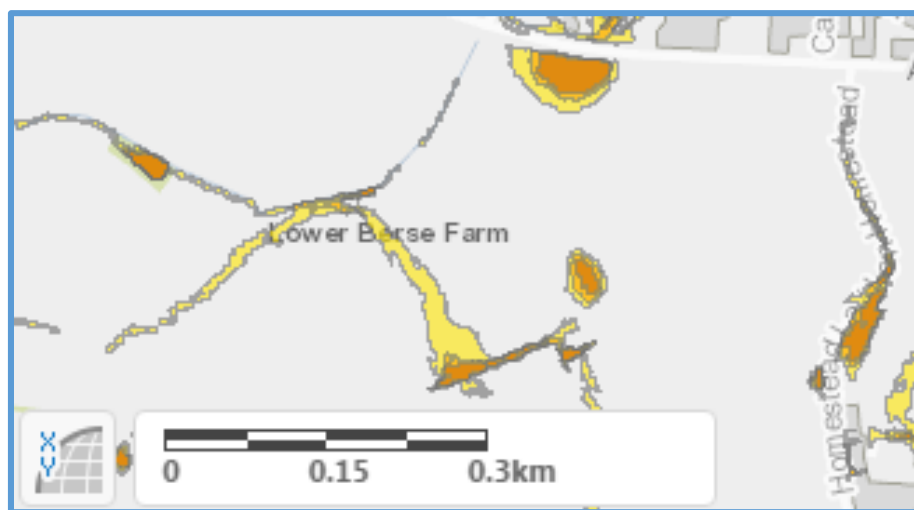
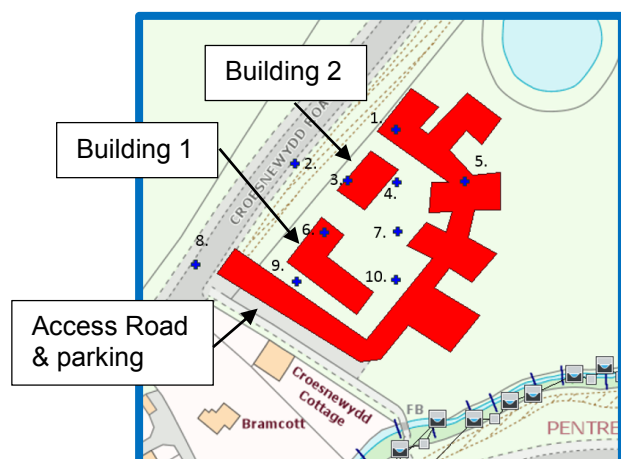


Figure 15: NRW flood risk map showing risk of surface water flooding south of Ruthin Road.

Once flow arrives at Ruthin Road it passes under the road through two 0.3m diameter culverts. NRW maps show that within the field just south of Ruthin Road a high risk surface water ponding is present. Our model also demonstrates the same results. This would suggest that the culverts running under Ruthin Road has capacity issues in transferring the flow. The flood model shows at each event greater than 1 in 100 year the depth of flooding at this point to be in excess of 1.0m which causes water to flow over Ruthin Road and flooding the houses at Bro Deg. A culvert of 1.0m diameter runs under Bryn Coch, which again restricts the flow of water causing larger scale flooding of the houses of Bro Deg and Bryn Coch.

Flow from the western watercourse is considerably smaller. The watercourse originates from a pond some 250m from Croesnewydd Road. It passes under two culverts, both of 0.5m in diameter, one under Pendinas and the other at Croesnewydd Road. The culvert under Croesnewydd Road also appears to have capacity issues at higher flows. This causes surcharging at the culvert which rises above the level of Croesnewydd Road. This water then runs along Croesnewydd Road and towards the development site. NRW flood risk maps show that Croesnewydd Road is at a risk of flooding from surface water. Our flood model also indicates that flooding occurs along Croesnewydd Road, which flows through the site at the location of the proposed building. The depth of this flooding however does not seem to exceed depths greater than 0.02m which would not be able to overtop the pavement nor freeboard of a proposed building.

The outline of the proposed buildings and access road can be seen below along with 10 points on the site were picked at random. Building 1 has a proposed finish floor level of 93.00m and building 2 a proposed finish floor level of 92.75m.



Point	Easting (X)	Northing (Y)
1	331960	950290
2	331930	350280
3	331945	350275
4	331960	350275
5	331980	350275
6	331940	350260
7	331960	350260
8	331900	350250
9	331930	350245
10	331960	350245

Figure 16: Points chosen on proposed site to represent flood depths for various scenarios and events.

A summary table of each run showing flood depths at the above points can be seen below.

Event	Blockage	1	2	3	4	5	6	7	8	9	10
1 in 100	0%	-	-	-	-	0.02	-	0.02	0.18	0.01	0.02
1 in 100 + CC	0%	-	-	-	-	0.02	-	0.02	0.18	0.02	0.02
1 in 1000	0%	-	-	-	-	0.02	-	0.02	0.18	0.01	0.02
1 in 100	33%	-	-	-	-	0.02	-	0.02	0.18	0.02	0.02
1 in 100 + CC	33%	-	-	-	-	0.02	0.02	0.03	0.18	0.02	-
1 in 1000	33%	-	-	-	-	0.02	0.02	0.02	0.18	0.02	0.02
1 in 100	80%	-	-	-	-	0.03	0.01	0.02	0.18	0.02	0.02
1 in 100 + CC	80%	-	-	-	0.02	0.03	0.02	0.03	0.20	0.02	0.02
1 in 1000	80%	-	-	-	-	0.02	0.02	0.02	0.18	0.02	0.02

Table 5: Points chosen on proposed site to represent flood depths for various scenarios and events.

The table above and corresponding figures below show that very little variation of flood extents occurs on site. The majority of water seems restricted by the culverts even when no blockage had been placed upon them, and hence a limited volume of floodwater is able to reach the site.

Figure 17 below demonstrates the extent of flooding on and near the site during each flood event with a 0% blockage at the culverts under current ground elevations. No alterations to ground elevation in order to accommodate the finish floor levels have been made.

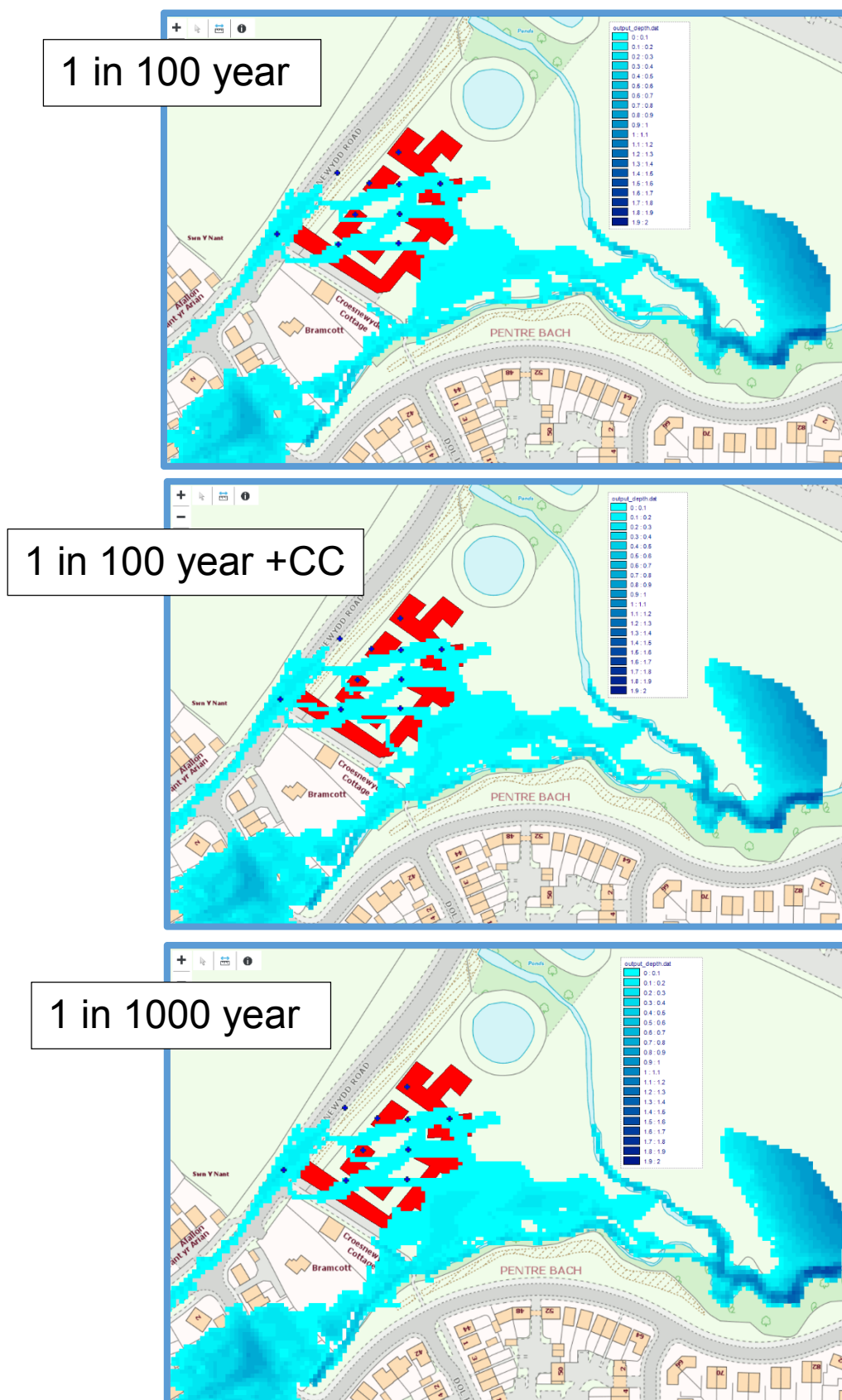
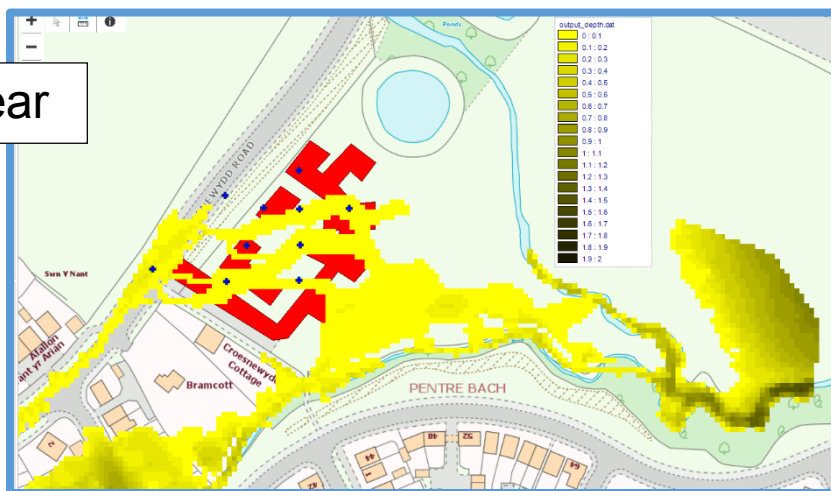


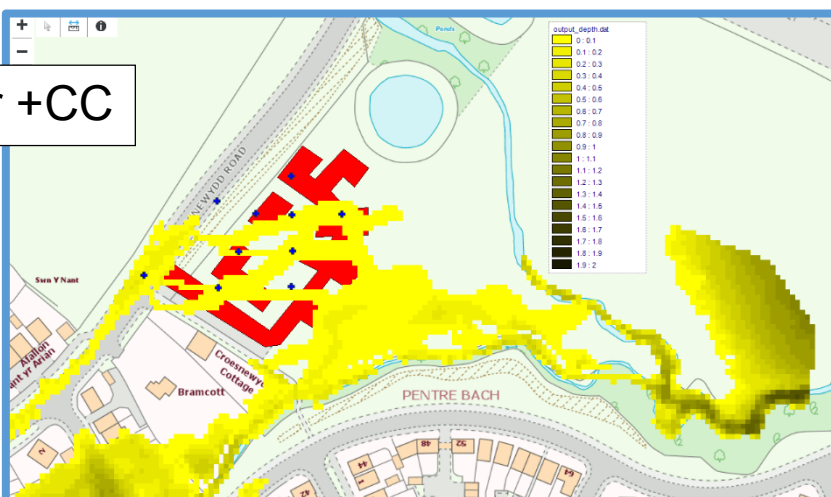
Figure 17: Flood extent of the various flood events during a blockage proportion of 0%

Figure 18 below demonstrates the extent of flooding on and near the site during each flood event with a 33% blockage at the culverts under current ground elevations.

1 in 100 year



1 in 100 year +CC



1 in 1000 year

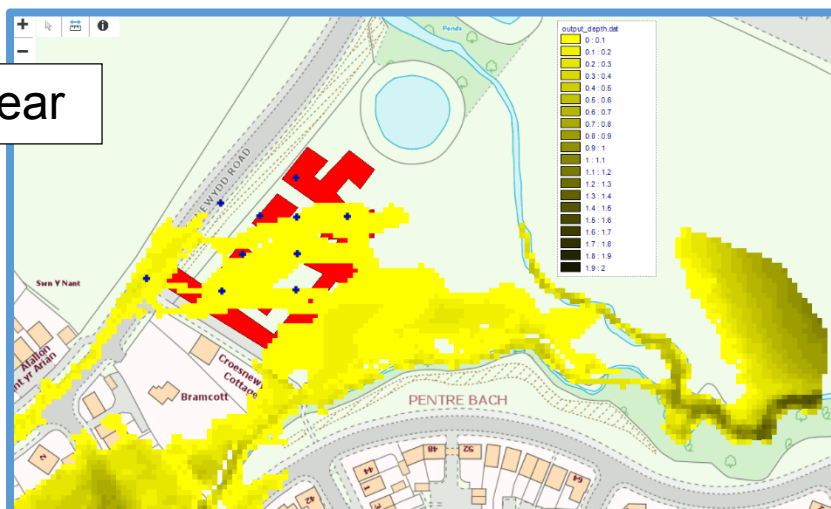
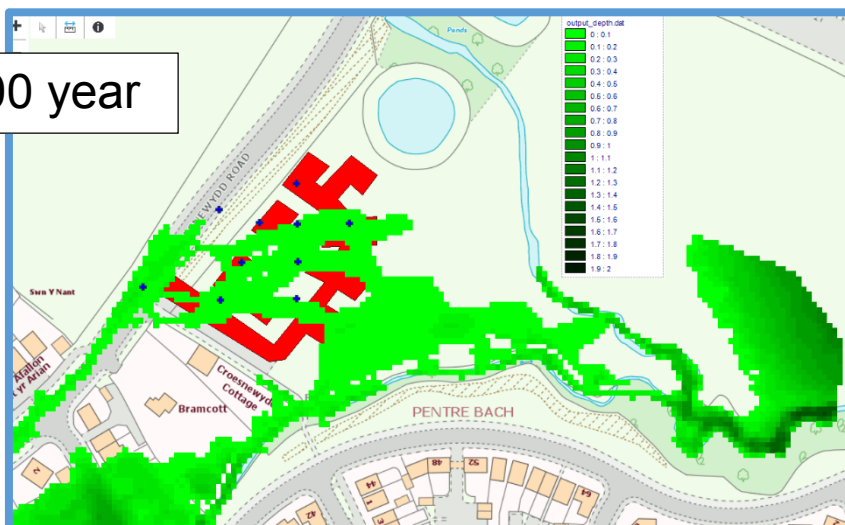


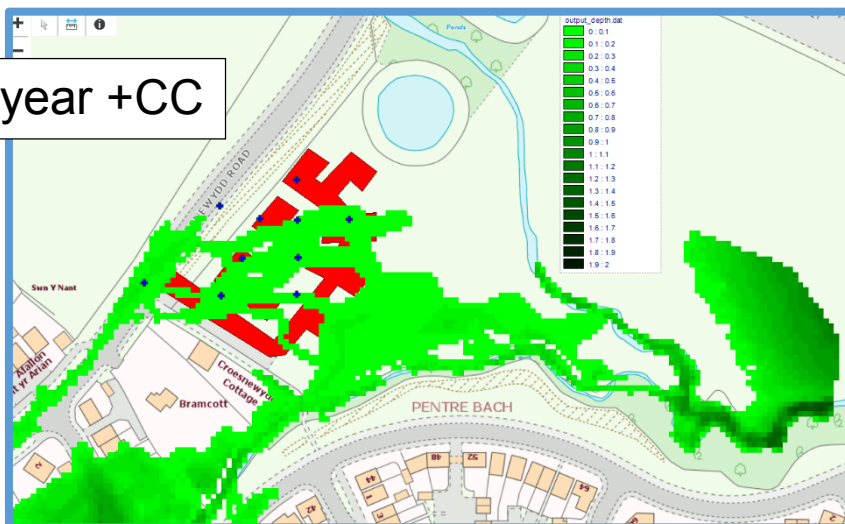
Figure 18: Flood extent of the various flood events during a blockage proportion of 33%

Figure 19 below demonstrates the extent of flooding on and near the site during each flood event with an 80% blockage at the culverts under current ground elevations.

1 in 100 year



1 in 100 year +CC



1 in 1000 year

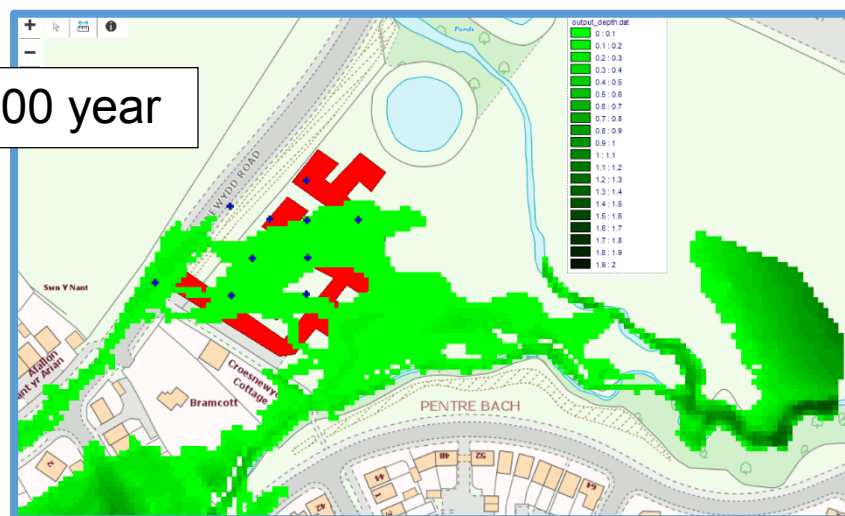


Figure 19: Flood extent of the various flood events during a blockage proportion of 80%

It has been proposed that building 1 is to have a minimum finish floor level of 93.00m and building 2 will be set at a minimum of 92.75m. In order to review the effect that raising these finished floor levels would have on the site and surrounding, the finish floor levels were superimposed onto the ground elevation and the threshold event and the extreme event were both simulated with an 80% blockage. The results are to be seen below in figure 20 and 21.

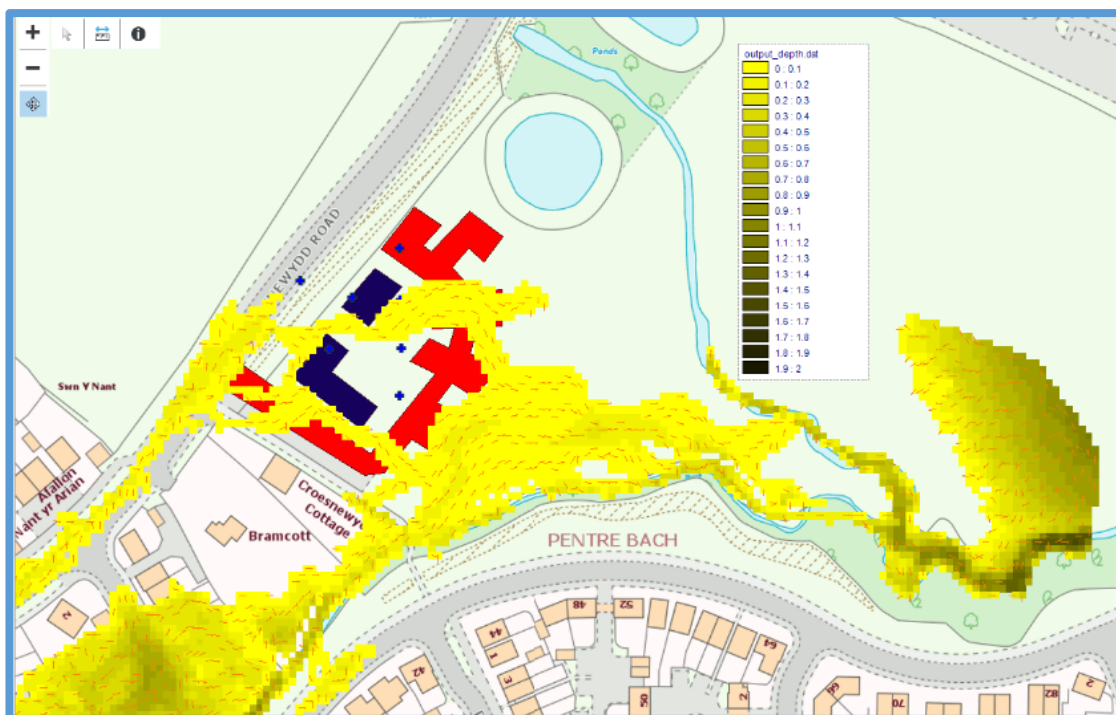


Figure 20: Flood extent of the threshold event having included minimum finish floor levels

There is no increase in flooding to nearby properties with the inclusion of the proposed development set at levels to make it flood free under both the threshold and extreme event. The flood depths on the site remain very low and the proposed buildings remain flood free.

Figure 22 shows the depth of flooding in more detail. As is shown in the colour ramp, the depth of flooding around the building in the extreme event with an 80% blockage does not exceed 0.04m.

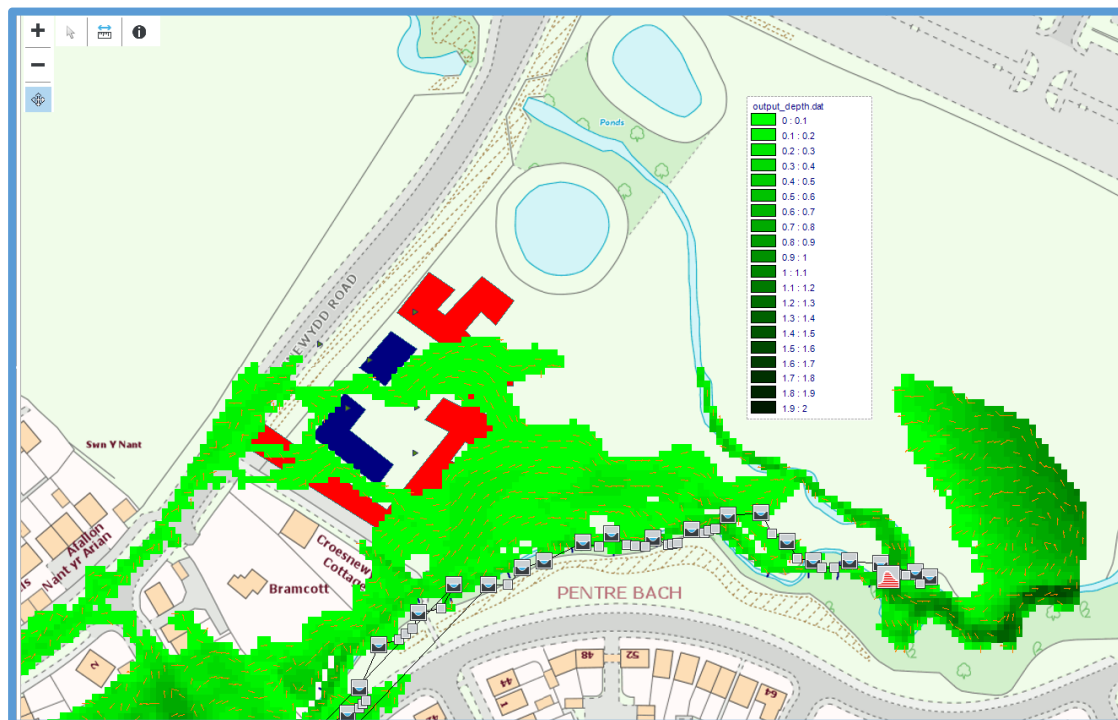


Figure 21: Flood extent of the extreme event having included minimum finish floor levels

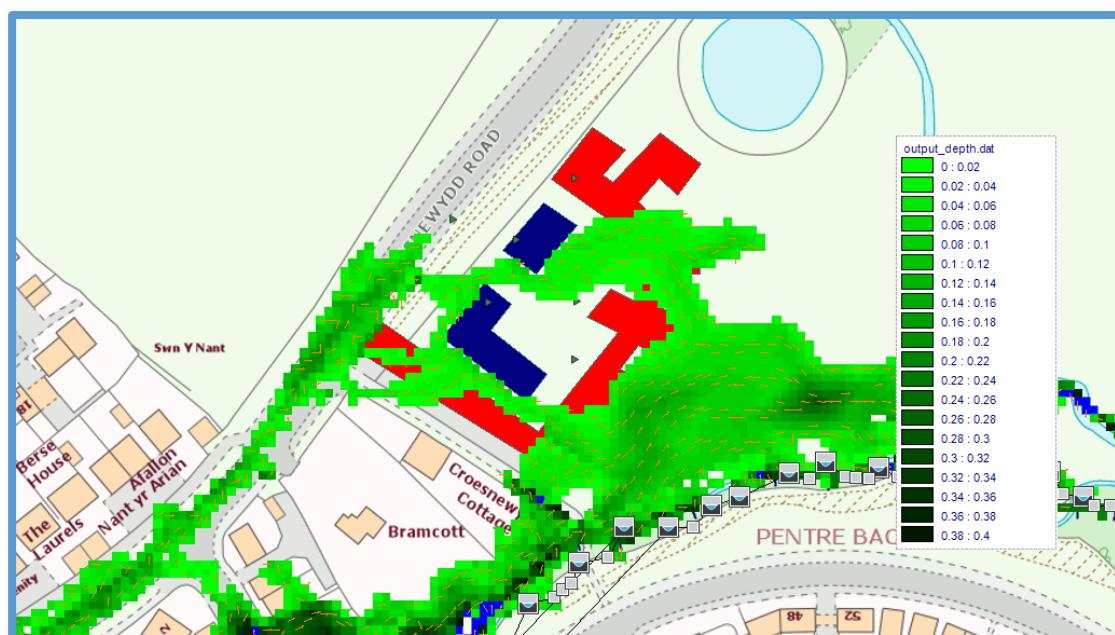


Figure 22: Detailed colour ramp shows the extent of flooding during the extreme event with blockages to culverts.

5.0 CONCLUSIONS

This flood model report has investigated the flood risk associated with the proposed development at Croesnewydd Road, Wrexham.

The site boundary contains zones A, B and C2 according to the Development Advice Maps. Highly vulnerable developments should not be located within the C2 flood zones according to TAN 15.

Correspondence with NRW indicated that the development may be considered providing flood extents were modelled for the southern watercourse with the inclusion of the tributary watercourse from the west. A 1D-2D linked model was required in order to include the simulation of blockages to culverts near the site.

The finished floor level of the 2 bedroom block of flats will be set at 93.00m and the 1 bedroom block of flats a finish floor level of 92.75 in order to provide a minimum 0.15m freeboard above the average flood level modelled for the site during the threshold event of a Clwyd defended in a 1 in 100 + 30 %increase due to climate change effects.

NRW flood risk maps, the Development Advice Maps and also Datrys simulations show considerable flooding within the area due to a capacity issues within multiple culverts. A risk of potential surface water flooding in the field south of Ruthin Road, within the Bryn Coch housing estate and up Croesnewydd Road is apparent.

Simulations show that the starting water level at the junction between the southern watercourse and Afon Gwenfro has very little effect on the extent and depth of flooding to the proposed development. A head of water of 90.5m was therefore used at this junction as indicated by JBA's previous flood study would correspond to a 1 in 100 year level at Gwenfro.

The main flood risk to the proposed development comes from the surface water flooding on Croesnewydd Road. This risk of flooding originates from western watercourse at the culvert running under Croesnewydd Road. Although flood water is

shown to flow directly between the proposed buildings the depth of flooding is less than 0.05m for each flood event and each blockage scenario.

Including the proposed finish floor levels to the elevation map and simulating both the threshold event and the extreme event shows no additional risk to nearby properties. It also shows the buildings to be flood free.

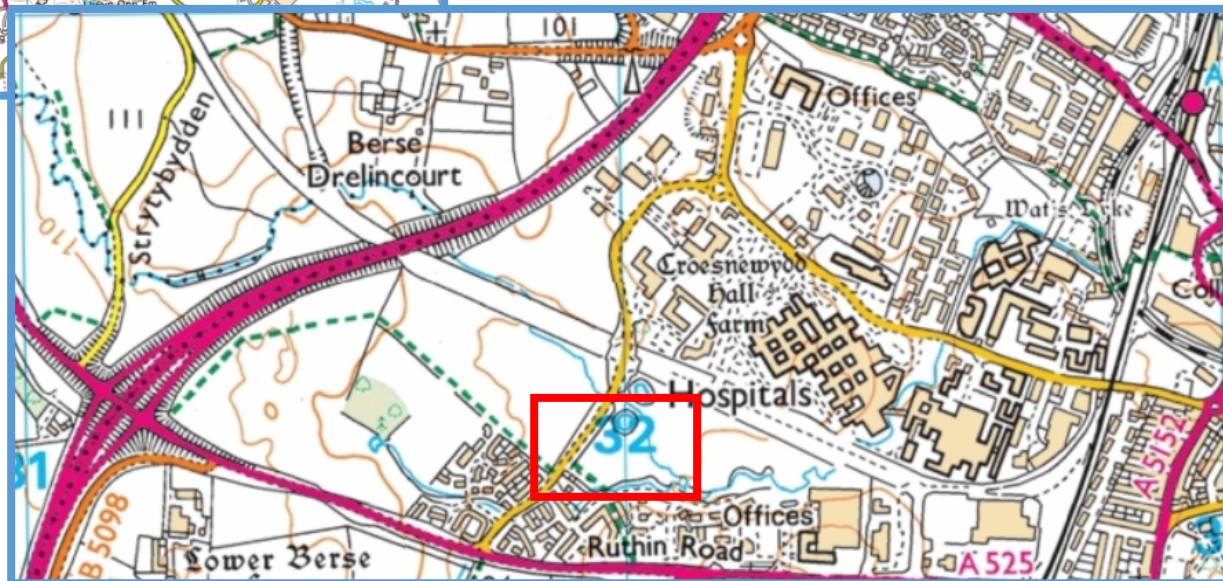
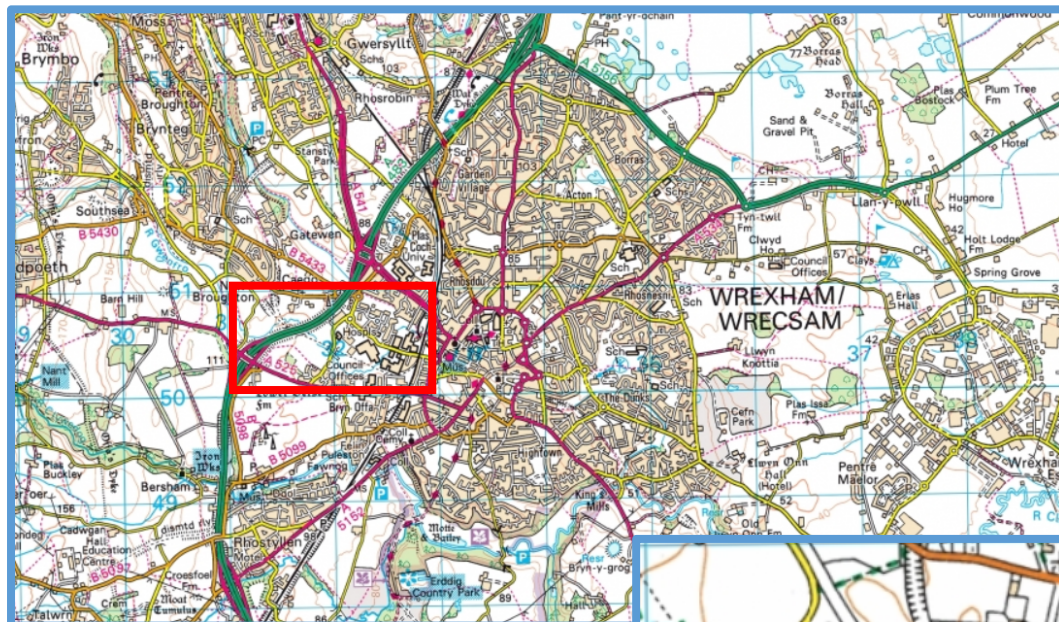
TAN 15 states that in the event of a flood a residential property would need to demonstrate that no flooding deeper than 0.6m occurs during the extreme event. The simulation of the extreme event with 80% blockages indicates a maximum depth of flooding on the site of 0.04 with the buildings remaining flood free.

APPENDICES

APPENDIX A

Site Location Plan

Site Location Plan – Croesnewydd Road, Wrexham



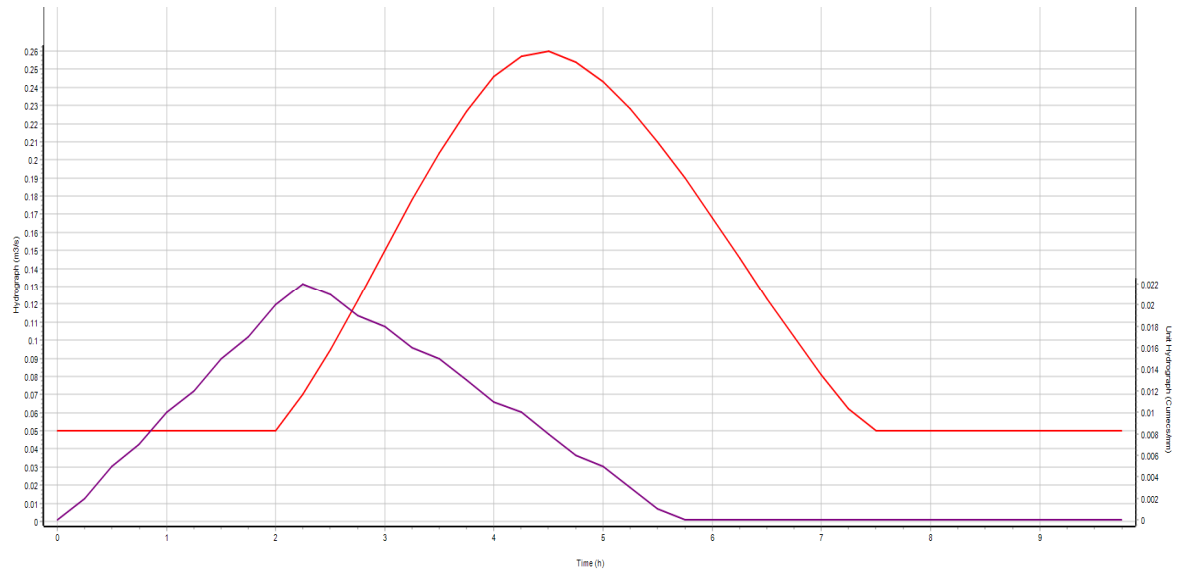
APPENDIX B

Topographical Survey

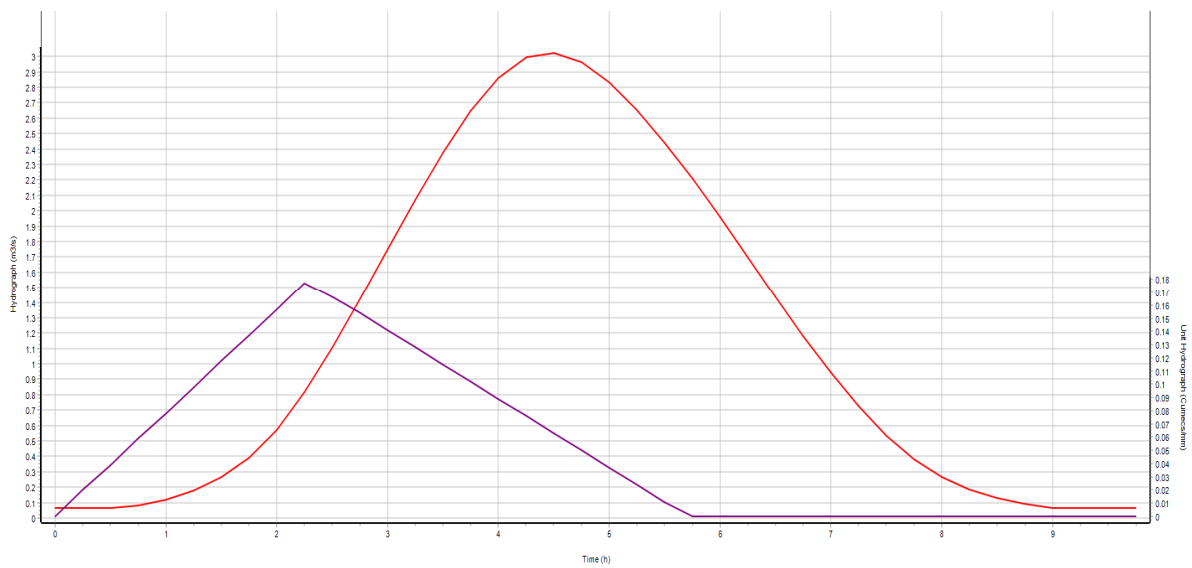
APPENDIX C

Full Hydrographs

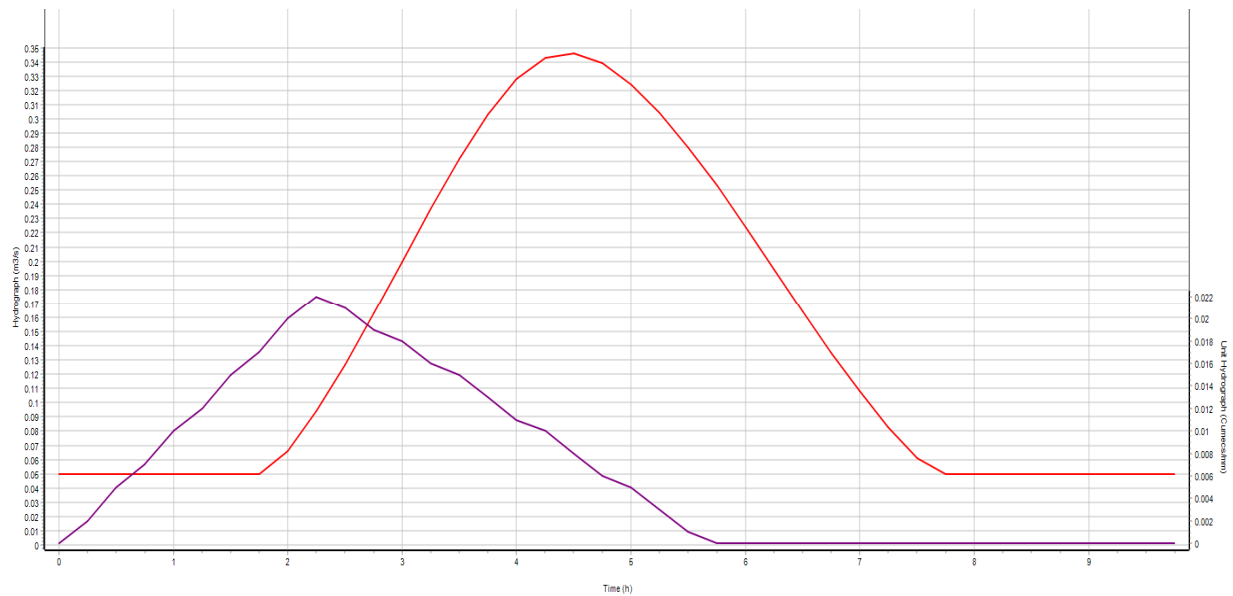
Western Hydrograph 1 in 100 year



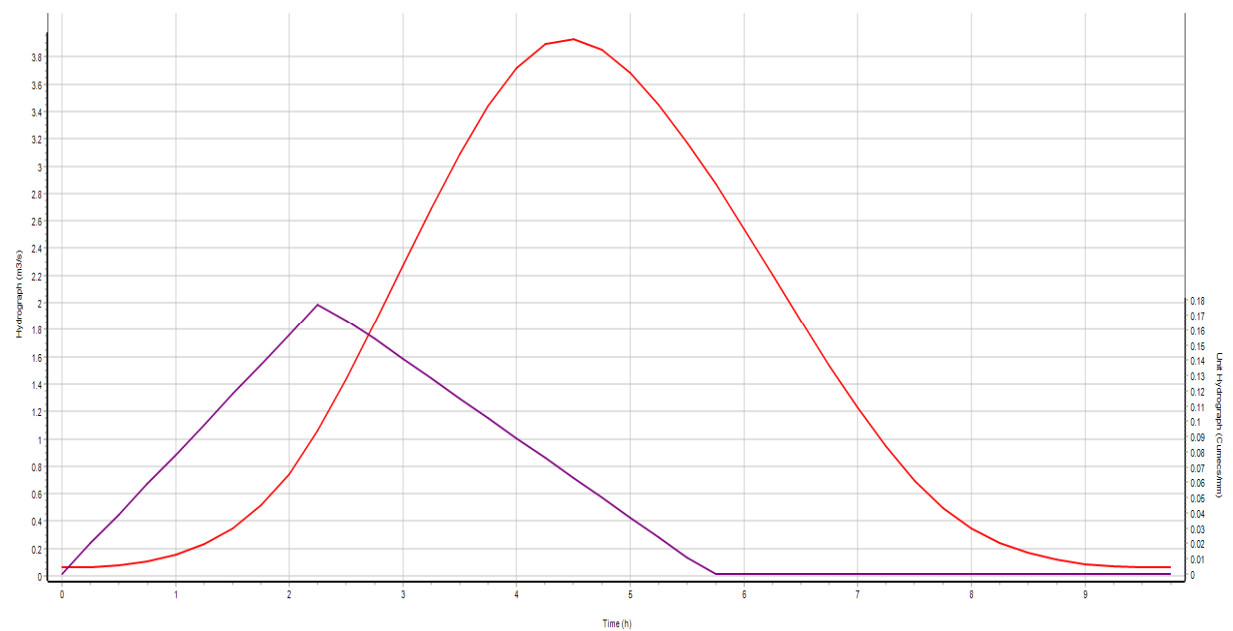
Southern Hydrograph 1 in 100 year



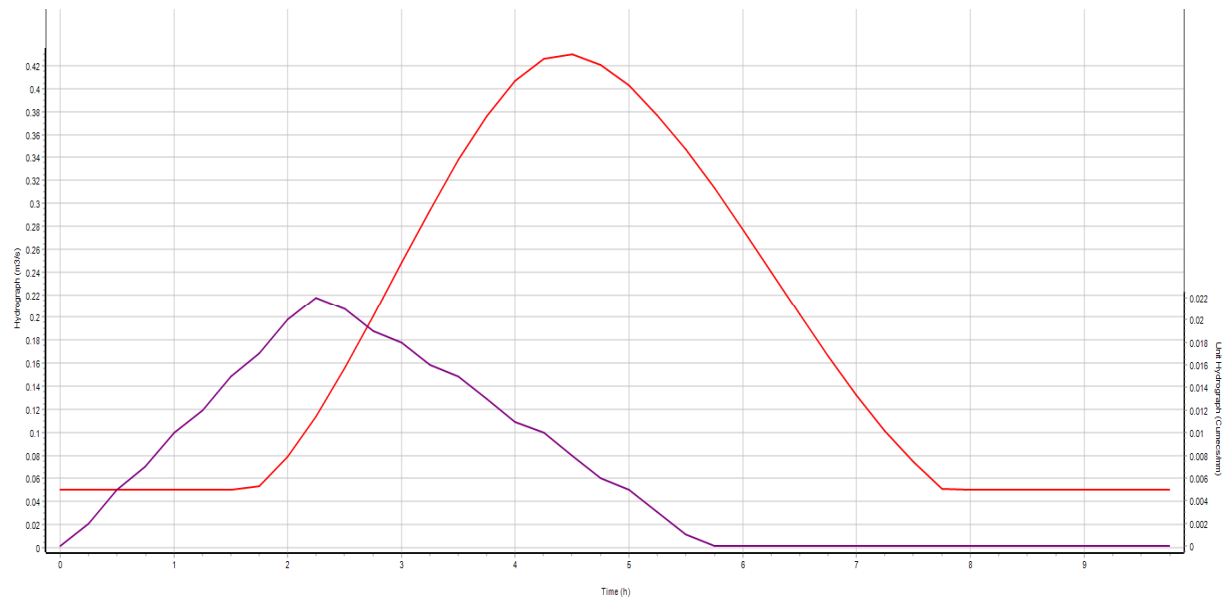
Western Hydrograph 1 in 100 year + 30% Climate Change



Southern Hydrograph 1 in 100 year + 30% Climate Change



Western Hydrograph 1 in 1000 year



Southern Hydrograph 1 in 1000 year

