

# TECHNICAL NOTE

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| <b>DATE:</b>    | 26 August 2020                                                             | <b>CONFIDENTIALITY:</b> | Public          |
| <b>SUBJECT:</b> | Gwynant - Hydraulic Modelling Assessment and Flood Risk Management Options |                         |                 |
| <b>PROJECT:</b> | 70049679                                                                   | <b>AUTHOR:</b>          | Ajinkya Kemble  |
| <b>CHECKED:</b> | Pravin Ghimire                                                             | <b>APPROVED:</b>        | Mike Wellington |

## Introduction

WSP were commissioned by Wrexham County Borough Council (WCBC) to undertake a hydraulic modelling assessment for blockage scenarios of a culverted section of the Rhosymedre Brook beneath the A539 Llangollen Road. The aim of this assessment was to provide information on flood levels to support the findings of a previous Flood Consequences Assessment (FCA) for the redevelopment of two residential plots of land located off Gwynant (road) in the village on recommended finished floor levels.

The results of the assessment are included in the subsequent sections of this Technical Note which should be read in conjunction with the WSP FCA report and Technical Note references as listed below:

- Residential Development at Plas Madoc, Wrexham, Flood Consequences Assessment and Drainage Strategy, February 2019, ref: 70049679/FCADS/01
- Technical Note - Response to NRW Comments, WSP, October 2019

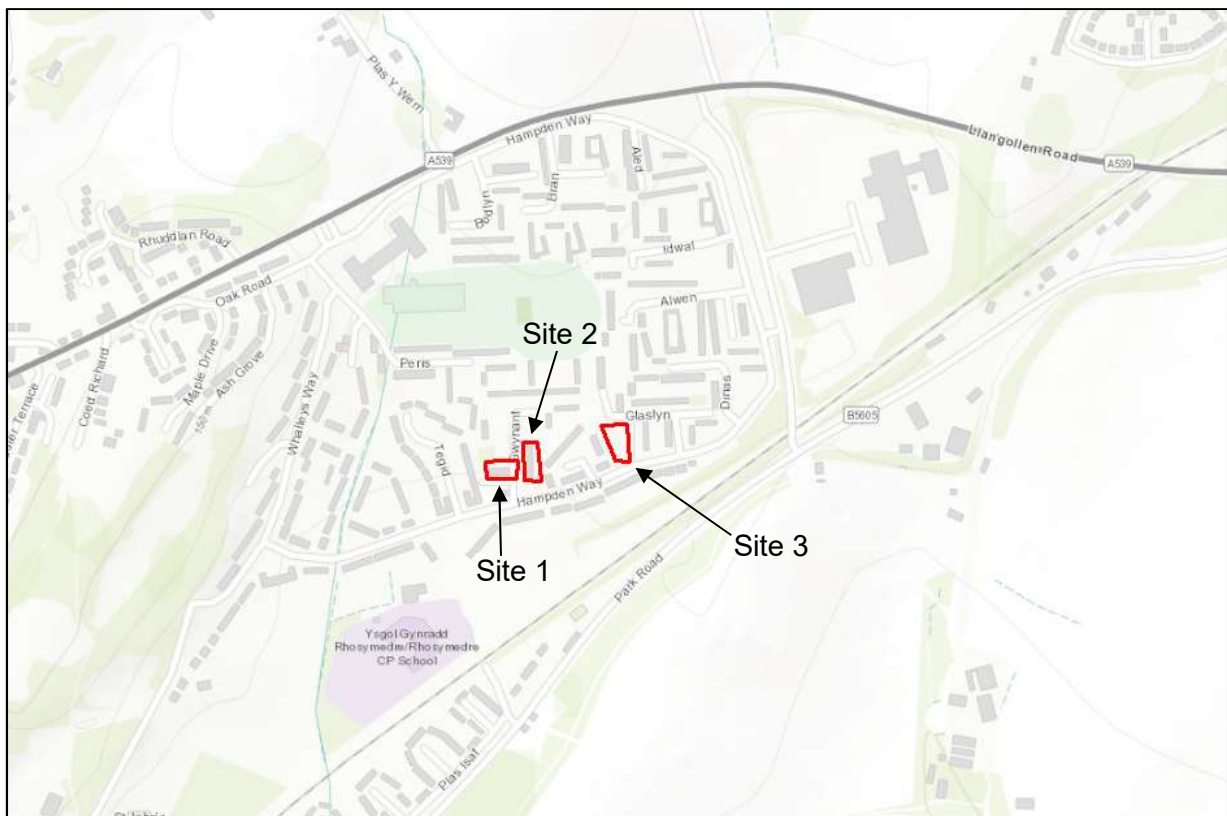
In addition to the above work, WSP were also appointed to provide preliminary options for a flood risk management scheme to reduce the risk of fluvial flooding to the wider village located to the south of the culvert and the A539 Llangollen Road.

## Proposed Development

The proposed development is comprised of three land parcels which have previously been utilised for residential development. The residential developments were demolished, and the land is now brownfield. Two land parcels out of three are located along Gwynant (Road), Plas Madoc, Wrexham. Figure below shows the locations of these three sites within the development area. The scope of this study covers only two sites i.e site 1 and site 2. Therefore, site 3 has not been included in this study.

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**Figure 1: Site Location Plan**

## ■ Site 1

Site 1 is centred on Grid reference 328838E, 328838N and has an approximate area of 814m<sup>2</sup> of which 526m<sup>2</sup> is hardstanding area and therefore impermeable.

## ■ Site 2

Site 2 is centred on Grid reference 328874E, 343221N and has an approximate area of 1257m<sup>2</sup> of which 805m<sup>2</sup> is considered impermeable.

## ■ Site 3

Site 3 is centred on Grid reference 328986E, 343246N and has an approximate area of 1246m<sup>2</sup> of which 759m<sup>2</sup> is considered impermeable.

The sites are all located within an existing area of residential housing and are bound by roads, paved areas and open green spaces.

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### Scope of Hydraulic Modelling

The Client instructed WSP to assess the flood risk impact of blocking the existing A539 Road culvert (with blockage proportions of 30% (Low), 67% (Medium) & >90% (High) on the two proposed development land parcels (site 1 and site 2) located along Gwynant Road for 1%AEP+CC and 0.1%AEP events.

The objectives of this study and the additional hydraulic modelling, set out according to the Client requirements, are to:

- Review the existing Rhosymedre Brook hydraulic modelling and reports available,
- Undertake hydraulic modelling simulations for blockage scenarios at A539 culvert structure and the blockage proportions of 30% Low, 67% Medium & >90% High for the 1%AEP+CC and 0.1%AEP (proposed scenarios) and
- Prepare technical note on the findings of the hydraulic modelling and the updated flood outline mapping

As part of the study WSP used the hydrological calculations previously developed in consultation with the NRW to model the blockage scenarios for the “Proposed Development”.

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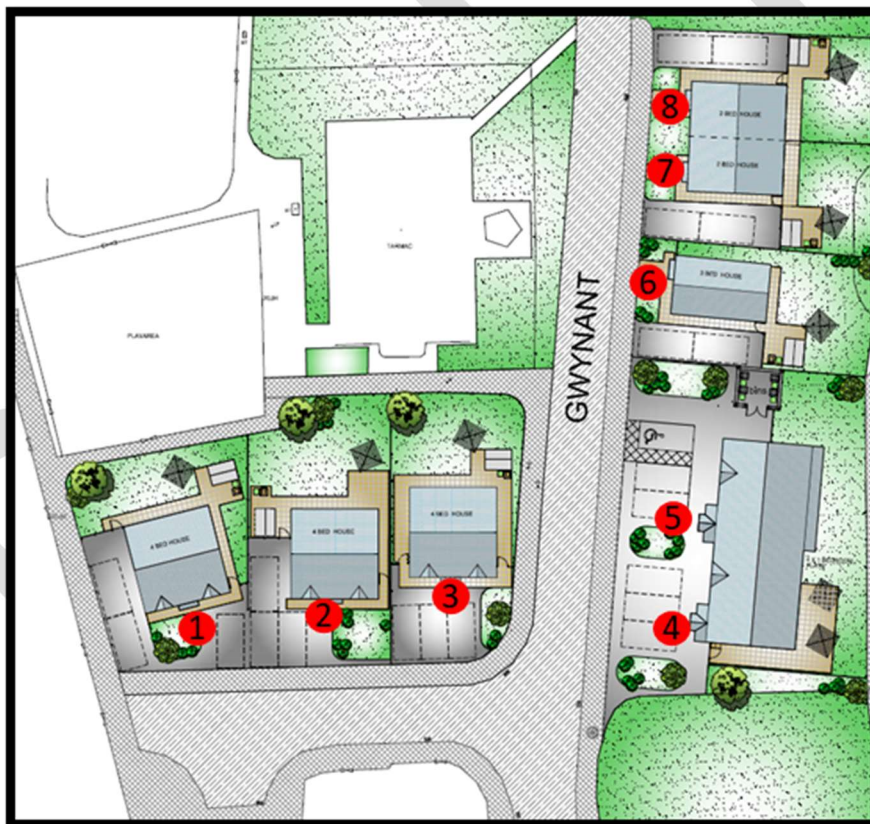
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## Results

The detailed results in terms of maximum flood depths and maximum flood velocities in each of the 8 locations for “Proposed Development” scenario and associated blockage scenarios (30% Low, 67% Medium and 90% High) with development area are presented in

Table 1 and Table 2 respectively.

Figure 2 below shows the development plan of the designed properties and the location of extraction points for the flood depth and flood velocity data from site 1 and 2. Locations 1, 2 and 3 are in site 1, whilst locations 4, 5, 6, 7 and 8 are in site 2.



**Figure 2: Location of extraction points for depth and velocity results**

Table 1, below summarises the flood depths for the blockage scenarios modelled:

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Table 1: Maximum flood depth (mm) outside of the proposed development access

| Location | Proposed Development |          | 30% blockage |          | 67% Blockage |          | 90% Blockage |          |
|----------|----------------------|----------|--------------|----------|--------------|----------|--------------|----------|
|          | 1% AEP + 45%CC       | 0.1% AEP | 1%AEP +45%CC | 0.1% AEP | 1%AEP +45%CC | 0.1% AEP | 1%AEP +45%CC | 0.1% AEP |
| <b>1</b> | 20.5                 | 36.8     | 24.9         | 50.4     | 24.9         | 50.4     | 24.7         | 49.3     |
| <b>2</b> | 6.2                  | 12.3     | 24.6         | 34.7     | 24.6         | 34.6     | 24.4         | 33.9     |
| <b>3</b> | 3.8                  | 17.7     | 33.7         | 50.8     | 33.7         | 50.7     | 33.2         | 49.6     |
| <b>4</b> | 71.7                 | 116.5    | 66           | 92.1     | 66.1         | 92       | 66.4         | 90.2     |
| <b>5</b> | -                    | -        | -            | -        | -            | -        | -            | -        |
| <b>6</b> | -                    | -        | -            | -        | -            | -        | -            | -        |
| <b>7</b> | -                    | -        | -            | -        | -            | -        | -            | -        |
| <b>8</b> | -                    | -        | -            | -        | -            | -        | -            | -        |

Note: '-' indicates that the flood extent does not reach the location

Table 2 shows the maximum flood velocities at Site 1 and Site 2 for with and without blockage scenarios for all the modelled events.

Table 2: Maximum flood velocities (m/s) outside of the proposed development access

| Location | Proposed Development |          | 30% blockage |          | 67% Blockage |          | 90% Blockage |          |
|----------|----------------------|----------|--------------|----------|--------------|----------|--------------|----------|
|          | 1% AEP + 45%CC       | 0.1% AEP | 1%AEP +45%CC | 0.1% AEP | 1%AEP +45%CC | 0.1% AEP | 1%AEP +45%CC | 0.1% AEP |
| <b>1</b> | 0.30                 | 0.44     | 0.08         | 0.11     | 0.08         | 0.11     | 0.08         | 0.10     |
| <b>2</b> | 0.17                 | 0.26     | 0.04         | 0.04     | 0.04         | 0.04     | 0.04         | 0.04     |
| <b>3</b> | 0.03                 | 0.02     | 0.04         | 0.05     | 0.04         | 0.05     | 0.04         | 0.05     |
| <b>4</b> | 0.00                 | 0.01     | 0.00         | 0.00     | 0.00         | 0.00     | 0.00         | 0.00     |
| <b>5</b> | -                    | -        | -            | -        | -            | -        | -            | -        |
| <b>6</b> | -                    | -        | -            | -        | -            | -        | -            | -        |
| <b>7</b> | -                    | -        | -            | -        | -            | -        | -            | -        |
| <b>8</b> | -                    | -        | -            | -        | -            | -        | -            | -        |

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## Discussion

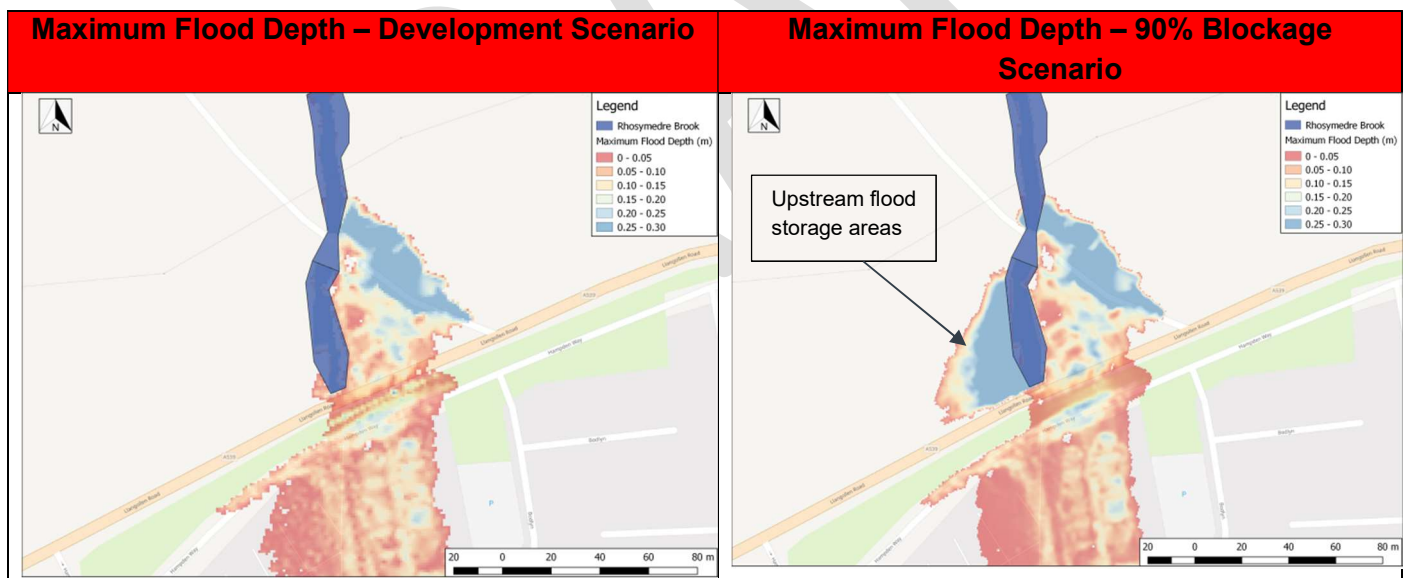
### Flood Depths

Table 1 shows the comparison of maximum flood depths within the development area at 8 locations for all the three blockage scenarios, for 1% AEP plus 45% Climate change and 0.1% AEP events. The comparison of maximum flow velocities for all the three blockage scenarios, for 1% AEP plus 45% Climate change and 0.1% AEP events are presented in Table 2 which shows the impact of culvert blockages on the flow velocities in the areas of development site.

The results showed that, when the flow was obstructed (30% Low, 67% Medium and 90% High blockages) at the inlet of the A539 culvert, the water level in the watercourse upstream of the A539 culvert increased significantly (

Table ) and more flow was initially spilled into the available upstream floodplain at the location of the culvert. This area therefore acted as a reservoir for flood storage and hence the flood levels at the site did not increase linearly with the extents of blockage increases. This is shown in Figure 3 below.

Figure 3: Figures showing the comparison of Maximum Flood Extent Upstream of A539 Road Culvert



Locations 1, 2 and 3 shown in Figure 2 showed small increases in the maximum flood depth in the range of 4.2mm to 29.9mm and for the 1% AEP plus 45% climate change scenario. The increase for the 0.1% AEP event was 12.5mm to 33.1mm.

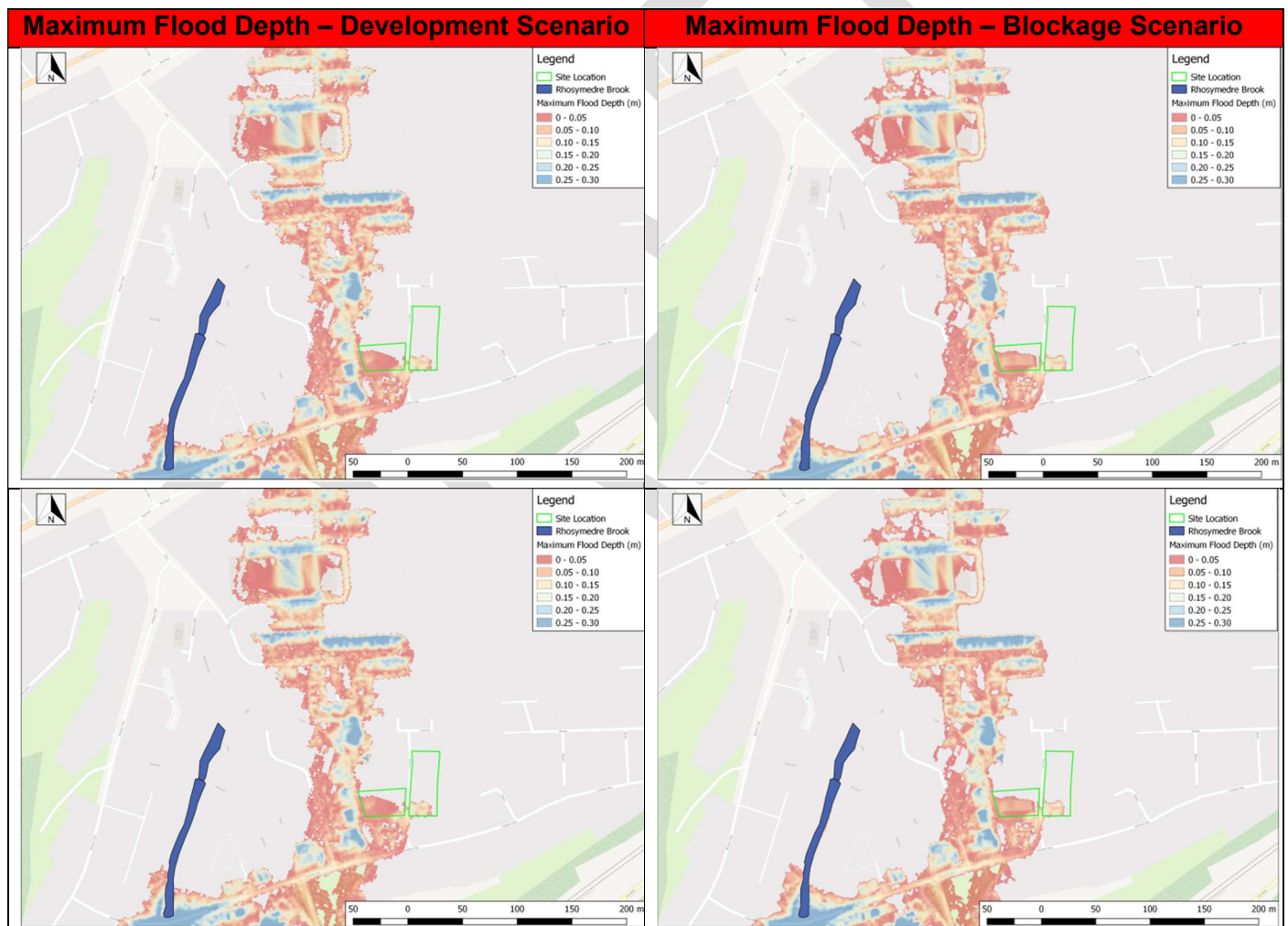
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Location 4 showed a reduction on the maximum flood depths as the water spilled into the upstream floodplain was stored and did not flow downstream across the A539 Road as it acted as a reservoir during peak of the hydrograph.

This storage of flow volume in the upstream floodplain of the watercourse was noted to reduce the volume of flow passed downstream and thus reducing the flood depths at Location 4 in the development site. The overall reduction in maximum flood depths at Location 4 was in the range of 5.3mm to 26.3 mm for the simulated flood events. Figure 4 shows the comparison of maximum flood depths for 1%+ 45% climate change AEP event without blockage and with blockage scenarios.

Figure 4: Figure showing the Comparison of Maximum Flood Depths between Development Scenario and Various Blockage Scenarios (30%, 67%, and 90%) for 1% AEP Plus 45% Events for site 1 and 2.



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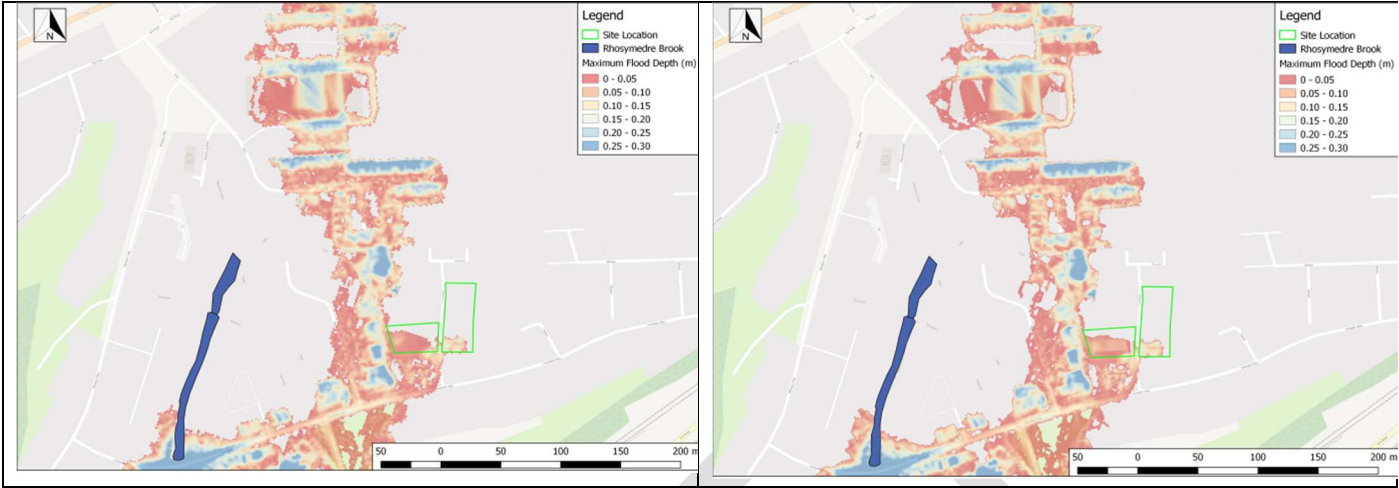
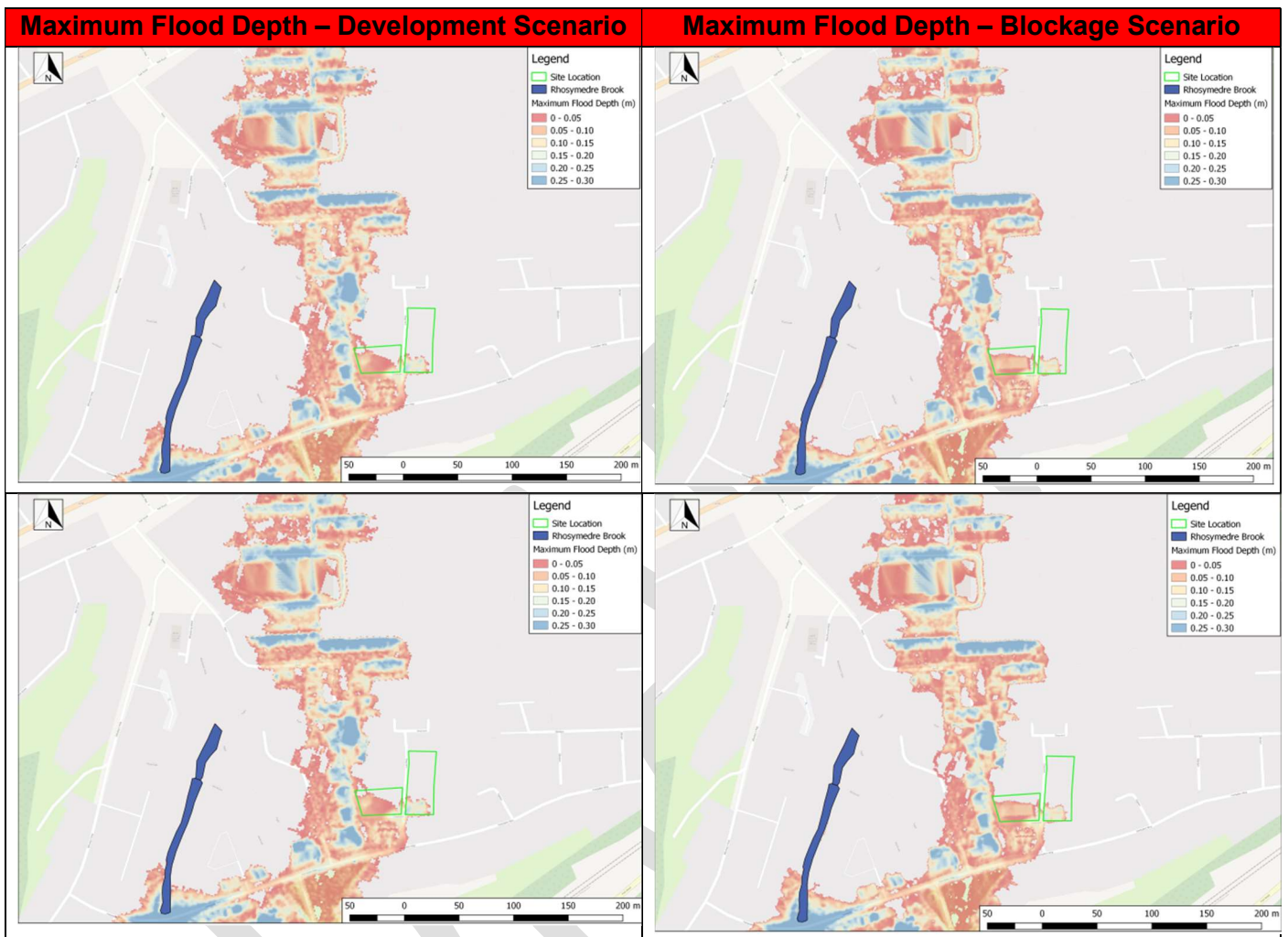


Figure 5 shows the comparison of maximum flood depths for 0.1% AEP event without blockage and blockage scenarios within and adjacent to the site 1 and 2.

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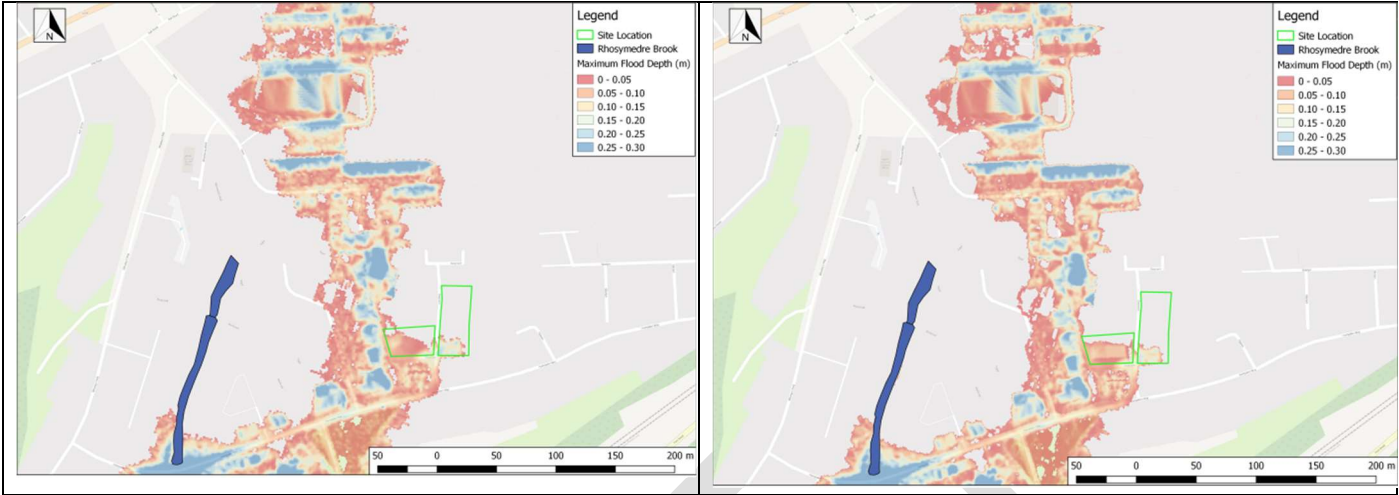
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Figure 5: Figure showing the Comparison of Maximum Flood Depths between Development Scenario and Various Blockage Scenarios (30%, 67%, and 90%) for 0.1% AEP Event



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## Flow Velocity

The blockage at the A539 culvert was noted to reduce the velocities downstream and the impact can be seen into the development site. The velocities in the development site reduced from 0.3 m/sec to 0.08 m/sec at Location 1 for the 1% AEP plus 45% Climate change event whereas the velocities are reduced from 0.44 m/sec to 0.11 m/sec for 0.1% AEP event. Location 2 also shows reduction in velocity with the blockage compared to without blockage scenarios for both 0.1% and 1% AEP plus 45% Climate change event. Changes in the velocity at location 3 and 4 are not significant.

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### Mitigation Measures

The flood Consequence Assessment published in February 2019, recommend raising the finished flood level of the proposed development 150mm above the modelled 1%AEP +45%CC event, for sites 1 and site 2 resulting in recommends of 119.94mAOD for site 1 and 119.36mAOD for site 2.

The additional blockage scenario modelling undertaken as part of this technical note, shows the maximum flood level for the 90% blockage at a 0.1%AEP event the sites could experience was approximate 92.0mAOD, around 300mm lower than the proposed developments lowest flood level.

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## Flood Risk Management Options

WSP were also appointed to provide information on potential options for flood risk management for the wider village located to the south of the A539 Llangollen Road.

A feasibility study of the potential flood mitigation measures that could be undertaken on the watercourse adjacent to Gwynant should be undertaken. This study would determine the best strategies for implementing improvement works that would have the maximum benefit to the local area.

Flood risk management schemes generally start with a review of historical flooding information and a thorough review of the existing drainage asset records within the village and upstream and downstream of the village. An up to date model of the existing baseline scenario, using the latest drainage asset survey information would set out the current standard of protection and following on from this, flood risk management options can be modelled to assess their effectiveness and viability both from economics and environmental benefit perspective.

The study would include examples of proposed improvement works on the watercourse that could include the following:

- Maintenance and improvements of existing structures such as culverts and bridges, inspections for removing intrusions and obstructions to flow.
- Installation of new up to date grillage (and potential upstream coarse screen) at culvert inlets including maintenance access arrangement in accordance with Natural Resources Wales guidance.
- New flood walls that provide additional protection to adjacent areas and re-route flood waters to specific locations where damages to property will be limited/reduced.
- Localised upsizing (or additional) lengths of culvert to increase flow capacity in vulnerable areas.
- Potential small-scale river diversion works that re-route sections of the river away from particularly vulnerable areas
- Increase flow capacity of open channel sections by reprofiling the watercourse and raising the adjacent embankments. This could be done using soft or hard engineering techniques such as earth embankments or flood walls.
- Upstream online or offline storage facility to provide flood flow attenuation for the increased volume passing through the watercourse. This would also include a spillway/flow control structure.
- New network of swales to direct surface water to strategic locations where damages will be avoided/reduced.
- Property level protection/resilience measures to houses within the areas susceptible to fluvial and surface water flooding, this could include demountable flood barriers, replacement of existing external doors with watertight doors, non-return valves on foul outlets.

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Additionally, to reduce the impact of highway surface water contributing to fluvial flooding, local highway improvement works could also be included which could include:

- Survey and subsequent jetting and cleaning of existing drainage network to ensure that it is working suitably.
- Additional highway gullies and new highway drains to provide additional underground attenuation.
- Installation of a highway drainage attenuation system to reduce inflow rates on the main culvert.
- Re-profiling of highways and installation of new kerb lines to re-direct flood waters away from residential properties.
- Raising footway levels to protect pedestrians during storm events.

The above options could provide improved protection against fluvial and highway surface water flooding.

The above options are all subject to surveys, hydraulic modelling and an economic appraisal to determine the most cost beneficial option to reduce flood risk to the village.

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## CONCLUSIONS

### Hydraulic modelling

The hydraulic modelling results have demonstrated that the increase in the extent of the blockage from (low to high) at the Rhosymedre Brook culvert inlet structure has negligible impact on increases on flood depth and flood velocity at the proposed development Sites 1 and 2. During the 0.1% AEP blockage events compared to the 1%AEP +45%CC event for the 30%, 67% and 90% scenarios, the maximum water level the results have identified for the blockages scenario was 92.10mAOD, and below the 1.0%AEP+45%CC level of 119.55mADO that was used within the FCA's (Feb 2019) development finished floor level assessment.

On the basis of, the updated results of the blockage analyses undertaken, the original proposed floor level of 150mm (119.363mAOD & 119.939mAOD) for the development still remains relevant ensuring the properties remain flood free during the modelled blockage and climate change events.

### **Way Forward**

Following the additional modelling, the suggested way forward is to share the results of the blockage scenarios with Natural Resources Wales Planning department and follow up meeting to discuss the results and the developments proposed Floor Level, regarding the NRW previous comments and requirements.

### Flood Risk Management Options

Following the completion of the FCA and the identification of the flood risk, it is recommended the Strategic Outline Case of Welsh Governments Business Model is undertaken to review the options of implementing a flood Risk Management Scheme to reduce the flood risk to the wider village.

The feasibility study will help identify a flood risk management option which would be technically and economically viable to promote capital improvement work along the Rhosymedre Brook. On this basis the following are recommended:

- Arrangements would need to be made to carry out further surveys and investigations to more accurately define the requisite works and derive a more accurate benefit/cost ratio and look to promote a scheme for inclusion in the Council's FCERM programme.
- Funding could be sought through FDGIA grants or partnership funding or third-party contributions from landowners or other community-based sources.
- A potential scheme should be included in the Council's Strategic Outline Programme with funding arrangements sought for a Strategic Outline Case to be prepared.

### **Way Forward**

To implement the Flood Risk Management Scheme, WCBC will need to apply for funding from the Welsh Government Flood Defence Granting Aid budget, for the Strategic Outline Case report, this will require additional modelling and investigations as outlined in the Flood Risk Management section. The SOC report will enable WCBC to identify the options and funding required for the next stages of the business case, design and construction stage.