

# Croesnewydd Road, Wrexham Flood Consequence Assessment

Final Report

**January 2016**

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## Contract

This report describes work commissioned by Huw Thomas, on behalf of First Choice Housing Association Ltd, by email dated 7th September 2016. Tasmin Fletcher, Holly Laws and Charlotte Beattie of JBA Consulting carried out this work.

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## Abbreviations

|              |                                                       |
|--------------|-------------------------------------------------------|
| AEP .....    | Annual Exceedance Probability                         |
| DAM .....    | Development Advice Maps                               |
| DCWW .....   | Welsh Water                                           |
| FCA .....    | Flood Consequence Assessment                          |
| FCHA .....   | First Choice Housing Association Ltd                  |
| FFL .....    | Finished Floor Level                                  |
| FZ .....     | Flood Zone                                            |
| LPA .....    | Local Planning Authority                              |
| m AOD .....  | Metres Above Ordnance Datum                           |
| NRW .....    | Natural Resources Wales                               |
| SFCA .....   | Strategic Flood Consequence Assessment                |
| TAN15 .....  | Technical Advice Note 15 - Development and Flood Risk |
| UKCP09 ..... | UK Climate Projections                                |
| WAST .....   | Welsh Ambulance Services NHS Trust                    |
| WCBC .....   | Wrexham County Borough Council                        |

## Definitions

### TAN15 Flood Zones

The following table is a reproduction of Figure 1 of the Technical Advice Note (TAN) 15: Development and Flood Risk (2004). These refer to the probability of river and sea flooding as shown on the Welsh Government's Development Advice Map (DAM).

| <b>Flood Zone</b> | <b>Definition</b>                                                                                             |
|-------------------|---------------------------------------------------------------------------------------------------------------|
| <b>Zone A</b>     | Considered to be little or no risk of fluvial or tidal/coastal flooding                                       |
| <b>Zone B</b>     | Areas known to have flooded in the past evidenced by sedimentary deposits                                     |
| <b>Zone C</b>     | Based on Environment Agency extreme flood outline, equal to or greater than 0.1% (river, tidal or coastal)    |
| <b>Zone C1</b>    | Areas of floodplain having a high risk from flooding. They tend to be developed and protected                 |
| <b>Zone C2</b>    | Areas of floodplain with a high risk from flooding but do not have a significant flood defence infrastructure |

### Flood Frequencies

| <b>Return Period</b> | <b>Annual Exceedance Probability</b> |
|----------------------|--------------------------------------|
| 1 in 1000 years      | 0.1%                                 |
| 1 in 100 years       | 1.0%                                 |
| 1 in 30 years        | 3.33%                                |

# 1 Introduction

## 1.1 Overview

This report has been prepared following an initial email request on 7th September 2016 by First Choice Housing Association Ltd (FCHA) for a Flood Consequence Assessment (FCA) for the proposed development at Croesnewydd Road, Wrexham.

The proposed development is to build residential apartments to provide ex-forces accommodation, along with a landscaped shared-use area and an access road connecting to Croesnewydd Road. The development will comprise of 10 two-bedroom and 6 one-bedroom apartments, along with access roads, an informal play area, public open space, shared garden space and an attenuation swale. The site is currently undeveloped greenfield land to the west of Wrexham town centre.

According to the current Natural Resources Wales (NRW) Development Advice Map (DAM)<sup>1</sup>, approximately 60% of the development site red line boundary is located within Flood Zone C2, 10% within Flood Zone B and 30% within Flood Zone A. Flood Zone C2 is based on NRW's extreme flood outline and has an equal to or greater than 0.1% probability of fluvial flooding in a given year and has no significant flood defence infrastructure. The building footprint is proposed to be outside of Flood Zone C2 and lies equally within Flood Zones B and A.

From discussions with the Local Authority and updated river modelling project for the River Gwenfro, it is evident that the site has undergone recent re-profiling within the proposed site. This involved the removal of high spots and levelling of the land following the completion of the road realignment to Croesnewydd Road. The current ground levels, based on LiDAR, have been used to update the model and these have resulted in changes to the flood outlines. The flood outlines presented in this report are considered to provide the most up-to-date information on flood risk at this site following the completion of the updated River Gwenfro model project.

## 1.2 TAN: 15 Development and Flood Risk

TAN15 recognises that climate change is a key factor affecting the flood risk over the lifetime of a new development and requires that climate change is included in any analysis of the flood risk of a new development. The impacts of climate change have been considered in accordance with recent Welsh Government guidance "CL-03-16 - Climate change allowances for Planning purposes", which are based on UKCP09 data<sup>2</sup>. Local planning authorities, applicants and their consultants are expected to use these climate projections from 1 December 2016.

## 1.3 Information provided

The following information has been provided by FCHA:

- Proposed Site Plan Appendix A.1
- Topographical Survey Appendix A.2
- Proposed Floor Plan and Elevation Drawings Appendix A.3
- Surface Water Drainage Report Appendix A.4

The following information has been obtained through the Welsh Government Website:

- TAN15 Development and Flood Risk: Development Advice Map (2015) Appendix B.1

The following information has been provided by WCBC:

- River Gwenfro 2016 hydraulic model

The following information has been obtained through the Natural Resources Wales website:

- Risk of Flooding from Reservoirs map Appendix C.1
- Risk of Flooding from Surface Water map Appendix C.2

The following information has been obtained through the Lle Geo-Portal:

- Flood Map for Surface Water

<sup>1</sup> <http://data.wales.gov.uk/apps/floodmapping/>

<sup>2</sup> <http://gov.wales/topics/planning/policy/policyclarificationletters/2016/cl-03-16-climate-change-allowances-for-planning-purposes/?lang=en>

## 1.4 Scope of FCA

This report assesses flood risk associated with the proposed development of residential accommodation on undeveloped greenfield land on Croesnewydd Road, Wrexham. The development site is classified as highly vulnerable under Technical Advice Note (TAN) 15: Development and Flood Risk, therefore can only take place subject to application of the justification test, including acceptability of consequences if applicable.

## 2 Development location and description

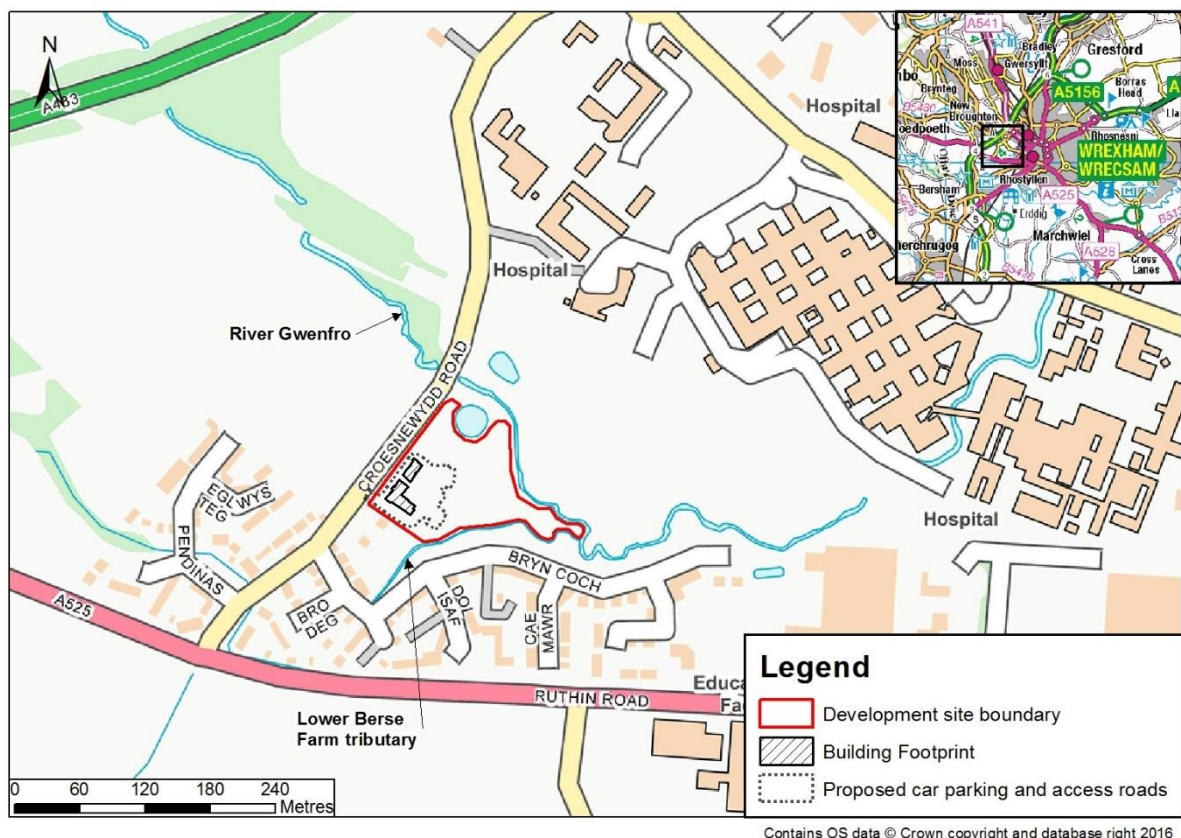
The development site is located to the west of Wrexham town centre, between the A525 to the south and the River Gwenfro to the north. The site is to the north of the recently developed Pentre Bach site, and will be accessed from Croesnewydd Road.

At its nearest point, the site is approximately 100m to the south of the River Gwenfro. Immediately adjacent to the site is a small attenuation pond associated with road infrastructure of Croesnewydd Road, which lies between the north of the site and the Gwenfro. Another ordinary watercourse, known as the Lower Berse Farm tributary for the purposes of the modelling study, lies to the south of the development site and discharges into the Gwenfro to the east.

The site was reprofiled in 2013 in conjunction with the realignment of Croesnewydd Road and the construction of the downstream attenuation ponds, resulting in an increase in ground levels. The Topographical Survey indicates that current ground levels in the vicinity of the proposed development are between 90.75 mAOD and 93.00 mAOD.

Wrexham County Borough Council is the Local Planning Authority (LPA) for this area.

Figure 2-1 Location map and proposed site layout



## 3 Sources of flooding

This section identifies all potential sources of flood risk to the development site. Further consideration of recognised sources of flood risk are given in subsequent sections.

### 3.1 Fluvial

The DAM (2015) shows that 60% of the red line boundary site is located within Flood Zone (FZ) C2. The building footprint is located within remaining 40% of site (10% within FZ B and 30% within FZ A). Access routes are proposed to be outside of FZ C2, however parking facilities are mostly within FZ C2. Areas in FZ C2 have an equal to or greater than 0.1% probability of fluvial flooding in a given year and have no significant flood defence infrastructure.

Recent reprofiling of the land within the proposed site has led to an increase in ground levels, which have since been included in a detailed flood modelling study of the River Gwenfro. Consequently, the previous extreme flood outline is superseded by the most recent modelling. The corresponding flood mapping shows the site to now be at a lower risk of flooding, with the whole site within low risk Flood Zone A as it is not at risk of inundation during a 0.1% AEP event.

The modelling considers flood risk to the site before and after development, as well as an evaluation of the risk associated with blockage of culverts beneath Croesnewydd Road before and after development. Climate change enhancement is included in all both scenarios. Further details of fluvial flood risk and management measures are given in Section 4.

### 3.2 Surface Water

The Flood Map for Surface Water (Appendix C.2) indicates that there are areas at a low (0.1% AEP rainfall event) risk of surface water flooding within the development site footprint. A Surface Water Drainage Report has been produced for the site. Highway runoff from the access road will be attenuated separately from domestic runoff associated with the buildings. Some further details of surface water flood risk and management measures are given in Section 5. But this is limited to highway drainage and domestic run off.

### 3.3 Groundwater

Analysis suggests that the site is likely be at risk of alluvial groundwater flooding due to its situation on highly permeable alluvial sand and gravel deposits. Further details of groundwater flood risk are given in Section 6.

### 3.4 Sewer

The development is proposed on a greenfield site and there is no known flood risk from sewer flooding. As part of this FCA it is envisaged that there will be a request and formal agreement required to establish a connection to the existing foul sewer network.

### 3.5 Canal

There are no canals in the vicinity of the development site therefore it is deemed not to be at risk of flooding from canals.

### 3.6 Reservoir

NRW's online Risk of Flooding from Reservoirs map<sup>3</sup> indicates that the development site is not at risk of flooding as a result of an uncontrolled release of water from any reservoirs.

<sup>3</sup> <https://naturalresources.wales/our-evidence-and-reports/maps/flood-risk-map/?lang=en>

## 4 Fluvial flood risk

The DAM (2015) shows that the development site is located partially within Flood Zone C2, which is based on NRW's extreme flood outline and is defined as having an equal to or greater than 0.1% probability of flooding in a given year with no significant flood defence infrastructure. This outline has since been superseded by an update to the hydraulic model undertaken by JBA Consulting in 2016, which included updates to the ground levels at this site based on recent topographical survey. This highlighted ground levels reprofiling work that had occurred in 2013 in conjunction with the realignment of Croesnewydd Road and the construction of the downstream attenuation ponds. As a result, the banks of the channel have been raised slightly through this reach, resulting in flows being contained within the channel. The results of this modelling are used in this FCA and show the updated flood risk to this site.

TAN15 guidance requires that residential sites are designed to be free from flooding in the 1% AEP event over a presumed 100-year lifetime, including allowances for climate change and that the consequences of flooding are considered up to and including the 0.1% AEP event plus climate change. In this event flood water depth must not exceed 600mm in properties and on access roads.

The impacts of climate change have been considered in accordance with recent Welsh Government guidance "CL-03-16 - Climate change allowances for Planning purposes". Local planning authorities, applicants and their consultants are expected to use these climate projections as a requirement of TAN15 from 1 December 2016.

In line with this guidance, climate change has been incorporated into fluvial flood risk via a 20% increase in fluvial inflows, which is the central estimate (change factor) for the Dee river basin district up to the 2080s. This approach has been used in this FCA to analyse both the future 1% AEP and 0.1% AEP fluvial flood events. Given the uncertainty associated with future climate change, the upper end estimate has also been investigated for the 1% AEP event by increasing fluvial inflows by 45%. This will be used to inform mitigation measures for the long term resilience of the development.

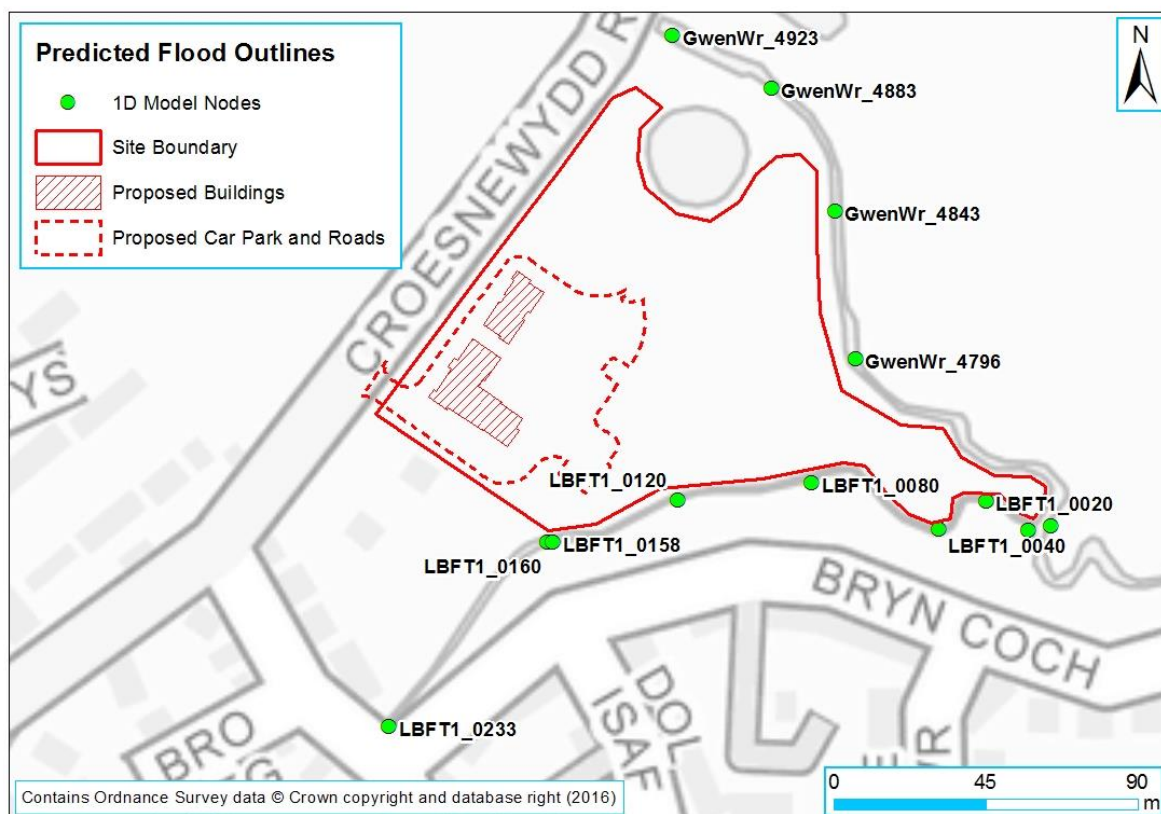
### 4.1 Hydraulic modelling overview

The assessment of the fluvial flood risk from the River Gwenfro and its main tributary (referred to here as Lower Berse Farm tributary) to the proposed development site was carried out using the 1D-2D (ISIS-TUFLOW) hydraulic model. The node locations for this model are shown in Figure 4-1. Note that the model outlines presented in this report are the raw outputs of the model and have not been cleaned to removed dry islands or isolated polygons. This does not affect the analysis of flood risk to the site.

This phase of the work has consisted of:

- The evaluation of the pre-development baseline risk using Wrexham County Borough Council's recently updated (2016) hydraulic model, plus climate change enhancement.
- The evaluation of the post-development risk (i.e. with the proposed buildings and ground surface changes in place), plus climate change enhancement.
- The evaluation of residual risk associated with the blockage of culverts beneath Croesnewydd Road (modelled separately) for both the existing and post-development scenarios, plus climate change enhancement.

Figure 4-1: Site map showing node locations for hydraulic modelling



## 4.2 Flood risk from bank overtopping

### 4.2.1 Pre-development flood risk

Figures 4-2 and 4-3 illustrate the peak modelled flood levels in the River Gwenfro and Lower Berse Farm tributary between Croesnewydd Road and the confluence of these watercourses. Climate change has been accounted for via a 20% increase (central estimate) in fluvial inflows on both the 1% and 0.1% AEP events, and a 45% increase (upper estimate) in fluvial inflows for the 1% AEP event. The results show that flood levels would remain in-channel for both watercourses during the present day and climate change enhanced scenarios. Modelled water levels at nodes within the River Gwenfro channel adjacent to the site (see Figure 4-1) are provided in Table 4-1. As no bank overtopping occurs, there is no flood risk to the site in the existing scenario, as shown in Figure 4-4.

It is noted that previous studies have highlighted flood risk to the site due to overtopping of the left bank of the River Gwenfro downstream of Croesnewydd Road. However, ground levels reprofiling work in 2013 from both sides of the River has resulted in the raising of channel banks throughout this reach, allowing flows to be contained within the channel.

Table 4-1: Predicted peak water levels within the River Gwenfro channel adjacent to the site

| Node Label  | Distance<br>Downstream<br>of<br>Croesnewydd<br>Road | Predicted Water Level (m AOD) |        |               |             |                 |
|-------------|-----------------------------------------------------|-------------------------------|--------|---------------|-------------|-----------------|
|             |                                                     | 3.33%<br>AEP                  | 1% AEP | 1% +CC<br>AEP | 0.1%<br>AEP | 0.1% +CC<br>AEP |
| GwenWr_4923 | 0                                                   | 92.077                        | 92.142 | 92.192        | 92.33       | 92.395          |
| GwenWr_4883 | 40                                                  | 91.78                         | 91.857 | 91.919        | 92.041      | 92.105          |
| GwenWr_4843 | 80                                                  | 91.462                        | 91.528 | 91.581        | 91.733      | 91.798          |
| GwenWr_4796 | 122                                                 | 91.1                          | 91.157 | 91.208        | 91.355      | 91.412          |
| GwenWr_4715 | 203                                                 | 90.252                        | 90.31  | 90.358        | 90.501      | 90.579          |

Figure 4-2: Predicted peak water levels in the River Gwenfro adjacent to the site

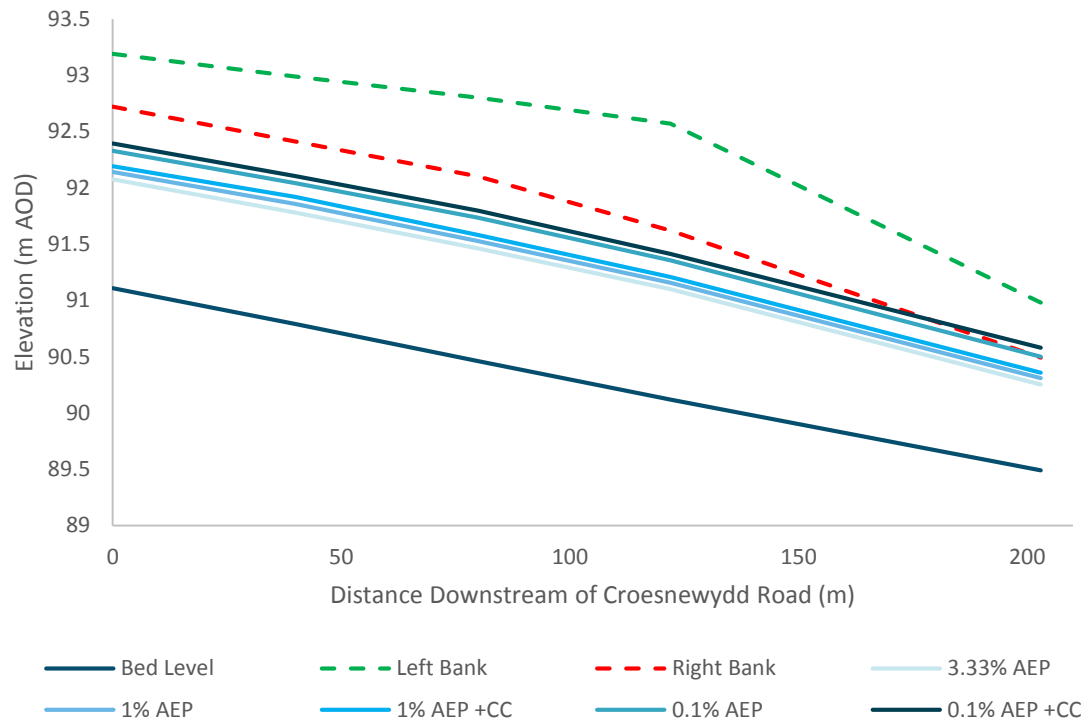


Figure 4-3: Predicted peak water levels on the Lower Berse Farm tributary adjacent to the site

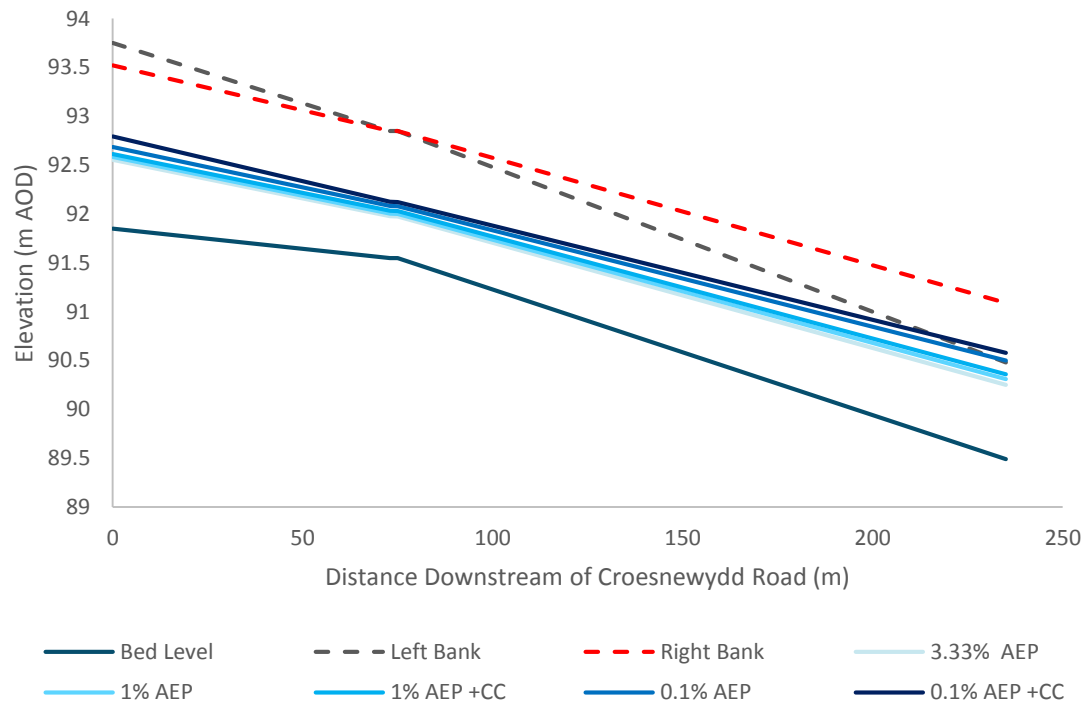
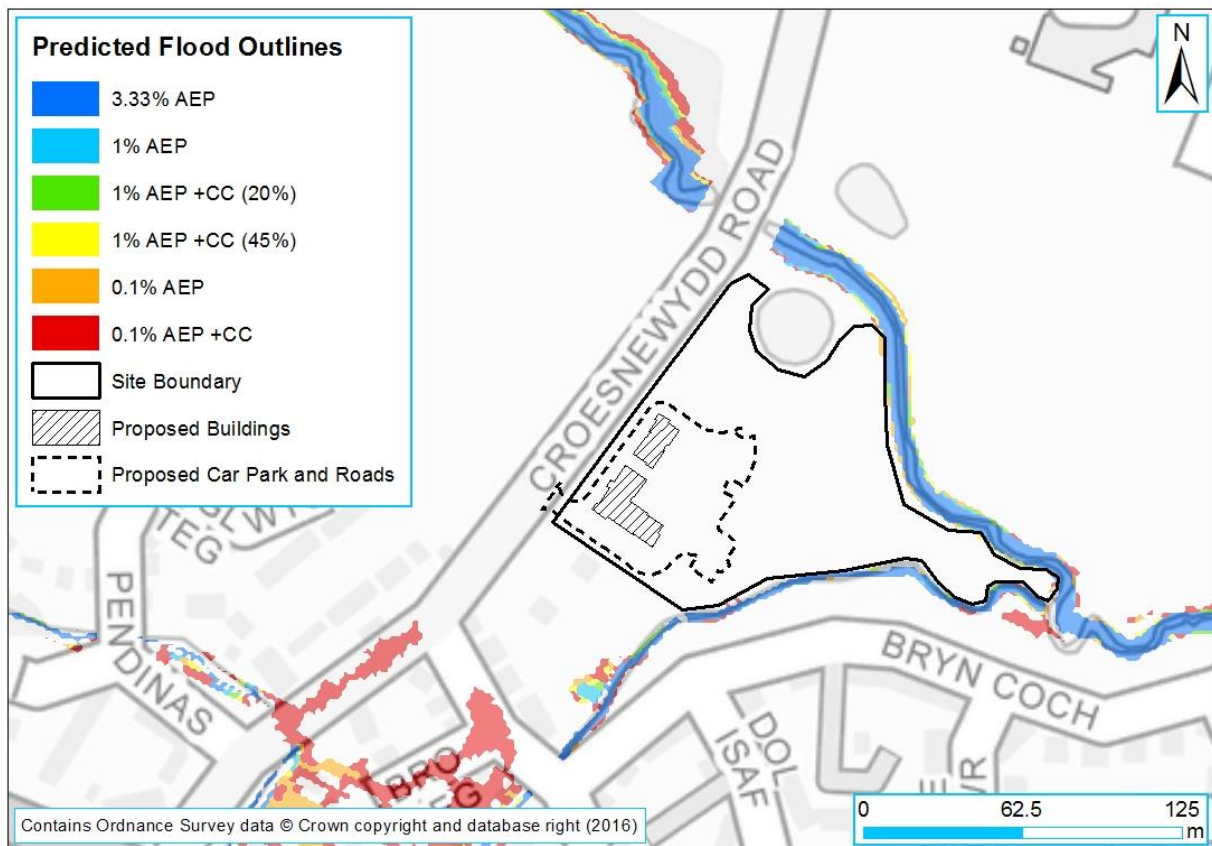


Figure 4-4: Predicted peak flood outlines for the existing pre-development (baseline) scenario. Development shown as indicative only.



#### 4.2.2 Post-development flood risk

As floodwater is contained within the channel during all modelled events, the proposed development is not shown to impact local flood risk, and therefore the predicted flood outlines for the post development baseline scenario remains unchanged relative to the existing baseline scenario (see Figure 4-3). The development is not at risk from fluvial inundation during a 0.1% AEP including climate change scenario.

### 4.3 Flood risk associated with culvert blockages

The impact of blockage at two structures beneath Croesnewydd Road has been assessed; the culvert on the River Gwenfro and the culvert on the Lower Berse Farm tributary. Low (30%), medium (67%) and high (100%) culvert blockage scenarios have been modelled for both structures individually, in accordance with the latest NRW guidance<sup>4</sup>. Blockage scenarios have been run for the two scenarios; the 1%+CC AEP event and the 0.1% AEP event.

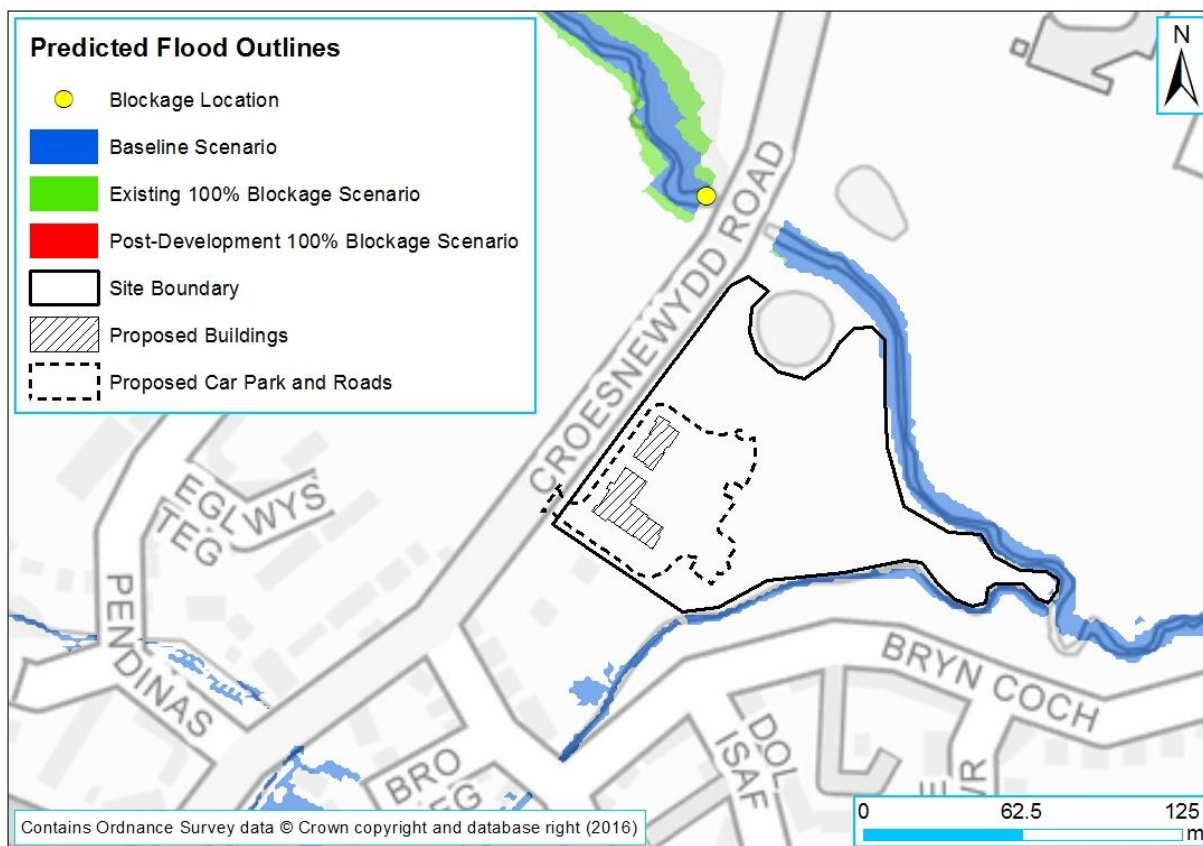
#### 4.3.1 River Gwenfro blockage scenario

The results of the modelling show that there was no increase in flood risk to the site at either low or medium blockages on the River Gwenfro culvert for either of the scenarios.

Figure 4-5 presents the modelled peak flood extents for the high (100%) blockage scenario at the culvert beneath Croesnewydd Road on the River Gwenfro during the 0.1% AEP event. Although flooding upstream of Croesnewydd Road is increased, the road is not overtopped and therefore blockage of this structure does not affect flood risk to the site. Subsequently, the development of the site is not shown to impact flood risk across the wider local area. Flood extents were comparable for the high blockage 1%+CC AEP event, with no increase in wider flood risk.

<sup>4</sup> Flood Risk Management: Modelling blockage and breach scenarios, December 2014, Natural Resources Wales.  
2016s5086 Croesnewydd Road, Wrexham FCA FINAL REPORT v2.3

Figure 4-5: Predicted peak flood outlines for the River Gwenfro high blockage scenario relative to the baseline scenario during the 0.1% AEP event



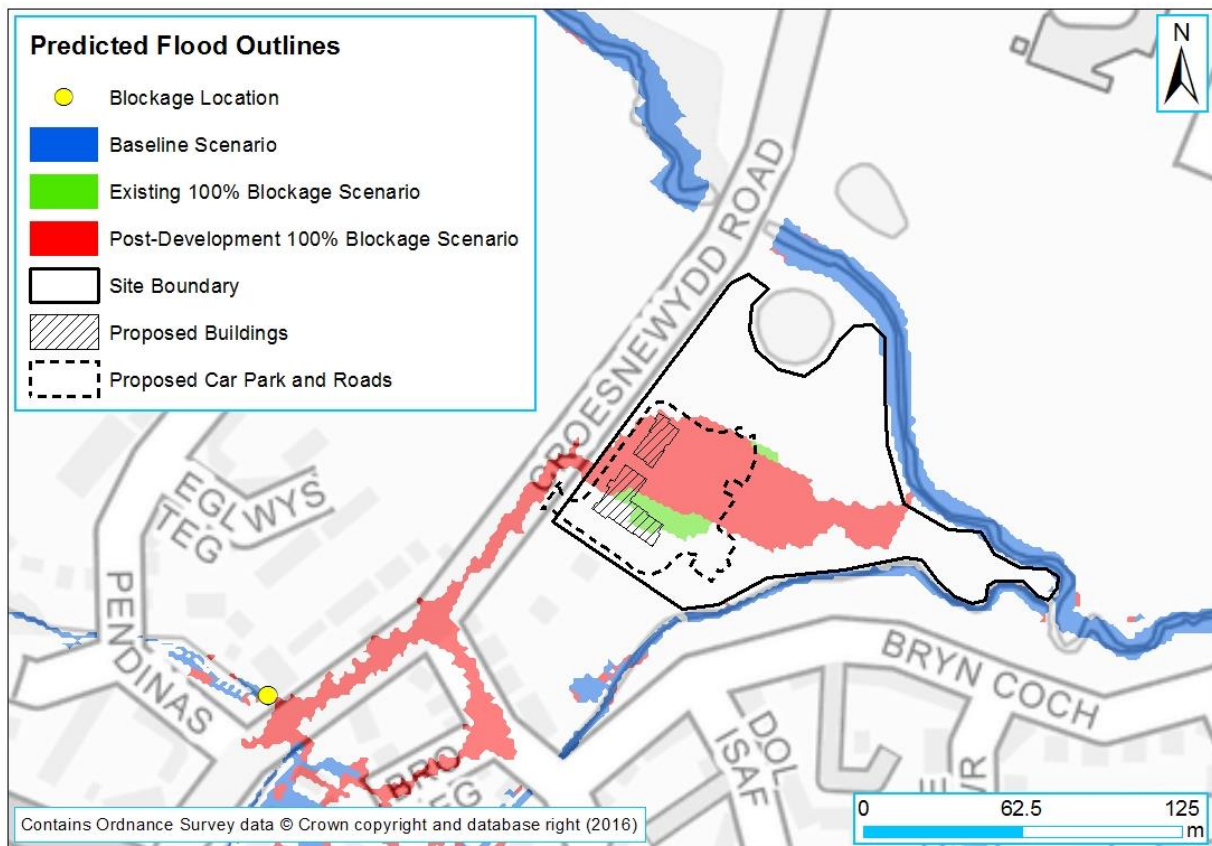
#### 4.3.2 Lower Berse Farm tributary blockage scenario

During both the 1%+CC and 0.1% AEP events, neither the low and medium blockage scenarios at the culvert beneath Croesnewydd Road on the Lower Berse Farm tributary are shown to influence flood risk at the site. Similarly, no flooding is predicted at the site during the 1%+CC AEP event for the high blockage scenario at this structure. However, some flooding is predicted at the site in the 0.1% AEP event for the high blockage scenario, as shown in Figure 4-5. Flooding occurs as the culvert is overtopped, with flood water flowing down Croesnewydd Road before passing through the site and re-entering the River Gwnefro. In the pre-development scenario, flood depths of up to 200mm are predicted on the site, to the south east of the buildings. Depths in the vicinity of the proposed buildings are up to 80mm.

Blockage of this culvert in the post-development scenario is predicted to limit the area of flooding at the site. This subsequently raises water levels in the vicinity of the housing units by up to 70mm, resulting in an overall maximum flood depth of 150mm (92.9m AOD) post-development.

It is noted that as flow is directed through the site as a result of blockage on the Lower Berse Farm tributary and enters the River Gwenfro immediately adjacent to the site, there are no off-site impacts of the development on flood risk across the wider local area.

Figure 4-6: Predicted peak flood outlines for the Lower Berse Farm tributary high blockage scenario relative to the baseline scenario during the 0.1% AEP event.



The results of the modelling show that the development site is free from all but residual risk flooding in the 0.1% AEP event 100% blockage scenario. In this scenario, maximum flood depths are predicted to be 150mm localised near to the buildings, within a flow route shown from the road through the site towards to the river, which is below the threshold given in TAN15 for this AEP event detailed in Appendix A.14 of Technical Advice Note 15: Development and flood risk.

## 4.4 Mitigation measures

### 4.4.1 Flood water rerouting through landscaping

Due to the existing ground surface, in the 0.1% AEP event 100% blockage scenario for the Lower Berse Farm tributary culvert floodwater flows along Croesnewydd Road and into the development site, before rejoining the River Gwenfro. As water depths are sufficiently shallow, there is the potential to reroute this water via a landscaped depression or shallow swale to the north of the site and into the Gwenfro further upstream, near the attenuation ponds, as shown in Figure 4-7. This would alleviate shallow flooding flow routes around the buildings and lower flood water depths to below proposed floor levels. This could inform the proposed landscape management plan for the site.

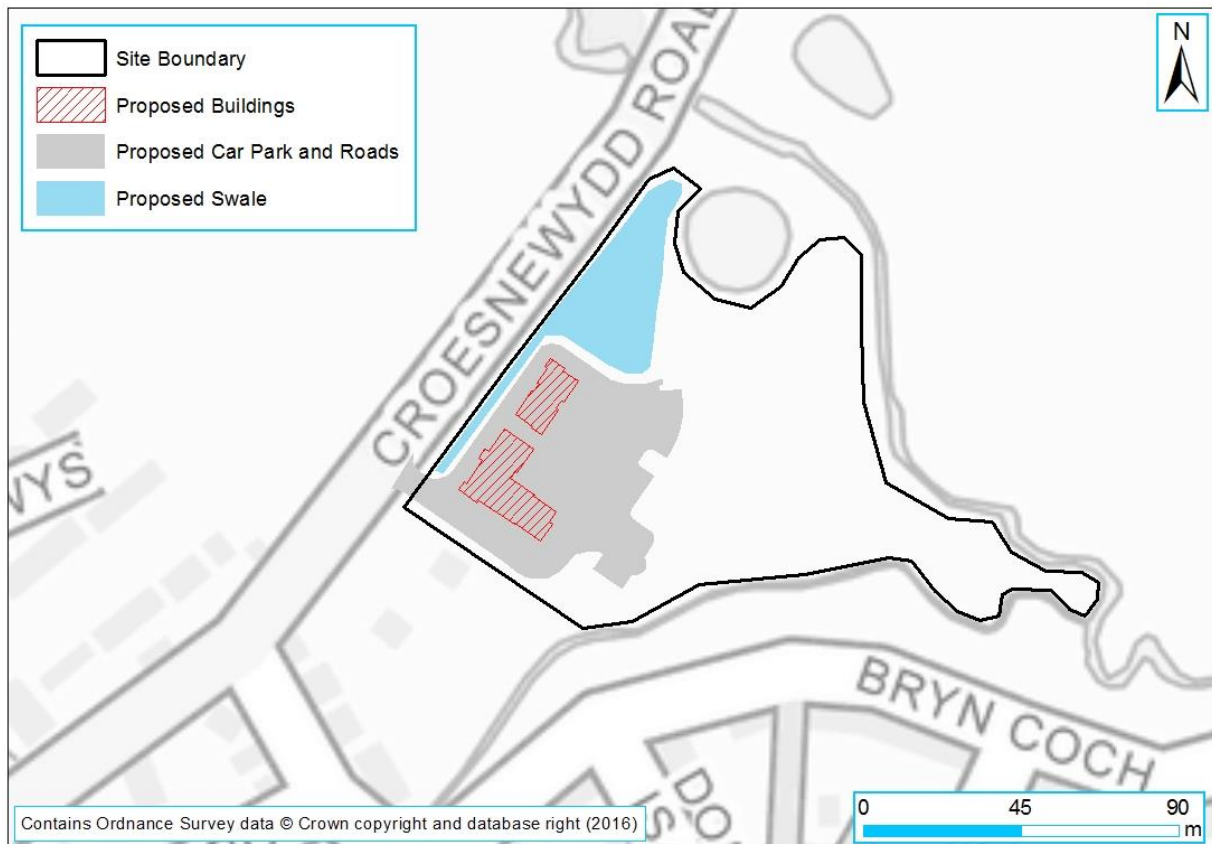


Figure 4-7: Site plan with suggested swale for residual flood risk alleviation

#### 4.4.2 Finished Floor Levels

Finished Floor Levels (FFL) for the site range from 92.45m AOD to 93.00m AOD. The Floor and Elevation Drawings (Appendix A.3) show the ground floor to be 150mm above existing ground level. Considering that the maximum flood depth in the 0.1% AEP event 100% blockage scenario for the Lower Berse Farm tributary culvert is predicted to be 150mm (92.9m AOD), this would be equivalent to the ground floor level. To mitigate the risk from this extreme residual risk scenario. It is recommended FFL for the buildings are at least 150mm above the maximum flood depth, and raised to 300mm from ground level, to 93.05m AOD. Together with the rerouting of flood water away from the buildings by inclusion of shallow depression swale between Croesnewydd Road and the footprint of the buildings which would intercept channel flows and diverting run off and reducing water depths to below FFL.

#### 4.4.3 Flood Warning

The proposed development is not at risk of flooding during the 0.1% AEP event including climate change.

The development site is not within a Flood Warning Area, however it is within the Lower Dee Valley Flood Alert Area, for Llangollen to Trevalyn Meadows. Therefore, it is eligible to receive flood alerts when flooding is possible. There are no existing river gauges on the River Gwenfro to facilitate a direct flood warning system.

The outputs from the River Gwenfro modelling project will be used to update the DAM's. At present the DAM's is the publically available information on flood risk and will be used by insurance companies to assess flood risks.

#### 4.4.4 Access and Egress

The site and site access is not at risk from fluvial inundation during events up to and including the 0.1% AEP including climate change.

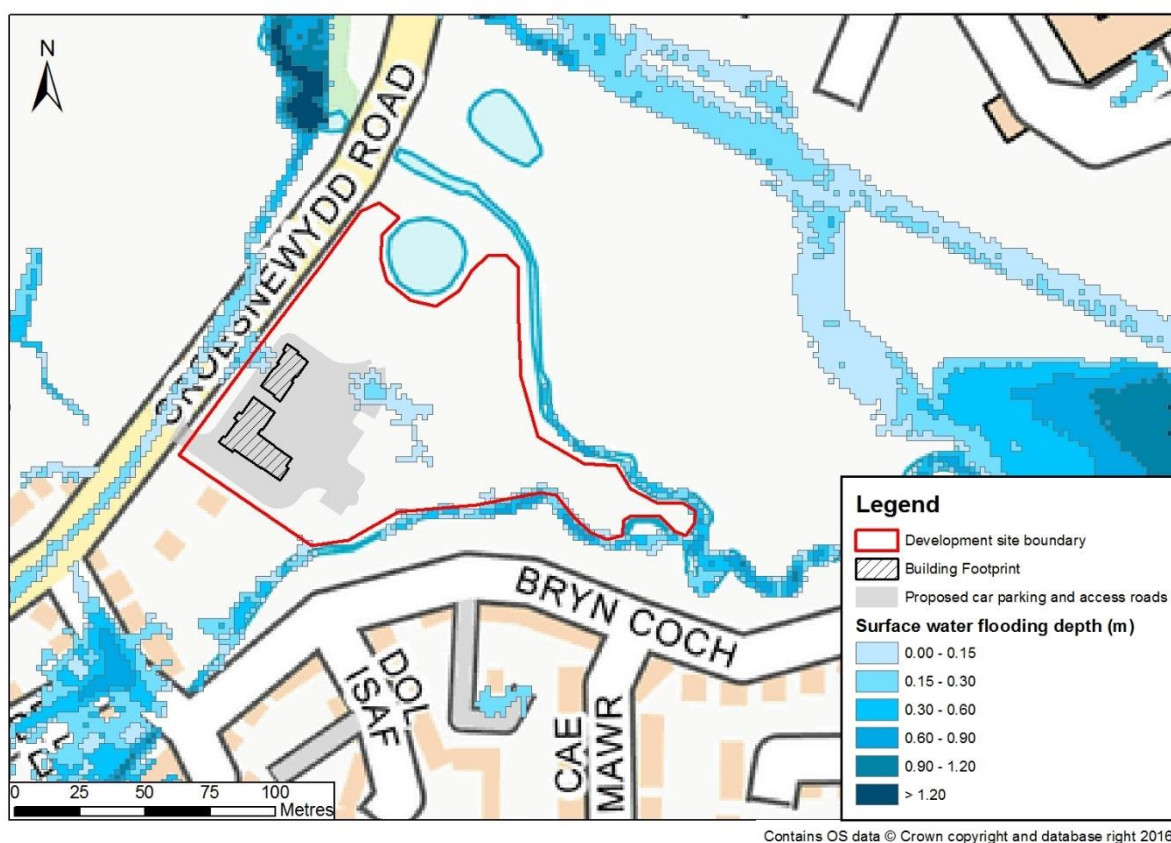
## 5 Surface water management

This section assesses the volumes of surface water runoff likely to be generated by the proposed development. The development is to be constructed on greenfield land, therefore has the potential to increase surface water runoff if there is an increase in the impermeable surfaces. Proposals for surface water management must ensure that surface water is attenuated and stored below ground to a 3.33% AEP event, and that in the 1% AEP event plus climate change surface water must be contained on site without posing inherent threat to nearby inhabitants. Increased runoff should not cause flood risk elsewhere, in accordance with TAN15.

### 5.1 Existing surface water flood risk

NRW's Flood Map for Surface Water (Appendix C.2) shows the development site to be free from surface water flooding in the 3.33% and 1% AEP rainfall events, but at risk following a 0.1% AEP rainfall event. In this event, depths are predicted to up to 0.3m (300mm) at the site, as shown in Figure 5-1. Depths are not predicted to exceed the recommended limit of 600mm for the 0.1% AEP event of given by TAN15 and are not within the building footprint.

Figure 5-1: Risk of flooding from surface water 0.1% AEP rainfall event



### 5.2 Outline drainage strategy

A Surface Water Drainage Report for the site was produced by Datrys in June 2016. A copy of this report is included as Appendix A.4. This report included a runoff assessment, the results of which are shown in Table 5-1.

Table 5-1: Site surface water peak flow runoff rates pre- and post-development

| Storm event        | Pre-development runoff | Post-development runoff |
|--------------------|------------------------|-------------------------|
| Annual storm event | 0.27 L/s               | 0.59 L/s                |
| 1% AEP             | 0.69 L/s               | 1.51 L/s                |

The report concluded that infiltration systems such as soakaways are suitable, based on porosity tests carried out on site. It is proposed to attenuate surface water runoff in underground trench soakaways, with above ground storage swales that will have capacity for storing the additional runoff to a 1% AEP event plus 30% increase due to climate change. Surface water drains will be connected to the soakaways to manage water at the surface.

It is understood that preventative measures such as pervious surfaces have not been proposed at this stage. These could be used to reduce impermeable paths and parking surfaces. In addition, water quality requirements should be considered and an operation and maintenance plan is required. The introduction of a shallow depression swale between Croesnewydd Road and footprint of new buildings could easily be incorporated into a detailed drainage design strategy, required to discharge of condition of planning application (LPA reference P/2016/0401).

## 6 Groundwater flood risk

The site is underlain by alluvial deposits comprising clay, silt, sand and gravel, as shown on the BGS geological map of the area<sup>5</sup>. The alluvium could in turn be underlain by glaciofluvial deposits comprising sand and gravel. Sand and gravel deposits generally have a relatively high permeability, which means they can readily store and transmit water.

The location of the site close to the River Gwenfro and the Lower Berse Farm tributary, coupled with its location overlying alluvial deposits and potential for glaciofluvial deposits means it is likely to be well connected to the main river and therefore the alluvial groundwater flooding mechanism is likely to be the most important in this case. This is when groundwater levels rise in response to high water levels in a river connected to the aquifer.

It is likely that there is the possibility of alluvial groundwater flooding to occur on site. This would only occur if the initial groundwater levels beneath the site were already high, for instance following a period of prolonged rainfall in the winter. The close proximity of the site to the River Gwenfro, and the Lower Berse Farm tributary means that water could flow from the rivers through permeable sediments in the ground towards the site. This can result in rising groundwater levels beneath the site, up to the level of the flood within the river.

During a river flood event the normal baseflow to the river will not be able to discharge to the river and this will also contribute to rising groundwater levels beneath the site. High rainfall and infiltration of rainfall recharge to the ground will also contribute to high groundwater levels.

It should be noted that groundwater flooding requires initial high groundwater levels combined with an exceptional recharge event (either through flow from rivers or a huge amount of rainfall recharge). Therefore groundwater flooding is highly unlikely during summer months where background groundwater levels are naturally low. Similarly, flash floods during a dry winter would be unlikely to trigger groundwater flooding, but high rainfall following a wet summer and wet autumn would be likely to result in groundwater flooding.

These risks should be used to inform layout, detailed drainage layout, construction methods and design/use of materials for buildings and external landscaping.

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<sup>5</sup> British Geological Survey, 1994. 1:50,000 scale Geological Map, Sheet 121 Wrexham. Solid and Drift Edition  
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## 7 Conclusion and recommendations

This report has been prepared following an initial request on 7th September 2016 by FHCA for a FCA for the proposed development at Croesnewydd Road, Wrexham. The development is for residential apartments and is therefore classed as 'highly vulnerable' according to TAN15.

The Development Advice Map (2015) obtained from NRW indicates that the red line boundary of site is located 60% within Flood Zone C2, which is based on NRW's extreme flood outline and is defined as having an equal to or greater than 0.1% probability of flooding in a given year with no significant flood defence infrastructure. The building footprint is located outside of FZ C2 however parking facilities are within FZ C2. This outline has since been superseded by an update to the hydraulic model undertaken by JBA Consulting in 2016, which included updates to the ground levels at this site following reprofiling work and raising of the channel banks throughout this reach. The results of the model are used in this FCA and show that flow is contained within the channel during the extreme event. The development site is within the Lower Dee Valley Flood Alert Area.

TAN15 guidance suggests that residential developments should be free from flooding during the 1% AEP fluvial flood event and have a maximum floodwater depth of 600mm in residential properties with ground floor accommodation. TAN15 requires that the impacts of climate change are assessed using the latest guidance, and in this study have been considered up to and including the 0.1% AEP event.

Further modelling has now been undertaken to take current ground levels and the latest climate change guidance into account. Modelled outputs show that the site is not at risk of fluvial flooding from bank overtopping in the baseline scenario in any AEP event up to and including the 0.1% AEP event plus upper end estimates for climate change (45% increase in flow). This is true for both pre- and post-development scenarios; therefore it can be concluded that the development does not increase fluvial flood risk in the wider area.

Current modelling demonstrates that the proposed development is not at risk of fluvial flooding during the 0.1% AEP event including climate change and access to the site will not be impeded under these conditions.

The model was also tested against 30%, 67% and 100% blockage scenarios for the two culverts on Croesnewydd Road, at a range of AEP events. None of the scenarios for the culvert on the River Gwenfro result in flooding of the site. Neither the 30% or 67% blockages at the culvert on the Lower Berse Farm tributary result in flooding of the site at any AEP event, nor the 100% blockage for the 1%+CC AEP event. However, the 100% blockage for the 0.1% AEP event causes the site to flood. Maximum flood depth within the site boundary for the pre-development scenario is 200mm and near the buildings is 80mm. The maximum depth localised near the buildings increases to 150mm in the post-development scenario.

Mitigation measures are recommended for the site, which would lessen the impact of any future flooding associated with the residual risk from culvert blockage (an extreme event). The introduction of shallow swale would direct flood water or overland flow, away from the buildings to the north of the site and into the Gwenfro downstream of the culvert. This would alleviate flooding around the buildings and lower flood water depths to below floor levels, which are proposed at 150mm above ground level. It is recommended that the FFL should also be raised above the maximum water depth, which for a freeboard of 150mm would require FFL to be set at 93.05m AOD increasing resilience to extreme flood events in the future.

NRW's Flood Map for Surface Water indicates that the development site is at risk of surface water flooding in the 0.1% AEP rainfall event. Depths are predicted to be up to 300mm therefore do not exceed the recommended limit of 600mm for the 0.1% AEP event of given by TAN15 and flood extents are not within the building footprint. A Surface Water Drainage Report has been produced for the development site, which includes proposals to attenuate surface water in underground soakaways and swales. These measures are suitable up to the 1% AEP event plus 30% climate change enhancement and a detailed drainage strategy is being developed. The introduction of small swale to intercept the mapped flow route would help to safely convey run off towards the river rather than letting it pond.

The possibility of alluvial groundwater flooding is likely at the site. Flooding by this mechanism would require initial high groundwater levels combined with an exceptional recharge event (either through flow from rivers or a huge amount of rainfall recharge), for example high rainfall following a wet summer and wet autumn.

## Appendices

### A

The following information has been provided by First Choice Housing Association.

- A.1 Proposed site plan
- A.2 Topographical survey
- A.3 Proposed floor plan and elevations drawings
- A.4 Surface water drainage report

### B

The following information has been obtained through the Welsh Government's website.

- B.1 TAN15 Development and Flood Risk: Development Advice Map 2015

### C

The following information has been obtained through the Natural Resources Wales website.

- C.1 Risk of flooding from surface water map
- C.2 Risk of flooding from reservoirs map

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