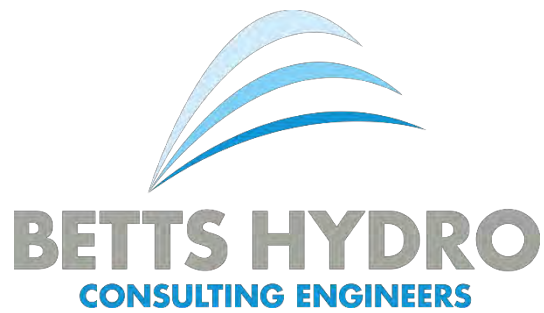




**LAND OFF BEDWELL ROAD
CROSS LANES**

**FLOOD CONSEQUENCE ASSESSMENT &
DRAINAGE MANAGEMENT STRATEGY**



For

Bowen Son and Watson
1 King Street
Wrexham
LL11 1HF



JULY 2018

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**LAND OFF BEDWELL ROAD
CROSS LANES, WREXHAM**

**FLOOD CONSEQUENCE ASSESSMENT &
DRAINAGE MANAGEMENT STRATEGY**

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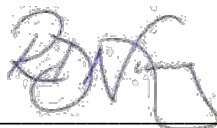
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EXECUTIVE SUMMARY

This Flood Consequence Assessment and Drainage Management Strategy has been prepared to support a full planning application for a residential development on land off Bedwell Road in Cross Lanes. This assessment has reviewed all sources of flood risk to both the site and existing adjacent development, because of the proposals, including; fluvial, tidal, pluvial, groundwater, sewers and flooding from artificial sources.

Flood Risk

The site covers 0.242ha and is located wholly within Flood Zone A based on the Development Advice Map, which is an area considered to be at little or no fluvial/tidal flood risk. The proposals are residential in nature, this is 'highly vulnerable' within Welsh Government Planning Policy and is acceptable (in accordance with TAN15) when located within Flood Zone A. The development site forms part of the wider land controlled by the developer, which is shown to be partly at risk of fluvial flooding associated with Clywedog Stream which flows parallel. The proposed development however will be located wholly within Flood Zone 1 and therefore the flood risks to the development would be low.

Review of online resources and consultation responses interested parties has failed to identify any significant historical flooding to have impacted the development site. This assessment has however considered the potential flood risks associated with the Clywedog Stream to the development site itself and the wider land controlled by the developer. Wrexham County Borough Council have conducted a Hydraulic Modelling study in 2009 of the Clywedog Stream and this assessment has considered the risks identified during this assessment against the current planning proposals. It can be stated that the development site will remain flood free in the key design events including the 1 in 100yr and 1 in 1000yr return period events.

Additional hydraulic modelling has been carried out to consider the residual risks from blockage and the potential mitigation required to safeguard the development proposals for their design life. The design life in this case is the 1 in 100yr return period event with climate change and planning policy states that residential property has a minimum finished floor level set 600mm above the predicted Top Water Level in the 1% AEP+CC event. Based on the most relevant cross-section, the finished floor level should be 37.758mAOD. Review of the topographic survey shows that the existing ground levels within the development area range from 42.2mAOD and 41.7mAOD. It is therefore likely that the proposed FFL will be significantly higher than the required minimum to safeguard against flooding when considering the other engineering constraints.

Overall the development site is at 'very low' flood risk from most flood sources reviewed, some surface water flood risk was identified which is closely associated with the existing topography and can be effectively managed as part of the proposals, through the implementation of mitigation measures proposed within this assessment.

Drainage Strategy

Because of the 'low' flood risks identified, the principle focus of this assessment is on the effective management of surface water run-off generated by future development, in accordance with the national and local drainage hierarchy. Based on the ground conditions identified it can be considered that infiltration is unlikely to provide a full viable drainage solution for surface water run-off generated by the proposals. In accordance with Wrexham County Borough Council's and

Welsh Water's requirements, Soakaway testing (to BRE365) may be required, to evidence that discharge to ground will not be a viable solution, before progressing with an alternative option.

Assuming infiltration is not feasible, the next method in the hierarchical approach is to consider a direct connection to the nearest watercourse. The nearest watercourse is Clywedog Stream approximately 100m to the north of the development area, through land in control of the developer. The existing ground levels within the development areas generally fall towards the north boundary and therefore a gravity solution could be feasible, subject to further analysis as part of detailed design stage.

Detailed design will be required to determine the feasibility of the overall strategy and whether a full gravity system is achievable following more in-depth levels review. Consents from the Lead Local Flood Authority (Wrexham County Borough Council) will be required for works effecting the Ordinary Watercourse, including agreement of any outfall structures and discharge rates. Early discussion is recommended to confirm they accept the proposed drainage strategy and identify if there are any additional constraints. Should any offsite routing be required then this will also need to be agreed with the relevant authority/land owner at an early stage.

The surface water run-off generated by the proposals will be required to be restricted, in accordance with policy all sites should endeavour to achieve as close to pre-development greenfield rates as is viable. When considering the development area a pre-development greenfield rate (QBar) of 1.2l/s has been calculated. Given the typical restrictions applied by standard flow control devices, the minimum discharge rate from the site will be 5.0l/s this is based on the minimum flow through the orifice plate (based on standard diameter). This will need to be considered in terms of attenuation as part of detailed design. It would be beneficial to implement SuDS features into the drainage strategy for attenuation, conveyance and water quality benefits although due to the scale of development proposed this nature of infrastructure would need to be located within the wider land in control of the developer and not the development area itself.

The potential residential development site has been justified in accordance with TAN15 and suitable mitigation measures have been proposed to ensure that the development is safe for its lifetime. This assessment illustrates that there is minimal impact on flood risk. This Flood Consequence Assessment is commensurate with the development proposals and in summary, the development can be considered appropriate in accordance with TAN15, providing the mitigation measures proposed are conformed to.

CONTENTS

Document Tracking Sheet.....	iii
EXECUTIVE SUMMARY	v
CONTENTS.....	vii
Figures & Tables.....	viii
Specialist Software.....	ix
Abbreviations & Acronyms.....	ix
1.0 INTRODUCTION	11
1.1 Planning Policy Context	11
<i>Technical Advice Note 15.....</i>	<i>11</i>
1.2 Site Context	11
1.3 Consultation.....	11
2.0 EXISTING SITE BACKGROUND	12
2.1 Location	12
2.2 Existing and Historical Land Use.....	12
2.3 Topography.....	13
2.4 Justification for Development.....	13
3.0 DEVELOPMENT PROPOSALS.....	14
3.1 Nature of the development.....	14
4.0 TECHNICAL ADVICE NOTE 15 (TAN15)	15
4.1 Flood Zone Classification.....	15
4.2 Category of Development.....	15
4.3 Acceptability Criteria	16
5.0 SOURCES OF FLOOD RISK	17
5.1 Fluvial Flood Risk	17
<i>Main Rivers</i>	<i>17</i>
<i>Ordinary Watercourses.....</i>	<i>18</i>
<i>Hydraulic Assessment</i>	<i>20</i>
<i>Mitigation.....</i>	<i>21</i>
<i>Flood Warning and Evacuation</i>	<i>21</i>
5.2 Tidal Flood Risk.....	22
5.3 Surface Water	22
5.4 Pluvial Flood Risk	23
5.5 Artificial Sources of Flood Risk	24
<i>Reservoirs</i>	<i>24</i>
<i>Canals.....</i>	<i>24</i>

5.6	Groundwater Flood Risk.....	24
5.7	Sewer Flood Risk.....	25
5.8	Historical and Anecdotal Flooding Information	25
5.9	Mitigation Measures and Residual Risks	26
	<i>Mitigation Measures</i>	26
	<i>Residual Risks</i>	27
6.0	SURFACE WATER MANAGEMENT	28
6.1	Pre-development Surface Water Run-off.....	28
6.2	Post-development Surface Water Run-off.....	28
6.3	Sustainable Drainage Systems (SuDS)	29
6.4	Methods of Surface Water Management.....	30
6.5	Discharge via Infiltration.....	30
6.6	Discharge to Watercourse.....	30
6.7	Discharge to Sewer.....	32
6.8	Climate Change	32
7.0	FOUL WATER MANAGEMENT	34
8.0	SUMMARY AND CONCLUSIONS	35
9.0	RECOMMENDATIONS	37
	BIBLIOGRAPHY & REFERENCES.....	38
	Web-based References.....	38

Figures & Tables

Figure 1:	Aerial Photograph of site (Bing Maps, 2018).....	12
Figure 2:	Photographs of Topographic Features (Betts Hydro, 2018)	13
Figure 3:	Planning Layout (D. S. Jones & Co., 2018).....	14
Figure 4:	Development Advice Map extract (Welsh Government, 2018).....	15
Table 1:	Development category of vulnerability (Source: TAN15: Section5)	16
Figure 5:	Flood Zone Map Extract (NRW, 2018)	17
Figure 6:	Cross-Section Locations within the Hydraulic Model (WCBC, 2009)	18
Table 2:	Predicted Flood Water Levels Along Clywedog Stream (WCBC, 2009)	19
Figure 7:	Floodplain Extents Plan with Layout overlay (Betts Hydro, 2017).....	19
Figure 8:	Flood Warning and Alert Areas Map extract (NRW, 2018).....	21
Figure 9:	Surface Water Flood Risk Map Extract (NRW, 2018)	22
Figure 10:	Surface Water Hazard Map Extract (NRW, 2018).....	23
Figure 11:	Reservoir Flood Map Extract (NRW, 2018)	24
Table 3:	Pre-Development Surface Water Run-Off Rates and Volumes (Betts Hydro, 2018)	28

Table 4:	Post-Development Un-Restricted Run-Off Rates and Volumes (Betts Hydro, 2018)	28
Figure 12:	SuDS Photographs (SusDrain, 2012)	29
Figure 13:	Proposed Drainage Strategy Plan (Betts Hydro, 2018)	31
Table 5:	Estimated Stormwater Storage Requirements (Betts Hydro, 2017)	32

APPENDIX A:	TAN15 EXTRACTS	
APPENDIX B:	NRW INFORMATION & CORRESPONDENCE	
APPENDIX C:	WW SEWER RECORDS & CORRESPONDENCE	
APPENDIX D:	LLFA CORRESPONDENCE	
APPENDIX E:	LOCATION PLAN	
APPENDIX F:	PHOTOGRAPHS	
APPENDIX G:	TOPOGRAPHIC SURVEY	
APPENDIX H:	PLANNING LAYOUT	
APPENDIX I:	LLFA HYDRAULIC MODELLING REPORT	
APPENDIX J:	HYDRAULIC ASSESSMENT OUTPUTS	
APPENDIX K:	PFRA/SPRA INFORMATION	
APPENDIX L:	SURFACE WATER RUN-OFF CALCULATIONS	
APPENDIX M:	IMPERMEABLE AREAS PLANS	
APPENDIX N:	TYPICAL SUDS DETAIL	
APPENDIX O:	PROPOSED DRAINAGE STRATEGY PLANS	
APPENDIX P:	STORMWATER STORAGE ESTIMATES	
APPENDIX Q:	OVERLAND FLOOD FLOW ROUTES	
APPENDIX R:	NOTES OF LIMITATIONS	

Specialist Software

 Flood Estimation Handbook FEH CD-ROM (v.3.0) – Determination of Catchment Descriptors and depths of rainfall.

 MicroDrainage WinDES (v.14.1) – Calculation of Greenfield run-off rates IH124/ICP-SUDS, Greenfield run-off volumes, rates of rainfall and stormwater storage estimates.

Abbreviations & Acronyms

AEP	Annual Exceedance Probability
BGS	British Geological Survey
CC	Climate Change

CFMP	Catchment Flood Management Plan
DAM	Development Advice Map
FCA	Flood Consequence Assessment
FEH	Flood Estimation Handbook
Ha	Hectare
LDP	Local Development Plan
LFRDP	Local Flood Risk Development Plan
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
mAOD	metres Above Ordnance Datum
NGR	National Grid Reference
NRW	National Resources Wales
NSRI	National Soil Resource Institute
OS	Ordnance Survey
PFRA	Preliminary Flood Risk Assessment
PPW	Planning Policy Wales
QSE	Quick Storage Estimate
SFCA	Strategic Flood Consequence Assessment
SuDS	Sustainable Drainage Systems
TAN15	Technical Advice Note 15
UKCIP	United Kingdom Climate Impacts Programme
WCBC	Wrexham County Borough Council
WW	Welsh Water

1.0 INTRODUCTION

1.1 Planning Policy Context

- 1.1.1 All forms of flooding and their impact on the natural and built environment are material planning considerations. Planning Policy Wales (PPW) sets out the Government's objectives for the planning system, and how planning should facilitate and promote sustainable patterns of development, avoiding flood risk and accommodating the impacts of climate change. Government policy with respect to development in flood risk areas is contained within the PPW, Technical Advice Note 15, (TAN15) 'Development and Flood Risk' issued in July 2004.

Technical Advice Note 15

- 1.1.2 TAN15 provides technical guidance to supplement the policy's set out in PPW with regards to 'development and flood risk', a framework is provided to enable new development to be considered appropriately with regards to arising risks of fluvial and tidal flooding along with risks associated with additional run-off from development in all locations (see **Appendix A**).

1.2 Site Context

- 1.2.1 This Flood Consequence Assessment (FCA) has been prepared to support a full planning application for a residential development on land in Cross Lanes (Wrexham). The proposals will be complete with access, car parking, external works and lighting, landscaping, boundary walls and fencing, external services and drainage. The proposals are Highly Vulnerable in accordance with the guidance found in TAN15, given their residential nature.
- 1.2.2 A FCA is required to justify that the proposed development is appropriate with reference to TAN15, this FCA will provide justification that;
-  The consequences of flooding to that development and elsewhere have been fully considered and implemented against for the lifetime of the development;
 -  No increase in flooding will occur to the development site or surrounding area due to the proposals including flooding from surface water and sewers;

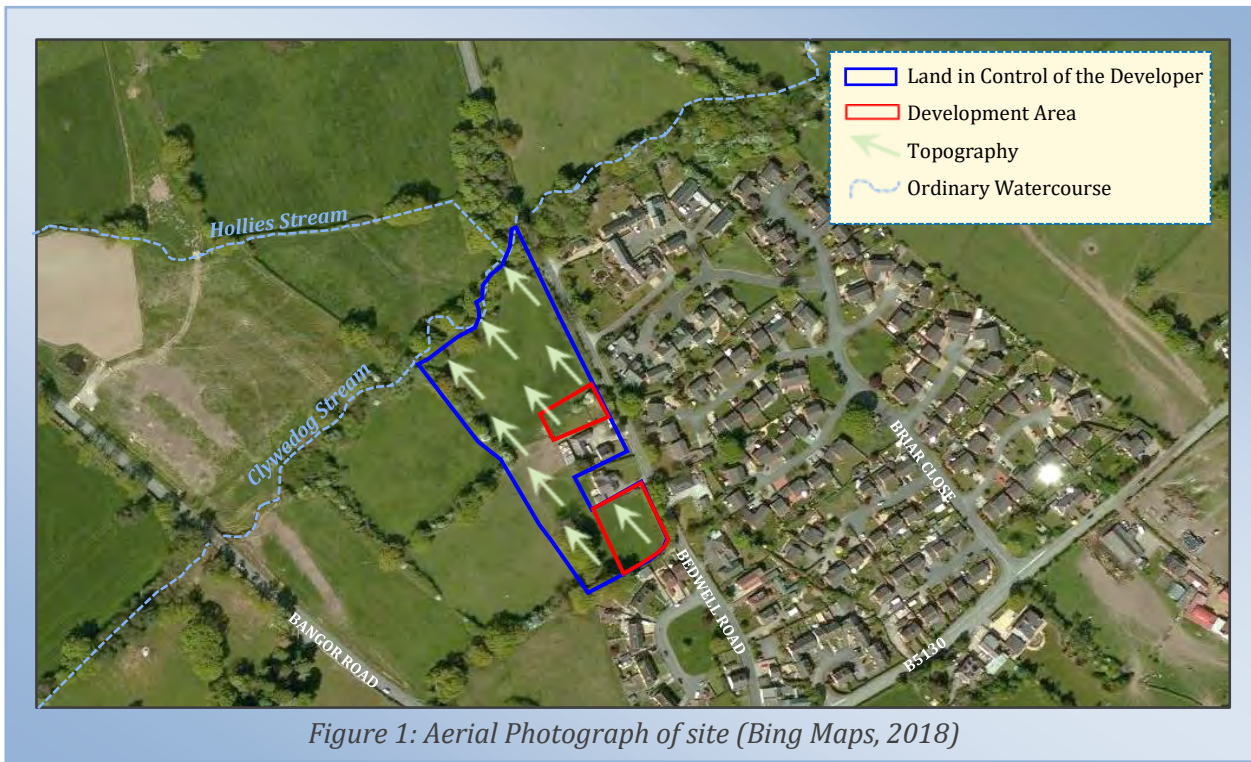
1.3 Consultation

- 1.3.1 The preparation of this report has been undertaken in consultation with the following interested parties; Natural Resources Wales (NRW), Welsh Water (WW) and Wrexham County Borough Council (WCBC), responses can be seen in **Appendix B, C and D**. The Local Planning Authority (LPA), WCBC (also acts as the Lead Local Flood Authority), will make the final decision about any planning permission. The LPA should consult with NRW who will provide advice and guidance on flood issues at a strategic level and in relation to planning applications.

2.0 EXISTING SITE BACKGROUND

2.1 Location

- 2.1.1 The development is accessed off Bedwell Road in Cross Lanes (near Wrexham). The Ordnance Survey National Grid Reference (OS NGR) for the site is E: 337522, N: 347194 and the nearest postcode is LL13 0TR. The site covers 1.269ha and is predominantly undeveloped (used for agricultural purposes), the wider site is edged in blue in **Figure 1**, with the development area being edged in red (see location plan in **Appendix E**).
- 2.1.2 The wider site is bounded to the north by Clywedog Stream, which is an Ordinary Watercourse flowing in a north-easterly direction to out-fall into the River Clywedog over 2km to the north-east of the site (illustrated in **Figure 1**). To the east of site is Bedwell Road, with the residential settlement of Cross Lanes beyond and to the south of the site lies residential dwellings accessed off Bedwell Crescent, with the B5130 beyond. Finally, to the west of the site lies undeveloped agricultural land with the A525 (Bangor Road) beyond.



2.2 Existing and Historical Land Use

- 2.2.1 The preparation of this report has identified that the site and development area is predominantly undeveloped and used for agricultural purposes (grazing) at this time. No other historical uses have been determined during this assessment. Vehicular access is currently off Bedwell Road, and this will continue to be the access point following development.
- 2.2.2 The site is currently classified as 'less vulnerable' by the Local Planning Authority, the nature of land-use will however increase to 'highly vulnerable' due to the residential nature of the proposals in accordance with TAN15.

- 2.2.3 A site walkover was undertaken by Betts Hydro in February 2018 and identified that the site was covered in grass type vegetation, as shown in **Figure 2**. Ground levels drop from the northern boundary of the site wider site towards Clywedog stream (refer to photographs in **Appendix F**).



Figure 2: Photographs of Topographic Features (Betts Hydro, 2018)

2.3 Topography

- 2.3.1 TAN15 requires all sources of flood risk to be considered and analysed with reference to the current levels of the site, a topographical survey has been reviewed as part of this FCA; such is included in **Appendix G**. The existing ground levels on site vary, however generally fall from the southern boundary toward the watercourse on the northern boundary (see illustration in **Figure 1**).
- 2.3.2 Existing ground levels within the wider site range from 42.68mAOD in the southern corner of the site and 35.5mAOD in the north-eastern corner of the site (adjacent to the Clywedog Stream). The development area has levels between 42.2mAOD and 41.7mAOD. Bedwell Road bounds the eastern boundary of both development parcels and following review of the topographic the survey development area is lower than this neighbouring highway, in some places.

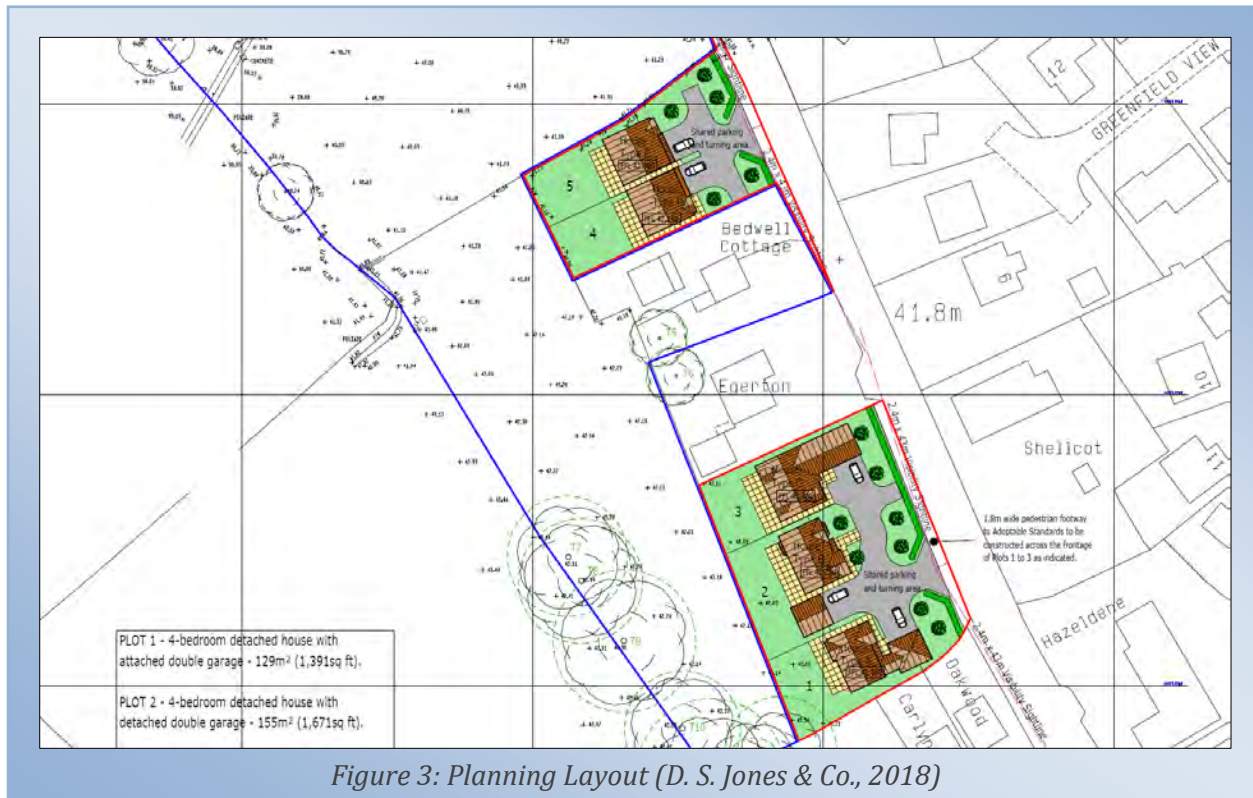
2.4 Justification for Development

- 2.4.1 Planning Policy Wales (5th Ed. – November 2012) states that the Welsh Government is committed to promoting ‘sustainable development’ by providing for homes, infrastructure, investment and jobs in a way which is consistent with sustainable development principles PPW Sec. 2.2). The FCA will be considerate to the nature and scale of the proposals and will review flood risk to and from the development along with considering any appropriate mitigation measures based on the identified sources of risk.
- 2.4.2 The development proposals are of a highly vulnerable nature and will be located solely within Flood Zone A. The development will ensure the provision of residential housing within the least vulnerable areas of the site, with public open space (POS) areas steered to those areas onsite where floodplain extents are anticipated.

3.0 DEVELOPMENT PROPOSALS

3.1 Nature of the development

- 3.1.1 This FCA has been prepared to support an full planning application for a residential development on land off Bedwell Road in Cross Lanes (near Wrexham), the proposals will be complete with, access, car parking, external works, landscaping, boundary fencing, external services and drainage as indicated in **Figure 3 (Appendix H)**.



- 3.1.2 The wider land controlled by the developer equates to 1.269ha, however the proposed development will take place on part of the wider site only, equating to 0.242ha as shown by the red edge in **Figure 3**. The existing development area is 11% impermeable at present, this relates to the existing residential development on the land. The impermeable areas of the site will increase post-development to cover 51% of the development area, this is 0.123ha.
- 3.1.3 The proposals should where at all possible incorporate Sustainable Drainage System features into the design to conform to the current guidance within the SuDS Manual (CIRIA C753, 2015) and the Non-Statutory Technical Standards for Sustainable Drainage Systems (DEFRA, 2015). Due to the nature of the proposals, there is minimal areas within the development area where SuDS could be implemented. The land to the north between the development area and the watercourse is in control of the developer therefore may offer the opportunity for inclusion of small-scale SuDS methods to assist with surface water management. The inclusion of SuDS into the surface water management regime will be reliant on ground conditions and maintenance/adoption agreements (to be determined at detailed design).

4.0 TECHNICAL ADVICE NOTE 15 (TAN15)

4.1 Flood Zone Classification

4.1.1 The Welsh Government Development Advice Map (DAM) is to be utilised when considering and determining flood risk associated with planning developments within Wales, these maps are based on extreme flood events outlined by the Natural Resources Wales (NRW) and British Geological Survey (BGS) data (TAN15). The DAM (**Appendix B**) identifies three key 'Flood Zones' for consideration, which are:

Flood Zone A

Areas considered to be at little or no risk of fluvial/tidal flooding.

Flood Zone B

Areas known to have historically flooded based on sedimentary evidence deposits.

Flood Zone C

Areas considered to be located on floodplain based on EA extreme flood outline data (equal to or greater than 0.1% fluvial/tidal flooding). This zone is subdivided into:

Zone C1 - Areas considered to be developed and served by significant infrastructure (flood defences).

Zone C2 - Areas considered to be located within natural floodplain without significant flood defences.

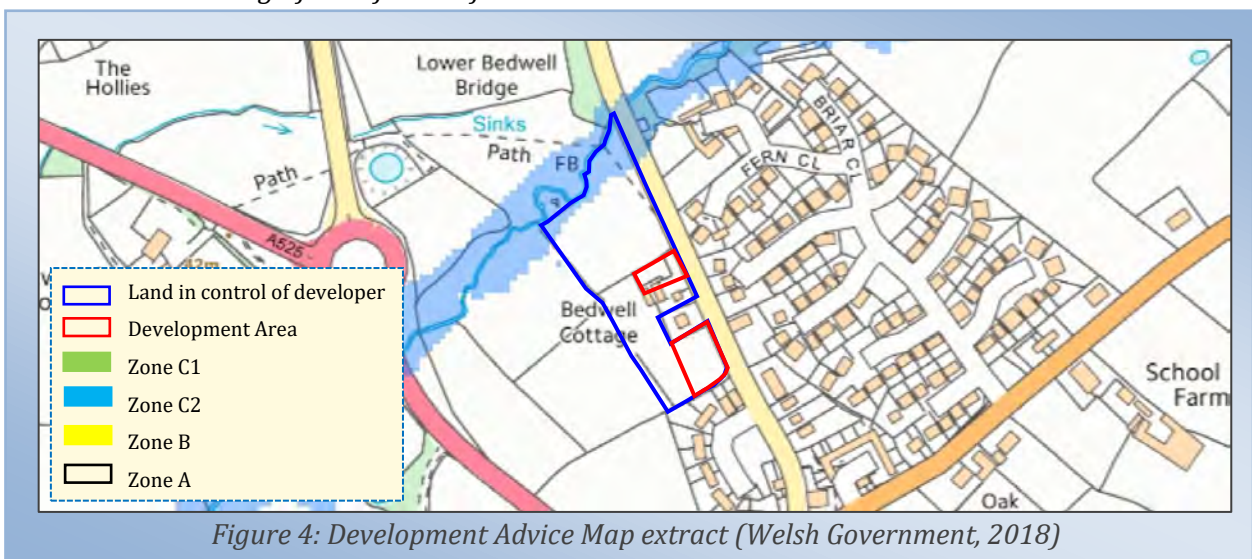


Figure 4: Development Advice Map extract (Welsh Government, 2018)

4.1.2 The development area is shown to be located within Flood Zone A on the DAM, as illustrated in **Figure 4**. Flood Zone A is an area considered to be at little or no risk of fluvial/tidal flooding.

4.2 Category of Development

4.2.1 TAN15 states that types of development may not be considered 'acceptable' based on their vulnerability to the consequences of flooding, identified on the DAM. The vulnerability of different land uses is described in detail in TAN15 however there are three key categories as summarised in **Table 1**.

4.2.2 The development proposals are 'highly vulnerable' in nature, based on the planning proposals and TAN15 guidance below.

Development Category	Description	Types
Emergency Services	Facilities which need to remain operational and accessible at all times.	❖ Hospitals & Ambulance Stations, ❖ Fire & Police Stations, ❖ Coastguard Stations.
Highly Vulnerable	Development where the ability of occupants to decide on whether they wish to accept the risk and manage the consequences associated with flooding is limited.	❖ Residential Developments, Hotels, Caravan Parks, Public Buildings. ❖ Power Stations, Chemical Plants, Waste Disposal.
Less Vulnerable	Development where the ability of occupants to decide on whether they wish to accept the risks associated with flooding is greater than 'highly vulnerable category'.	❖ General Industrial, ❖ Commercial Developments, ❖ Utilities Infrastructure, ❖ Transport.

Table 1: Development category of vulnerability (Source: TAN15: Section5)

4.3 Acceptability Criteria

- 4.3.1 Various criteria are identified within TAN15 (Section 7), these are used to determine whether residential development is 'acceptable' based on the nature and scale of proposals. Appropriate management should be considered with any proposed consequences of potential flooding.
- 4.3.2 The proposals are classified as 'highly vulnerable' in accordance with TAN15 and are located wholly within Flood Zone A, therefore the proposals are not at risk from fluvial/tidal flooding. In accordance with TAN15 highly vulnerable development is considered acceptable within Flood Zone A, providing surface water is appropriately managed. Sections 5.0 and 6.0 of this report assess flood risk and the consequences of potential flooding in accordance with the above.

5.0 SOURCES OF FLOOD RISK

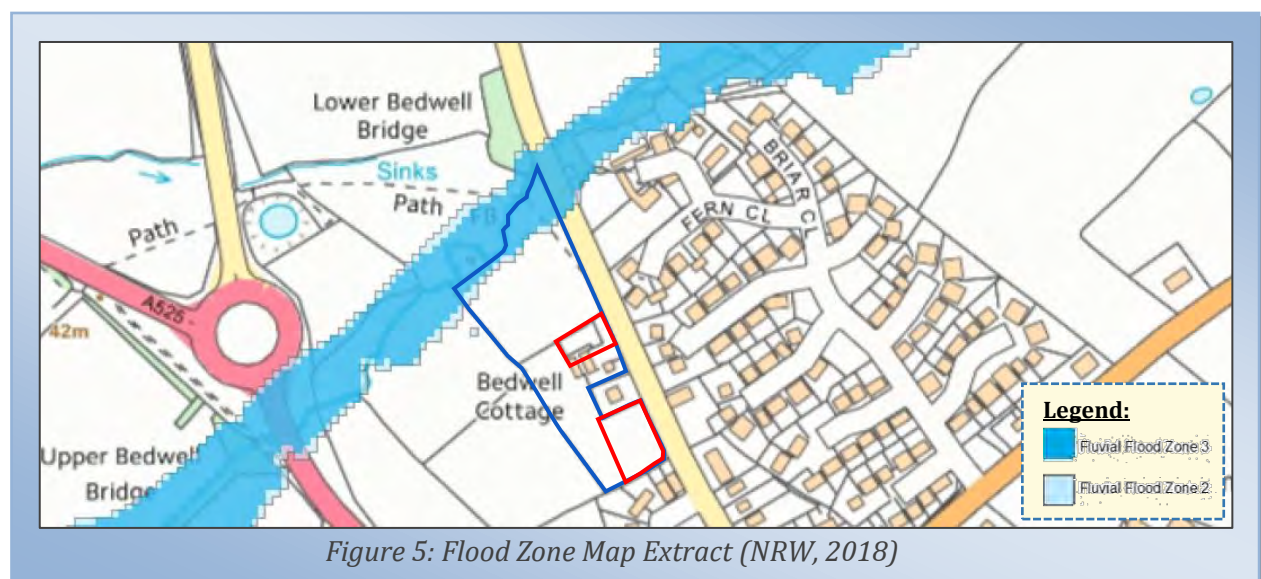
5.1 Fluvial Flood Risk

5.1.1 Information relating to the flood risk at the site has been obtained from the Welsh Government's DAM and the NRW online Flood Mapping (see **Appendix B** for full details). The nearest watercourse to the site is Clywedog Stream, which runs parallel to the northern boundary of the wider land in control of the developer. The Hollies Stream connects into this watercourse before it is culverted beneath Bedwell Road and flows north-east to discharge into the River Clywedog over 2km from the site. Based on the online flood mapping the development area (red edge) is at very low risk from flooding associated with fluvial/tidal sources as represented on the DAM.

5.1.2 The DAM notes the Development is located within Flood Zone A; however, this section of the report will refer to the potential flood risk in terms of the new NRW identified Flood Zones (Flood Zones 1, 2 and 3). NRW more accurately identifies the Flood Zones as:

- Flood Zone 1 as little or no flood risk.
- Flood Zone 2 is the extent of the 1 in 1000yr return period.
- Flood Zone 3 is the extent of the 1 in 100yr return period.

Based on this mapping (**Figure 5**), the site is shown to be located wholly within Flood Zone 1 and is therefore at little or no fluvial flood risk. The watercourse to the north of the development area is shown to exceed its capacity in the 1 in 100yr and 1 in 1000yr year events and is therefore at some fluvial flood risk based on the NRW mapping.

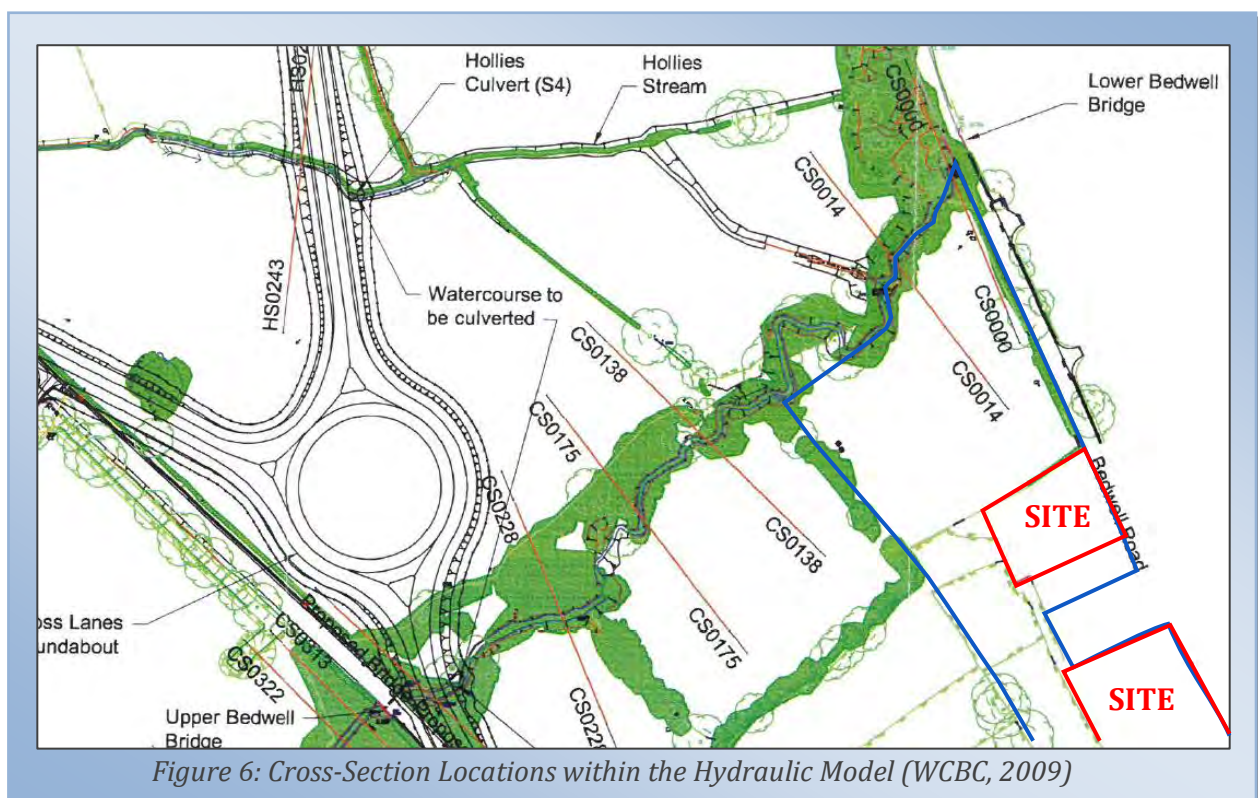


Main Rivers

5.1.3 The River Clywedog is Main River based on the NRW classification and consultation with NRW has been undertaken in accordance with TAN15 to determine the extents and potential depths of flooding onsite resulting from this source. NRW have confirmed that they have no information relevant to the proposed development area or wider site due to its proximity from the Main River model. They recommended however that further discussion with the Lead Local Flood Authority (WCBC) be undertaken as both Clywedog Stream and the Hollies Stream are Ordinary Watercourses.

Ordinary Watercourses

- 5.1.4 Clywedog Stream flows to the north of the development area adjacent to the wider site extents, the fluvial flood risks shown to the wider site are from this watercourse. Clywedog Stream is an Ordinary Watercourse and therefore discussion with the Lead Local Flood Authority has been undertaken to identify if there has been hydraulic modelling of this watercourse.
- 5.1.5 Correspondence with Wrexham County Borough Council has identified that hydraulic modelling of Clywedog Stream and its tributaries was undertaken in 2009 prior to the construction of the new link road to the Industrial Estate. The model report was provided for review and is included within the **Appendix I**. WCBC have confirmed that this is the most up to date modelling they have for Clywedog Stream and therefore the results have been considered in relation to the potential flood risk at the site.
- 5.1.6 The modelling results identified the predicted top water levels at various locations along Clywedog Stream for both the baseline scenario (prior to road construction) and the proposed scenario (post-construction). The hydraulic modelling was undertaken by Capita Symonds on behalf of WCBC and included various cross-sections along Clywedog Stream; **Figure 6** is an extract from the model report showing the location of the cross-sections used within the modelling in relation to the development.



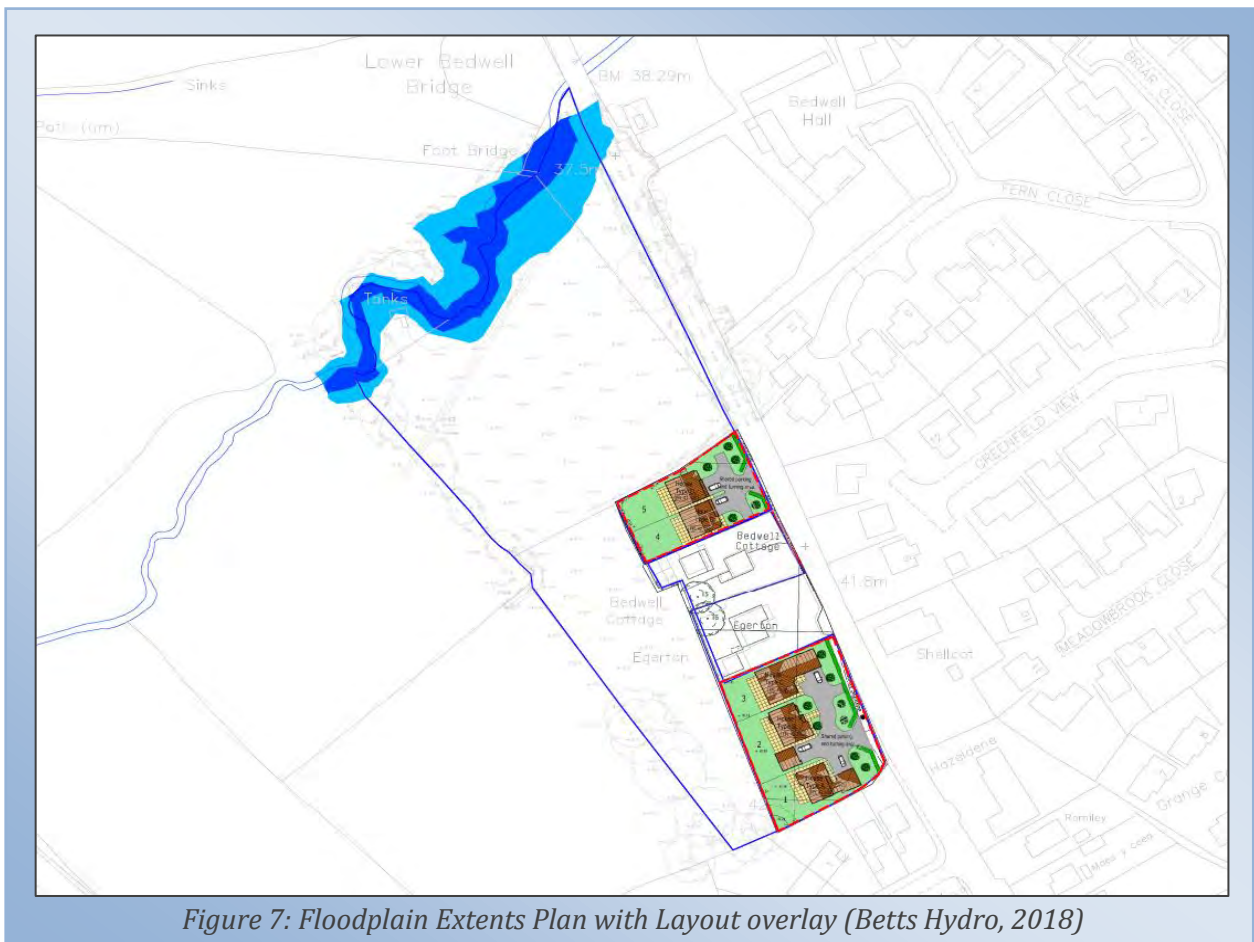
- 5.1.7 The upstream cross section is upstream of the site as indicated above, although the other cross sections are located along the length of watercourse adjacent to the site. Given that the Wrexham Industrial Estate Road has now been constructed the 'proposed scenario' results have been considered within our assessment as they represent the most up-to-date situation.

CROSS SECTION REFERENCE	FLUVIAL MODEL RESULTS FOR RETURN PERIOD EVENTS		
	1% AEP EVENT	1% AEP EVENT + 20% CC	0.1% AEP EVENT
CS0138	37.56 mAOD	37.61 mAOD	37.73 mAOD
CS0014	36.66 mAOD	36.68 mAOD	36.79 mAOD
FOOTBRIDGE	36.78 mAOD	36.85 mAOD	36.94 mAOD
CS0000	36.75 mAOD	36.81 mAOD	36.91 mAOD

Table 2: predicted flood water levels along Clywedog Stream (WCBC, 2009)

5.1.8 **Table 2** indicates the predicted top water levels at the key cross-sections for the design flood events (as indicated within the full model report). The existing ground levels on the site have been reviewed with these predicted top water levels to more accurately ascertain the level of fluvial flood risk from Clywedog Stream. The existing ground levels within the wider site area controlled by the developer range from 42.68mAOD in higher southern portion to 35.5mAOD in the lower areas neighbouring the watercourse. It can therefore be stated that the extents of the floodplain in the modelled events would encroach out of the main channel and partly into the wider site.

5.1.9 The existing ground levels on the development area itself however, range from 42.2mAOD and 41.7mAOD, this is significantly elevated (over 4.5m) above the worst case predicted top water level in **Table 2** above. The residential development proposals will be located wholly within Flood Zone 1 to minimise any residual flood risk, therefore the overall flood risk to the proposals is very low.



5.1.10 To assist in showing that the proposed development has been sequentially steered towards the areas considered to be at lowest flood risk, a composite floodplain plan has been prepared based on the predicted TWL's in the hydraulic assessment and the existing ground levels onsite (**Appendix I**). The indicative proposals have also been overlaid onto the floodplain plan to clearly show the extents of the floodplain. As illustrated in **Figure 7**, the residential dwellings will be located within the extents of Flood Zone 1 and outside of the extents of floodplain associated with both the 1% AEP and 0.1% AEP events.

Hydraulic Assessment

5.1.11 It was identified through discussion with Natural Resources Wales that hydraulic modelling of the watercourse would be required to consider the residual risks from Clywedog Stream in terms of a blockage of the downstream culvert. It was also identified that the existing data above did not consider the appropriate level of climate change allowance and that this should also be reviewed as part of the assessment. Full details of the methodology, hydrology and hydraulic model runs can be found in the summary found in **Appendix J**.

5.1.12 Flood Estimation Handbook (FEH) ReFH and statistical analyses were undertaken as part of a hydrological analysis, to determine peak design flows in the Clywedog Stream at a point upstream of Bedwell Road. This was used with the cross-sectional data from the older Capita Symons hydraulic river model (discussed above) and additional cross-sectional survey data collected for this assessment to create a 1-dimensional ISIS river model of Clywedog Stream.

5.1.13 The model was run in the 1 in 100 year and 1 in 100 climate change events, the upper (90th) percentile for the River Dee catchment anticipated for the 2080s has been used to assess climate change (45%). To satisfy NRW, both the unblocked and 95% blocked scenarios were considered during both events and the predicted top water levels at the key nodes in relation to the site are noted in **Table 3**.

CROSS SECTION REFERENCE	UNBLOCKED CULVERT		BLOCKED CULVERT	
	1% AEP EVENT	1% AEP EVENT + 45% CC	1% AEP EVENT	1% AEP EVENT + 45% CC
CS0138	37.629 mAOD	37.765 mAOD	37.905 mAOD	38.030 mAOD
CS0014	36.891 mAOD	37.158 mAOD	36.842 mAOD	37.979 mAOD
BL04	36.828 mAOD	37.100 mAOD	36.835 mAOD	37.967 mAOD
BL03	36.858 mAOD	37.123 mAOD	36.838 mAOD	37.971 mAOD

Table 3: Peak water levels from 1-dimensional ISIS model (Betts, 2018)

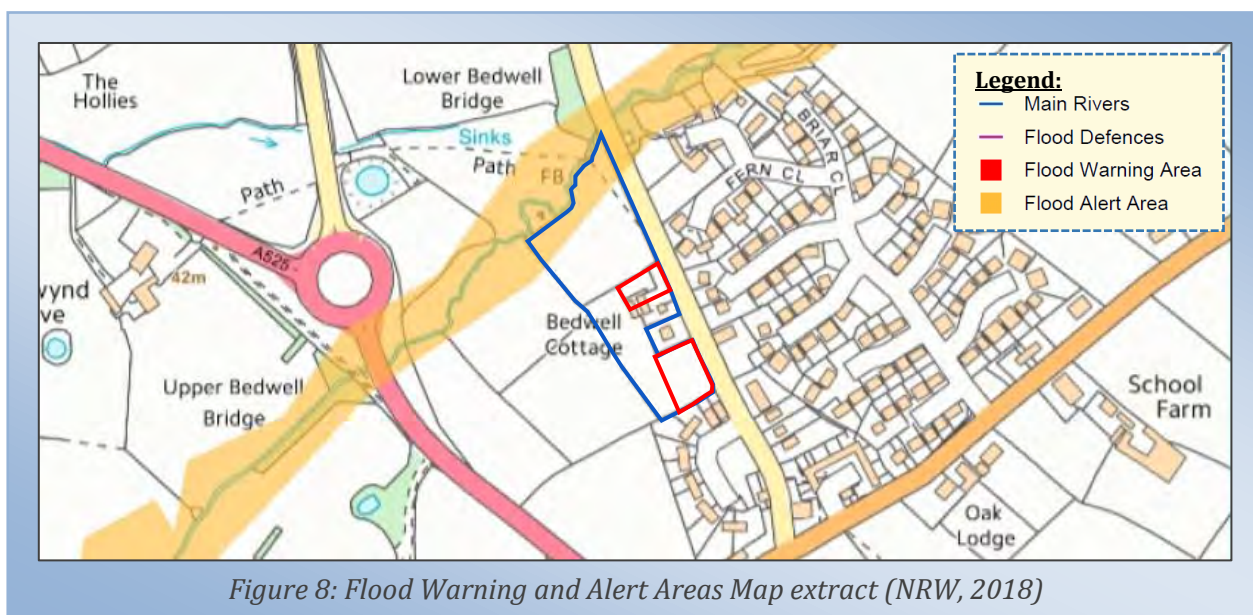
5.1.14 Based on the hydraulic model, the predicted top water level in the design event at the node location next to the wider site (CS0138) is 37.765mAOD. The existing ground levels on the development area start at 41.7mAOD, which is more than 3.9m above the predicted top water level in the design event (1 in 100yr plus climate change). If we consider the residual flood risks from blockage of the downstream culvert, then the development area is also elevated over 3.6m above the predicted top water levels along Clywedog Stream, the risk to the proposals from Clywedog Stream in the 1 in 100yr plus climate change event or the blockage scenario is therefore considered to be low.

Mitigation

- 5.1.15 Typically it would be recommended that the residential dwellings have a minimum Finished Floor Level (FFL) set to safeguard against potential residual flood risks. Although there will be no residential dwellings located within the floodplain extents, it would still be recommended that the dwellings onsite have a minimum FFL set 600mm above the predicted TWL in the 1% AEP+CC event. Based on the most relevant cross-section (CS0014) the FFL should be 37.758mAOD. Review of the topographic survey shows that the minimum existing ground level within the proposed development area is 41.7mAOD, therefore it is likely that the proposed FFL will be significantly higher than the required minimum to safeguard against flooding. No level raising within the floodplain to account for the proposals is required, therefore there is no requirement for compensatory floodplain storage.

Flood Warning and Evacuation

- 5.1.16 As part of the wider site is identified to be at risk from fluvial flooding, consideration has been given to safe emergency access and egress from the proposed development area. The primary flood risk to site is from Clywedog Stream (which is a tributary of the River Clywedog). NRW's flood mapping has identified that those areas of the site shown to be located within the floodplain are also located within their Flood Alert area (see mapping in **Appendix B**; extract in **Figure 8**).



- 5.1.17 Although the residential proposals will not be located within the floodplain or flood alert areas it would still be recommended that future residents sign up to the Floodline Service provided by NRW for the River Clywedog. This would provide residents with up-to-date alerts keeping them informed during any potential future flood event.
- 5.1.18 The residential development will take place within Flood Zone 1 only, however there is still a requirement to consider safe access and egress in accordance with TAN15. The primary access route into site will be from Bedwell Road (eastern boundary of the development areas). The Flood Zone map provided by NRW shows that at the point of access, Bedwell Road is located within Flood Zone 1 and therefore at little/no fluvial flood

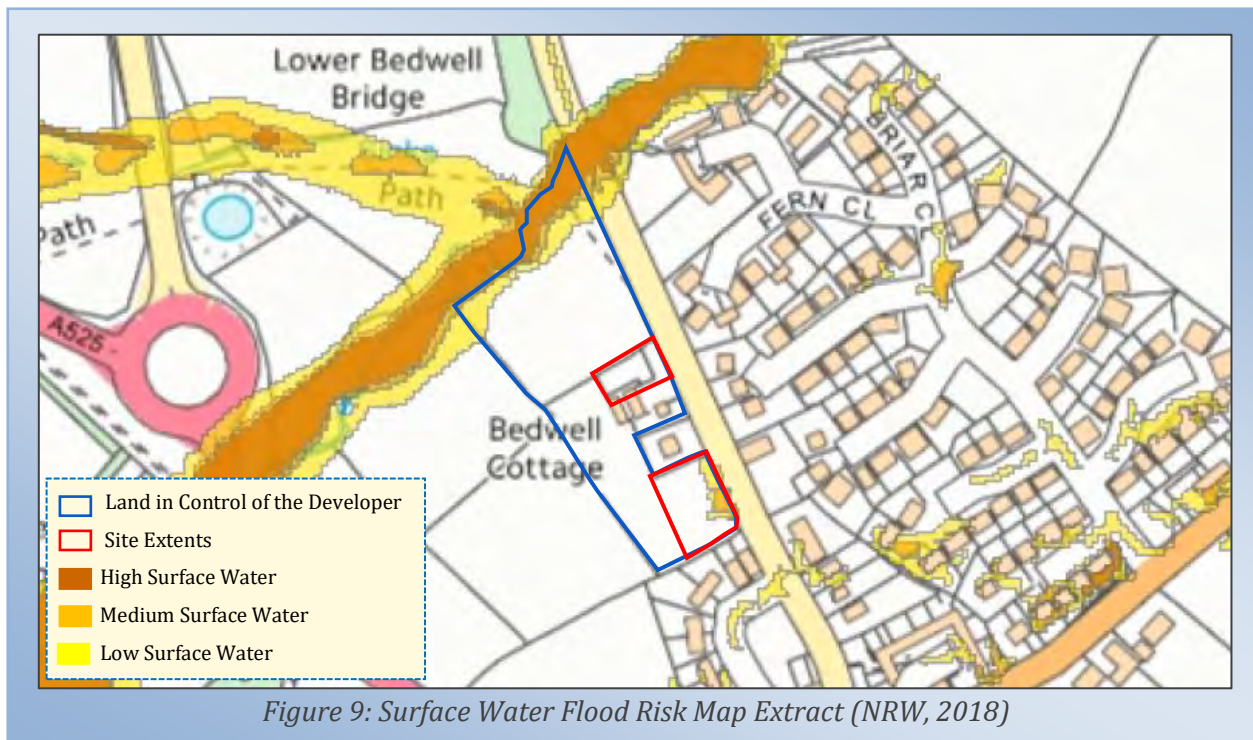
risk. Safe access and egress will therefore be maintained from Bedwell Road, when traveling south towards the B5130, Cross Lanes.

5.2 Tidal Flood Risk

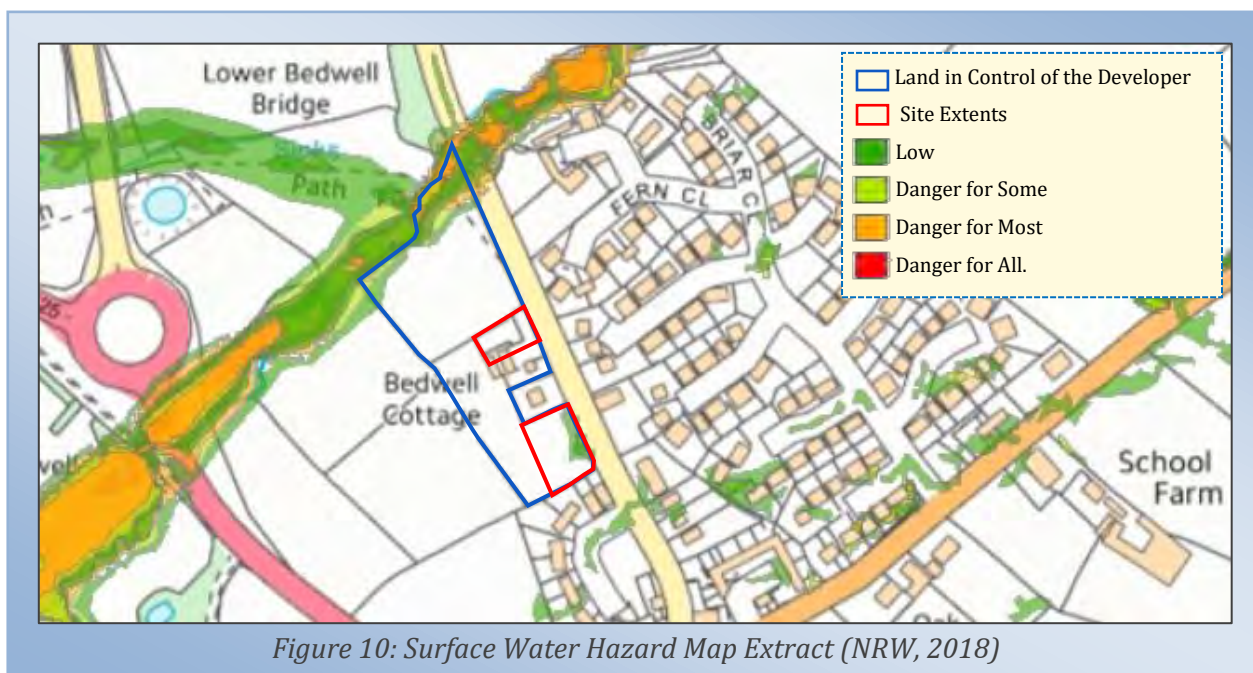
- 5.2.1 Due to the distance from the coast and estuarine waterways the risk of flooding from tidal sources is considered low.

5.3 Surface Water

- 5.3.1 Surface Water flooding occurs when rainwater is unable to drain away through the normal drainage systems or soak into the ground, but lies on or flows over the ground instead. An increase in impermeable areas through development can reduce percolation rates at source, therefore increasing surface water run-off. If this run-off is not controlled effectively it can increase the frequency and extent of localised flooding in neighbouring areas of the catchment. This section will consider the surface water flood risks associated with overland run-off (pluvial) and sewers.
- 5.3.2 TAN15 states therefore that ‘the aim should be for new development not to create additional run-off when compared with the undeveloped situation and re-development to reduce the overall run-off where possible’ (Section 8.3).
- 5.3.3 Overall the land controlled by the developer is shown to be at varying risk from surface water based on the NRW online mapping (**Figure 9**). The areas at risk of surface water flooding neighbour the existing watercourse and there is a requirement to maintain an 8m easement from this watercourse, meaning a large portion of the surface water flood risk area will be contained within the required no build easement area.



- 5.3.4 Furthermore, the proposed highly vulnerable residential development will take place within those areas indicated by the Red Edge in **Figure 9**. These areas are elevated in comparison to the low-lying watercourse area and the risk to the development proposals from this surface water flood risk area would be minimal. There are some surface water flood risk areas indicated in the southern development area (**Figure 9**). At present this area of the site is lower than the neighbouring highway and this combination increases the likelihood of pluvial/surface water overland flow and therefore susceptibility to ponding water in the extreme storm events.
- 5.3.5 NRW mapping provide additional information in terms of hazards risk and surface water, **Figure 10** is an extract of their hazard risk map which shows that although some areas of the proposed development area (blue dashed line) are considered to be at some risk from surface water the level of risk to people is predominantly low.



- 5.3.6 In order to mitigate any potential residual flood risk from surface water it is advised that (following any re-grade of the site) finished floor levels are raised a minimum of 150mm above the external levels to provide overland flood routes for excess surface water run-off. This will help protect properties from excess surface water run-off. The risk to the proposals from surface water would be further reduced post-development through the implementation of sustainable surface water management onsite. Refer to section 6.0 of this assessment for further details on surface water management, the exact management methodologies are to be confirmed during detailed design.

5.4 Pluvial Flood Risk

- 5.4.1 Intense rainfall that is unable to soak into the ground or enter drainage systems can run-off land and result in flooding. Local topography and the land use can have a strong influence on the direction and depth of flow. The surrounding areas to the east/south are developed and the risk of pluvial run-off onto the development areas from the east and south is minimal. The neighbouring areas to the west are undeveloped and have the

potential to generate pluvial run-off, however as levels generally fall north towards the watercourse, the risk directly to the development proposals would be minimal.

- 5.4.2 Any pluvial flows generated by the site will need to be catered for within the proposals through appropriate management and surface water infrastructure. The volume and rate of overland flow from land can be exacerbated if development increases the percentage of impermeable area. Any overland flows generated by the potential development must be carefully controlled; safe avenues directing overland flow away from the proposed or existing adjacent buildings is advised.

5.5 Artificial Sources of Flood Risk

- 5.5.1 TAN15 suggests that in order for development to be 'justified' then all sources of flood risk must be considered both to the development site and arising from the proposals.

Reservoirs

- 5.5.2 NRW consider reservoirs to be bodies of water holding over 25,000cu.m of water, based on the NRW reservoir flood mapping the proposed development areas (outlined in red in **Figure 11**) would not be influenced by any flooding associated with a reservoir breach/overtopping event.

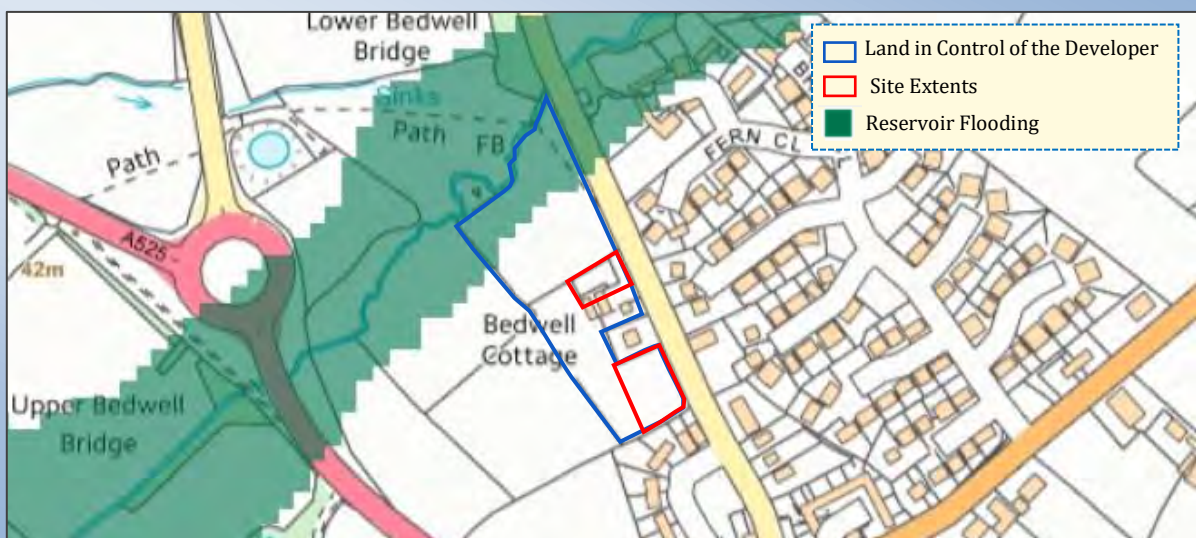


Figure 11: Reservoir Flood Map Extract (NRW, 2018)

Canals

- 5.5.4 There are no canals within the immediate vicinity of the proposed development considered to present a flood risk to the site.

5.6 Groundwater Flood Risk

- 5.6.1 Groundwater flooding is caused by unusually high groundwater levels, it occurs as excess water emerges at the ground surface (or within manmade underground structures). Groundwater flooding tends to be more persistent typically lasting for weeks or months and it can result in significant damage to property.

5.6.2 In general terms groundwater flooding can occur from three main sources:

- If groundwater levels are naturally close to the surface, then this can present a flood risk during times of intense rainfall. No groundwater flood risk has been identified during consultation with the various interested parties.
- Seepage and percolation occur where embankments above ground level hold water. In these cases, water travels through the embankment material and emerges on the opposite side of the embankment. At present there are no reported problems with groundwater flooding.
- Groundwater recovery/rebound occurs where the water table has been artificially depressed by abstraction. When the abstraction stops the watertable makes a recovery to its original level. There is the potential for groundwater flooding in low lying areas where groundwater levels have been depressed below their pre-pumping conditions, where these were at or close to ground level. As with the seepage scenario the likelihood of flooding from this source is low.

5.6.3 No historical flooding associated with groundwater has been identified during the preparation of this FCA. Should groundwater be encountered during any future construction phase(s) then suitable land-drainage will need to be installed to intercept groundwater flows. Any mitigation proposed to secure the development against the primary source of flooding would be suitable to mitigate other sources of flood risk such as groundwater flooding. Furthermore, as the proposed buildings will be elevated above the external levels there would scope for overland flow routes around the properties in the event of groundwater or other source of flooding resulting in overland flow.

5.7 Sewer Flood Risk

5.7.1 In urban areas, rainwater is frequently drained into surface water sewers or sewers containing both surface and waste water known as 'combined sewers'. Foul water flooding often occurs in areas prone to overland flow and can result when the sewer is overwhelmed by heavy rainfall and will continue until the water drains away. It can also occur when the sewer becomes blocked or is of inadequate capacity, this could lead to there being a high risk of internal property flooding with contaminated water.

5.7.2 Consultation with Welsh Water did not identify any existing sewer flood risk issues or historical flooding of the site area (refer to **Appendix C**). Review of the Welsh Water sewer records show there to be existing surface water and foul water sewer infrastructure to the east and south of the wider site, with a public combined sewer running to the west of the development areas within land in control of the developer. There will be a requirement to provide easements from any sewer asset within/adjacent to the site in accordance with UU standard guidance.

5.8 Historical and Anecdotal Flooding Information

5.8.1 An internet-based search for flooding did not identify any historical flooding events that impacted on the development area of the wider site. The Preliminary Flood Risk Assessment (PFRA) does not identify any past flooding of 'local significance' near the

proposed development, nor does it identify any past floods with 'significant harmful consequences'.

- 5.8.2 Consultation with the various interested parties including WCBC, WW and NRW also failed, to highlight any recorded historical flooding in the immediate vicinity of the site.

5.9 Mitigation Measures and Residual Risks

- 5.9.1 As the development will be located wholly within Flood Zone A on the DAM (Flood Zone 1 on the NRW mapping), the site is at little or no risk from fluvial/tidal flooding. Some mitigation measures have however been discussed below to consider the residual risks associated with other flood sources in compliance with TAN 15, considering the proximity of Clywedog Stream and its associated floodplain.

Mitigation Measures

- 5.9.2 An intra-sequential approach to flood risk has been adopted with the highly vulnerable residential properties being located wholly within Flood Zone 1. Typically, it is recommended that the residential dwellings have a minimum Finished Floor Level (FFL) set to safeguard against potential residual flood risks. Although there will be no residential dwellings located within the floodplain extents. It would still be recommended that the dwellings onsite have a minimum FFL set 600mm above the predicted TWL in the 1% AEP+CC event.
- 5.9.3 Based on the most relevant cross-section, the FFL should be 37.683mAOD, however the topographic survey shows that the existing ground levels within the development area range from 42.2mAOD and 41.7mAOD. It is therefore likely that the proposed FFL will be significantly higher than the required minimum to safeguard against flooding. No level raising within the floodplain will therefore be required to account for the proposals and there is therefore no requirement for compensatory floodplain storage.
- 5.9.4 As with any development it is advised that external levels fall away from the proposed buildings and any overland flows generated by the proposals are carefully controlled (safe avenues directing flow away from any existing and proposed buildings is advised).
- 5.9.5 To minimise the flood risk to the surrounding development and conform to the guidance set out in TAN15, it is proposed that surface water run-off be managed effectively, ideally with the peak rates of run-off being restricted to the equivalent of the pre-development greenfield situation.
- 5.9.6 Opportunities should be taken to provide soft landscaping where at all possible on site to assist in minimising surface water run-off. The opportunity should also be sought to incorporate SuDS where feasible into the drainage management approach, this will be determined as part of detailed design however given the nature and scale of the proposals there will potentially be scope to incorporate SuDS measures to the north of the scheme within land in control of the developer.
- 5.9.7 The development and its drainage systems should be designed to cope with intense storm events up to and including the 100 year return period rainfall event with an allowance for

Climate Change (CC). Based on the design life of the proposals (100yrs) this allowance will be 40%.

- 5.9.8 As with any drainage system blockages within either the foul or surface water system have the potential to cause flooding or disruption. It is important that should any drainage systems not be offered for adoption to either the Water Company or the Local Authority then an appropriate maintenance regime be scheduled with a suitably qualified management company for any private drainage systems.

Residual Risks

- 5.9.9 If an extreme rainfall event exceeds the design criteria for the drainage system it is likely that there will be some overland flows that are unable to enter the system, it is important that these potential overland flows are catered for within the proposed layout and levels design in the event that the capacity of the drainage system is exceeded.

6.0 SURFACE WATER MANAGEMENT

6.1 Pre-development Surface Water Run-off

- 6.1.1 The total development area covers 0.242ha and is 11% impermeable at present. Most of the development areas is permeable at present and naturally drains to Clywedog Stream to the north via overland run-off. The existing impermeable areas on the site are assumed to either have a formal connection to the main drainage systems in the neighbouring area or to drain via overland run-off to the watercourse.
- 6.1.2 Although there are existing impermeable areas on the site and these are likely to have some form of formal drainage in place, the proposals are to consider the site is 100% permeable for the purpose of calculating surface water run-off rates, which conforms to current guidance stating all new development should endeavour to achieve as close to pre-development greenfield rates as is viable.
- 6.1.3 The peak rates and volumes of run-off generated by the development area have been calculated for the storm events below using the Flood Estimation Handbook (FEH) and the Institute of Hydrology Report 124 (IH124) Greenfield run-off method using the rainfall characteristics from the FEH CD-ROM. Details of which are included in **Table 4** (full details **Appendix L**) based on the development area of 0.242ha.

Site Area	Run-Off Rates				Run-Off Volumes	
	1 In 1 Year	1 In 30 Year	1 In 100 Year	QBAR	1 In 1 Year	1 In 100 Year
0.242ha	1.1l/s	2.1l/s	2.6l/s	1.2l/s	15.5cu.m	51.5cu.m

Table 4: Pre-Development Surface Water Run-Off Rates and Volumes (Betts Hydro, 2018)

6.2 Post-development Surface Water Run-off

- 6.2.1 The residential nature of the proposals means that there will be an increase in the impermeable areas of the site, resulting in an increase in both the volume and the peak rates of run-off if flows are unrestricted. The post-development impermeable area is estimated to be 51% of the development area based on the planning layout, which equates to 0.123ha (**Appendix M**). The unrestricted post-development run-off rates have been calculated and detailed in **Table 5**, based on this estimated impermeable area.

Site Area	Run-Off Rates		
	1 In 1 Year	1 In 30 Year	1 In 100 Year +CC
0.123ha	4.2l/s	9.5l/s	16.6l/s

Table 5: Post-Development Un-Restricted Run-Off Rates and Volumes (Betts Hydro, 2018)

- 6.2.2 In accordance with national and local policies it is necessary to restrict surface water run-off generated by the development to mimic the pre-development greenfield run-off rates (noted in **Table 4**) where viable. The outline drainage strategy is discussed in full in Section 6.6 (following review of the hierarchy of drainage discharge options).

6.3 Sustainable Drainage Systems (SuDS)

- 6.3.1 Peak surface water discharge rates to watercourses and sewers should be appropriately managed and where possible reduced. Preference should always be given to Sustainable Drainage Systems (SuDS) over the traditional methods of buried sewers wherever possible and practical. SuDS have the ability to address four core objectives: water quantity, water quality, amenity and biodiversity.
- 6.3.2 SuDS include a broad range of features, both soft and hard solutions, some images are included in **Figure 12**. There are multiple benefits to using SuDS include the improvement of bio-diversity, aesthetics, ecology and water quality. Furthermore, there may be the potential to utilise some SuDS features for conveyance/attenuation of surface water flows, opposed to the traditional below ground storage methods (see **Appendix N** for typical details).



Figure 12: SuDS Photographs (SusDrain, 2012)

- 6.3.3 Should the ground conditions onsite prove favourable, this nature of development would suit a range of SuDS types associated with permeable surfaces, meaning the discharge of surface water would be dealt with at the source, limiting required attenuation and reducing the volume of surface water in the nearby sewer infrastructure. If infiltration is not feasible then the permeable paving should be lined with a positive connection into the main drainage for the site.
- 6.3.4 Although it would be beneficial to implement wider green space/POS area(s) in one or more locations within site, where SuDS features could be implemented, given the scale of development proposed it is unlikely that onsite SuDS features other than permeable surfacing could be incorporated into the scheme. There may be scope to incorporate an attenuation pond or basin within the wider site in control of the developer between the development areas and the watercourse. Detailed design would confirm suitability of SuDS following more detailed analysis of levels, ground conditions, and attenuation requirements as part of a subsequent application.

6.4 Methods of Surface Water Management

- 6.4.1 In order for the development proposals to be justified in line with the guidance set out in TAN15, development must not increase flood risk elsewhere within the catchment and where possible offer improvement on the pre-development situation. Surface water management is therefore a key focus (see TAN15: Section 8).
- 6.4.2 The surface water drainage hierarchy identified in national and local planning policy have been assessed in the order outlined below.
-  Discharge via infiltration
 -  Discharge to watercourse
 -  Discharge to sewerage system

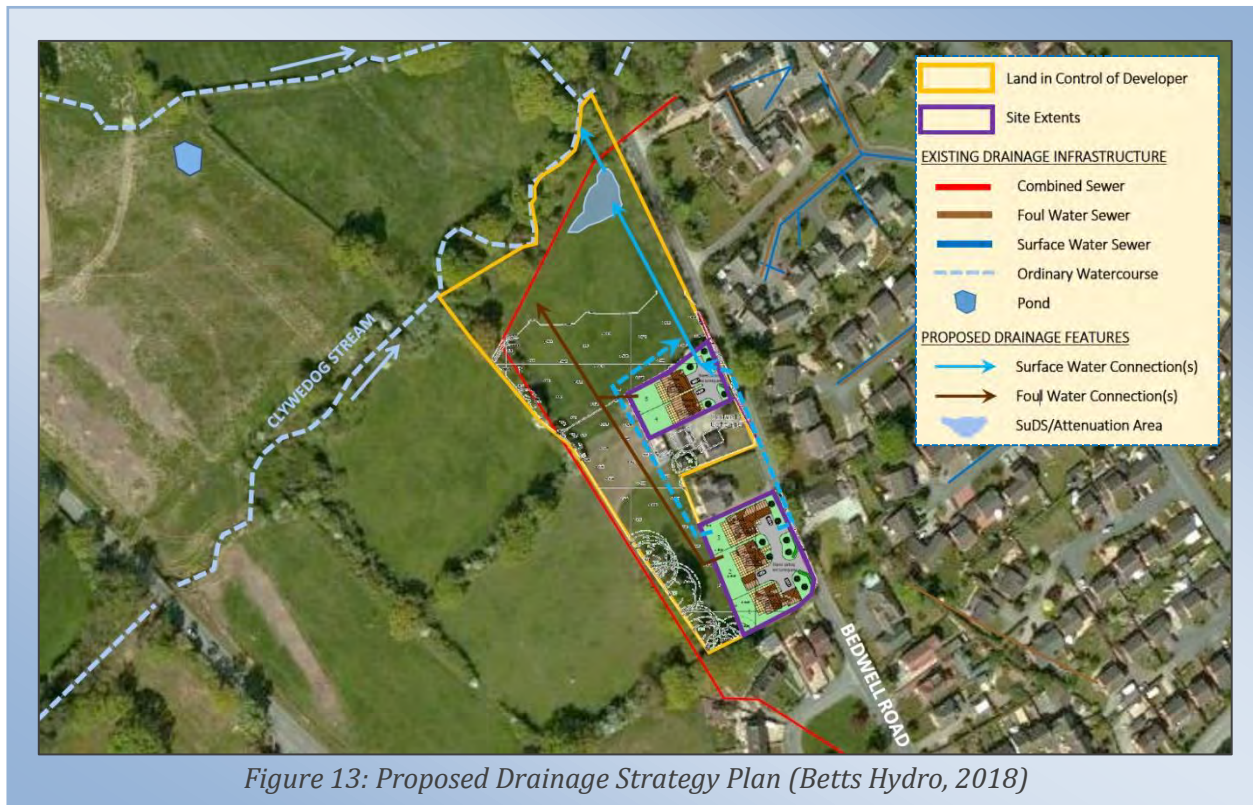
6.5 Discharge via Infiltration

- 6.5.1 Any impermeable areas that can drain to soakaway or an alternative method of infiltration would significantly improve the sustainability of any surface water systems.
- 6.5.2 The National Soils Resource Institute (NSRI) identifies the soils in this location as; *slowly permeable, seasonally wet, acid loamy and clayey soils*. The drainage is *impeded*. The British Geology Survey (BGS) mapping data indicates that ground conditions are as follows:
-  *bedrock geology description: Kinnerton Sandstone Formation - Sandstone.*
 -  *superficial deposits description: Till, Devensian - Diamicton. Superficial*
- 6.5.3 Based on the ground conditions identified by the online datasets, it can be considered that infiltration drainage is unlikely to provide a suitable means of surface water disposal for the flows generated by the whole development. In accordance with LPA's and WW requirements, Soakaway Testing to BRE365 may still need to be undertaken at site, to evidence that discharge to ground will not be a viable drainage solution for the site; prior to considering other discharge options in the drainage hierarchy.

6.6 Discharge to Watercourse

- 6.6.1 Assuming infiltration is not feasible for the surface water management at the site, the next method in accordance with the national and local drainage hierarchy is to discharge surface water run-off to the nearest watercourse. The proposals are to therefore discharge surface water run-off to the Ordinary Watercourse (Clywedog Stream) running to the north of the development adjacent to land in control of the developer (**Figure 13** refer to **Appendix O** for details).
- 6.6.2 The existing ground levels fall towards the watercourse at present through the neighbouring land in control of the developer and it is proposed that a new formal connection from the development area to Clywedog Stream be made. It is assumed that a gravity solution will be feasible, as naturally at present land falls in this manner (subject to further analysis as part of detailed design stage).
- 6.6.3 Consents from the Lead Local Flood Authority (Wrexham County Borough Council) will be required for works effecting the Ordinary Watercourse, including agreement of any

outfall structures and discharge rates. The LLFA will also require a maintenance easement to be maintained from the Ordinary Watercourse banks, typically an 8m no build zone is obligatory. Discussion with Natural Resources Wales may also be needed with regards to the proposed discharge rates. Should any offsite routing be required outside of land controlled by the developer then additional agreements will be needed for those land owners.



- 6.6.4 In order to comply with the guidance, the surface water run-off generated by the proposals will be required to be restricted to minimise the flood risk. In accordance with the SuDS Manual (CIRIA 753) and the Non-Statutory Technical Standards for Sustainable Drainage Systems (March 2015) all sites should endeavour to achieve as close to pre-development greenfield rates as is viable.
- 6.6.5 When considering the development area, this equates to 0.242ha and the pre-development greenfield rate (Q_{Bar}) is calculated to be 1.2l/s, calculated using the IH124 Method (see summary in **Appendix L**). A flow restriction will be most likely in the form of a Hydrobrake® or similar approved flow control device. Given the maximum restriction applied by standard flow control devices, the minimum discharge rate from the site will be 5.0l/s (based on the minimum flow through the orifice plate).
- 6.6.6 The restricted flow will generate a storage requirement during the extreme storm events (**Appendix P**). The stormwater storage figures quoted in **Table 6** are estimates only and detailed design will determine with accuracy the stormwater storage requirements. Should intrusive investigation or discussion identify a different rate is required then this will be addressed during detailed design stage.

Impermeable Area (0.123ha)	1 In 1 Year	1 In 30 Year	1 In 100 Year + 40% CC
Restricted Run-Off Rate	5.0l/s	5.0l/s	5.0l/s
Estimated Stormwater Storage Volume	2.3cu.m-6.3cu.m	16cu.m-24cu.m	41cu.m-57cu.m

Table 6: Estimated Stormwater Storage Requirements (Betts Hydro, 2017)

- 6.6.7 The proposed onsite surface water drainage system will need to be sized to contain the 30yr return period event below ground with overland run-off from storm events up to and including the 1 in 100 year return period storm event (with a 40% allowance for climate change) being contained onsite.
- 6.6.8 Although it would be beneficial to implement POS areas within site where SuDS features could be included, given the scale of the development area it is likely that for SuDS to be included these would need to be located outside of the development area, within land in control of the developer. A proposed connection to the watercourse to the north is the current surface water management strategy and if designed accordingly then an attenuation area adjacent to the proposed point of outfall would assist with providing the stormwater storage to cater for the extreme events.
- 6.6.9 Due to the scale of the development it is likely the attenuation generated in the smaller storm events will be catered for in the below ground pipe network. Detailed design will be required to confirm whether SuDS can be incorporated following a more detailed review of levels, capacity and attenuation requirements.

6.7 Discharge to Sewer

- 6.7.1 Should infiltration and a connection to the Ordinary Watercourse not be a feasible method for surface water management then the alternative method would be a connection to the neighbouring public sewer network. There are no proposals to discharge surface water run-off generated by the proposed development to the public sewer network given the close proximity of the watercourse.

6.8 Climate Change

- 6.8.1 There are significant indications that the UK climate is changing; the nature of this change will vary based on regional and catchment differences, consensus is that effects will become more pronounced over the coming decades. With reference to TAN15 the most likely effects to be experienced within Wales are:
-  Increases in sea levels
 -  Greater inflow into estuaries and the sea
 -  Significant changes in rainfall patterns seasonally
 -  Increased evapotranspiration
- 6.8.2 Making 'provisions' for these anticipated future changes to flood risk is considered to be an important action, ensuring future 'sustainable development' within Wales as identified within TAN15; Section 2.1. Current expert opinion indicates the likelihood of more frequent short duration and high intensity rainfall events and the addition of more

frequent periods of long duration rainfall meaning future flooding events will have a greater impact on the environment and society.

- 6.8.3 Any increase in the level of flood risk to the potential development from Climate Change is likely to be related to the increase in rainfall intensity and duration and its impact upon the surface water drainage system, along with the potential impact of sea level rise and its associated impact on flood water levels.
- 6.8.4 Climate Change should be accounted for within the design and it is recommended that an increase in peak rainfall intensity of 40% is allowed for as identified within TAN15.

7.0 FOUL WATER MANAGEMENT

- 7.1 Review of the Welsh Water sewer records identify public sewer infrastructure within close proximity of the site (see records in **Appendix G**). The nearest assets would be the public combined sewer to the west of the development area, within land in control of the developer. There will be a requirement to provide easements from any sewer assets within/adjacent to the site in accordance with standard guidance, further discussion with WW will confirm the specific easement requirements.
- 7.2 The foul water flows generated by the development are proposed to connect into the public combined sewer. Detailed drainage design will be required to confirm whether a site wide gravity solution would be feasible following further detailed investigations. Consents and relevant agreements will be required from WW prior to commencement of works.
- 7.3 Based on the proposals for the construction of up to 5no. residential units, the approximate peak foul water flows generated by the development are 0.23l/s. This is based on 4000 litres per dwelling per 24 hours; the guidance contained within Sewers for Adoption (SfA).
- 7.4 Early consultation with WW will identify their preferred point(s) of connection and any additional constraints which need to be considered. Routing would be required outside of the development area, but it is understood that offsite routing would be required within land controlled by the developer, thus consents can be obtained.

8.0 SUMMARY AND CONCLUSIONS

- 8.1 This Flood Consequence Assessment and Drainage Management Strategy has been prepared to support a full planning application for a residential development on land off Bedwell Road in Cross Lanes. This assessment has reviewed all sources of flood risk to both the site and existing adjacent development, because of the proposals, including; fluvial, tidal, pluvial, groundwater, sewers and flooding from artificial sources.

Flood Risk

- 8.2 The site covers 0.242ha and is located wholly within Flood Zone A based on the Development Advice Map, which is an area considered to be at little or no fluvial/tidal flood risk. The proposals are residential in nature, this is 'highly vulnerable' within Welsh Government Planning Policy and is acceptable (in accordance with TAN15) when located within Flood Zone A. The development site forms part of the wider land controlled by the developer, which is shown to be partly at risk of fluvial flooding associated with Clywedog Stream which flows parallel. The proposed development however will be located wholly within Flood Zone 1 and therefore the flood risks to the development would be low.
- 8.3 Review of online resources and consultation responses interested parties has failed to identify any significant historical flooding to have impacted the development site. this assessment has however considered the potential flood risks associated with the Clywedog Stream to the development site itself and the wider land controlled by the developer. Wrexham County Borough Council have conducted a Hydraulic Modelling study in 2009 of the Clywedog Stream and this assessment has considered the risks identified during this assessment against the current planning proposals. It can be stated that the development site will remain flood free in the key deign events including the 1 in 100yr and 1 in 1000yr return period events.
- 8.4 Additional hydraulic modelling has been carried out to consider the residual risks from blockage and the potential mitigation required to safeguard the development proposals for their design life. The design life in this case is the 1 in 100yr return period event with climate change and planning policy states that residential property have a minimum finished floor level set 600mm above the predicted Top Water Level in the 1% AEP+CC event. Based on the most relevant cross-section, the FFL should be 37.758mAOD. Review of the topographic survey shows that the existing ground levels within the development area rage from 42.2mAOD and 41.7mAOD. It is therefore likely that the proposed FFL will be significantly higher than the required minimum to safeguard against flooding when considering the other engineering constraints.
- 8.5 The proposed development has been justified in accordance with TAN15 and suitable mitigation measures proposed to ensure that the development is safe. Overall the development site is at 'very low' flood risk from most flood sources reviewed, some surface water flood risk was identified which is closely associated with the existing topography and can be effectively managed as part of the proposals, through the implementation of mitigation measures proposed within this assessment.

Drainage Strategy

- 8.6 As a result of the 'low' flood risks identified, the principle focus of this assessment is on the effective management of surface water run-off generated by future development, in accordance with the national and local drainage hierarchy. Based on the ground conditions identified it can be considered that infiltration is unlikely to provide a full viable drainage solution for surface water run-off generated by the proposals. In accordance with Wrexham County Borough Council's and Welsh Water's requirements, Soakaway testing (to BRE365) may be required, to evidence that discharge to ground will not be a viable solution, before progressing with an alternative option.
- 8.7 Assuming infiltration is not feasible, the next method in the hierarchical approach is to consider a direct connection to the nearest watercourse. The nearest watercourse is Clywedog Stream approximately 100m to the north of the development area, through land in control of the developer. The existing ground levels within the development areas generally fall towards the north boundary and therefore a gravity solution could be feasible, subject to further analysis as part of detailed design stage.
- 8.8 Detailed design will be required to determine the feasibility of the overall strategy and whether a full gravity system is achievable following more in-depth levels review. Consents from the Lead Local Flood Authority (Wrexham County Borough Council) will be required for works effecting the Ordinary Watercourse, including agreement of any outfall structures and discharge rates. Early discussion is recommended to confirm they accept the proposed drainage strategy and identify if there are any additional constraints. Should any offsite routing be required then this will also need to be agreed with the relevant authority/land owner at an early stage.
- 8.9 The surface water run-off generated by the proposals will be required to be restricted, in accordance with policy all sites should endeavour to achieve as close to pre-development greenfield rates as is viable. When considering the development area a pre-development greenfield rate (Q_{Bar}) of 1.2l/s has been calculated. Given the typical restrictions applied by standard flow control devices, the minimum discharge rate from the site will be 5.0l/s this is based on the minimum flow through the orifice plate (based on standard diameter). This will need to be considered in terms of attenuation as part of detailed design. It would be beneficial to implement SuDS features into the drainage strategy for attenuation, conveyance and water quality benefits although due to the scale of development proposed this nature of infrastructure would need to be located within the wider land in control of the developer and not the development area itself.
- 8.10 The potential residential development site has been justified in accordance with TAN15 and suitable mitigation measures have been proposed to ensure that the development is safe for its lifetime. This assessment illustrates that there is minimal impact on flood risk. This Flood Consequence Assessment is commensurate with the development proposals and in summary, the development can be considered appropriate in accordance with TAN15, providing the mitigation measures proposed are conformed to.

9.0 RECOMMENDATIONS

- 9.1 Although there will be no residential dwellings located within the floodplain extents, it would still be recommended that the dwellings onsite have a minimum FFL set 600mm above the predicted TWL in the 1% AEP+CC event. Based on the most relevant cross-section, the FFL should be 37.758mAOD. Review of the topographic survey shows that the minimum existing ground level within the proposed development area is 41.7mAOD, therefore it is likely that the proposed FFL will be significantly higher than the required minimum to safeguard against flooding. As with any development it is also advised that external levels fall away from property to minimise the flood risk from a variety of sources.
- 9.2 The Lead Local Flood Authority (Wrexham) will require a maintenance easement to be maintained from the Clywedog Stream flowing adjacent to the northern boundary of the site. Typically, an 8m no build zone is obligatory, this can be seen in the current indicative proposals which are located 100m from the watercourse.
- 9.3 It would be recommended that future occupants sign up to the flood warning service provided by Natural Resources Wales in the event of a future flood incident impacting the neighbouring river catchment. This will improve preparedness and alleviate residual flood risk and potential vulnerability.
- 9.4 Any overland flows generated by the proposed development must be controlled, safe avenues directing overland flow away from any existing and proposed buildings are advised.
- 9.5 To minimise the flood risk to the neighbouring property and proposed dwellings it is proposed that the surface water run-off generated by the proposals be managed effectively with the peak rates of run-off being restricted. Soakaway Testing to BRE365 will be required to be undertaken to evidence that discharge to ground will not be a viable solution prior to pursuing other options identified in the hierarchical approach. Detailed design will be required to confirm feasibility of the drainage strategy and early discussion with all relevant parties will identify any additional considerations/constraints.
- 9.6 Opportunities should be taken to provide soft landscaping where at all possible on site to assist in minimising surface water run-off. Added benefits include biodiversity and visual enhancements. It is proposed that SuDS systems are also considered within the scheme to in part manage the surface water run-off generated, particularly attenuation. Maintenance of any drainage systems not being offered for adoption (such as SuDS) is required to be considered for the design life of the development therefore as part of the proposals it is strongly recommended that an appropriate maintenance regime be scheduled with a suitably qualified management company for any private drainage systems within site.
- 9.7 It is proposed that the onsite surface water drainage system will need to be sized to prevent overland run-off offsite from storm events up to and including the 100-year return period storm event with a 40% allowance for climate change.

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Web-based References

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Streetmap – <http://www.streetmap.co.uk/>

US Army Corps of Engineers – <http://www.hec.usace.army.mil/software/hec-ras/>

Watertight International – <http://www.watertightinternational.com/>

Welsh Water - <http://www.dwrcymru.com/>

APPENDIX A: TAN15 EXTRACTS

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Figure 1

Description of Zone		Use within the precautionary framework
Considered to be at little or no risk of fluvial or tidal/coastal flooding.	A	Used to indicate that justification test is not applicable and no need to consider flood risk further.
Areas known to have been flooded in the past evidenced by sedimentary deposits.	B	Used as part of a precautionary approach to indicate where site levels should be checked against the extreme (0.1%) flood level. If site levels are greater than the flood levels used to define adjacent extreme flood outline there is no need to consider flood risk further.
Based on Environment Agency extreme flood outline, equal to or greater than 0.1% (river, tidal or coastal)	C	Used to indicate that flooding issues should be considered as an integral part of decision making by the application of the justification test including assessment of consequences.
Areas of the floodplain which are developed and served by significant infrastructure, including flood defences.	C1	Used to indicate that development can take place subject to application of justification test, including acceptability of consequences.
Areas of the floodplain without significant flood defence infrastructure.	C2	Used to indicate that only less vulnerable development should be considered subject to application of justification test, including acceptability of consequences. Emergency services and highly vulnerable development should not be considered.

Figure 2

Development category	Types
Emergency services	hospitals, ambulance stations, fire stations, police stations, coastguard stations, command centres, emergency depots and buildings used to provide emergency shelter in time of flood
Highly vulnerable development	all residential premises (including hotels and caravan parks), public buildings (e.g. schools, libraries, leisure centres), especially vulnerable industrial development (e.g. power stations, chemical plants, incinerators), and waste disposal sites
Less vulnerable development	General industrial, employment, commercial and retail development, transport and utilities infrastructure, car parks, mineral extraction sites and associated processing facilities, excluding waste disposal sites

Summary of Policy Requirements

DAM	Development Type (Section 5)	Planning Requirements (Section 4)	Acceptability Criteria (Section 7 & Appendix 1)	Development Advice (Section 5, 6, 7 & Appendix 1)
A	Emergency services Highly vulnerable development Less vulnerable development Other	- Justification test not applicable - Refer to surface water requirements	No increase in flooding elsewhere	No constraints relating to river or coastal flooding, other than to avoid increasing risk elsewhere.
B	Emergency services	- If site levels are greater than the flood levels used to define adjacent extreme flood outline there is no need to consider flood risk further. - Refer to surface water requirements	- Acceptable consequences for nature of use - Occupiers aware of flood risk - Escape/evacuation routes present - Effective flood warning provided - Flood emergency plans and procedures - Flood resistant design - No increase in flooding elsewhere	Generally suitable for most forms of development. Assessments, where required, are unlikely to identify consequences that cannot be overcome or managed to an acceptable level. It is unlikely, therefore, that these would result in a refusal of planning consent on the grounds of flooding.
	Highly vulnerable development		- Acceptable consequences for nature of use - Occupiers aware of flood risk - Escape/evacuation routes present - Effective flood warning provided - Flood emergency plans and procedures - No increase in flooding elsewhere - Occupiers aware of flood risk - No increase in flooding elsewhere	
	Less vulnerable development		- Occupiers aware of flood risk - No increase in flooding elsewhere	
	Other		- Refer to surface water requirements - No increase in flooding elsewhere	
C	Emergency services Highly vulnerable development Less vulnerable development	- Application of justification test (section 6), including acceptability of consequences (section 7 and appendix 1) - Refer to surface water requirements	- Acceptable consequences for nature of use - Flood defences adequate - Agreement for construction and maintenance costs secured - Occupiers aware of flood risk - Escape/evacuation routes present - Effective flood warning provided - Flood emergency plans and procedures - Flood resistant design - No increase in flooding elsewhere	Plan allocations and applications for all development can only proceed subject to justification in accordance with section 6 and acceptability of consequences in accordance with section 7 and Appendix 1.
	Other	- Application of acceptability of consequences (section 7 and appendix 1) - Refer to surface water requirements	- Acceptable consequences for nature of use - Occupiers aware of flood risk - Desirable if effective flood warning and evacuation routes/procedure provided depending on nature of proposal - No increase in flooding elsewhere	Plan allocations and applications for development should only be made if considered acceptable in accordance with section 7 and Appendix 1.

DAM	Development Type (Section 5)	Planning Requirements (Section 4)	Acceptability Criteria (Section 7 & Appendix 1)	Development Advice (Section 5, 6, 7 & Appendix 1)
C2	Emergency services Highly vulnerable development	The flooding consequences associated with Emergency Services and highly vulnerable development are not considered to be acceptable. Plan allocations should not be made for such development and planning applications not proposed.		
	Less vulnerable development	▪ Application of justification test (section 6) , including acceptability of consequences (section 7 and appendix 1) ▪ Refer to surface water requirements	▪ Acceptable consequences for nature of use ▪ Flood defences adequate ▪ Agreement for construction and maintenance costs secured ▪ Occupiers aware of flood risk ▪ Escape/evacuation routes present ▪ Effective flood warning provided ▪ Flood emergency plans and procedures	Plan allocations or applications for less vulnerable development can only proceed subject to justification in accordance with section 6 and acceptability of consequences in accordance with section 7 and Appendix 1.
	Other	▪ Application of acceptability of consequences (section 7 and appendix 1) ▪ Refer to surface water requirements	▪ Flood resistant design ▪ No increase in flooding elsewhere ▪ Acceptable consequences for nature of use ▪ Occupiers aware of flood risk ▪ Effective flood warning provided ▪ No increase in flooding elsewhere	Plan allocations and applications for development should only be made if considered acceptable in accordance with section 7 and Appendix

APPENDIX B: NRW INFORMATION & CORRESPONDENCE

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Wrexham County Borough Council

Ebost/Email: Northplanning@cyfoethnaturiolcymru.gov.uk
Ffôn/Phone: (0300) 065 3787

Date: 22nd March 2018

Dear Sir/Madam,

ERECTION OF 5 NO. DETACHED DWELLINGS INCLUDING MEANS OF ACCESS AND ASSOCIATED WORKS LAND AT BEDWELL ROAD, CROSS LANES, WREXHAM

Thank you for referring the above planning application received at our office 2nd March 2018.

We recommend that that you should only grant planning permission if the scheme can meet the following requirement and you attach the conditions listed below. These would address significant concerns that we have identified. Therefore, we would not object provided the requirement is met and you attach the conditions to the planning permission.

Requirement 1: Submission of a Flood Consequence Assessment

Condition 1: Submission and implementation of an avoidance based great crested newt conservation measures undertaken to the satisfaction of the local planning authority

Condition 2: Submission and implementation of a Biosecurity Risk Assessment undertaken to the satisfaction of the LPA.

Flood Risk

A previous outline application was submitted for this site (LPA reference P/2016/0273) for 24 houses and new access was refused and dismissed at appeal 28th November 2017. The Inspectors report (APP/H6955/A/17/3179242) identified the proposed development to be at risk of flooding. It notes that whilst the built development would be located outside of the Development Advice Map (DAM) Zone C2, the modelling study completed in 2009 should remain fit for purpose, it also refers to concerns raised by NRW with the completeness of the FCA because it had not used the latest climate change guidance and there was no assessment of blockage. The Inspector found the development proposed failed to satisfy policy EC12 of Wrexham UDP and TAN 15: Development and Flood Risk.

This would indicate that whilst the application site forms a smaller site of 0.24ha and affects two small areas of land fronting onto Bedwell Road, located either side of the existing cottages. In comparison to the larger appeal site (1.22ha) which bounded to the river in the north, the application site is outside of the Development Advice Map (DAM) Zone C2 and within Zone A. The inspectors report stated that flood risks for this site need to be assessed and this assessment will need to overcome the issues identified in the incomplete modelling completed in 2009 and the subsequent FCA, which failed to demonstrate consequences and impacts of the development of the whole site to demonstrate compliance with local and national planning policy.

The absence of an FCA and updated modelling report for this proposed residential development raises significant concerns because there has been no assessment of flood risk and it therefore fails to demonstrate compliance with TAN 15.

Requirement 1 – Submission of a Flood Consequence Assessment

Protected Species

No ecological report has been submitted to inform the planning decision making process

Great Crested Newt

We can confirm that ponds in the environs of the application site support populations of the great crested newt (GCN). This species is protected under the provisions of the Wildlife and Countryside Act 1981 (as amended) and the Conservation of Habitats and Species Regulations 2017. The current conservation status of local populations of this species is considered to be unfavourable.

The Regulations allow the approval of a scheme that would be likely to result in disturbance or harm to GCN, but only if satisfy an appropriate Habitats Directive derogation purpose and two tests before a licence can be issued from Natural Resources Wales.

In the case of development, the applicable derogation purpose is:

“Preserving public health or public safety or other imperative reasons of overriding public interest including those of a social or economic nature, and beneficial consequences of primary importance for the environment.”

Furthermore, the licence can only be issued by NRW on condition that there is:

“no satisfactory alternative”, and that

“the development will not be detrimental to the maintenance of the population of the species concerned at a favourable conservation status in their natural range”.

Paragraph 6.3.7 of TAN5 states that your Authority should not grant planning permission without having satisfied itself that the proposed scheme either would not impact adversely on any GCN's on the site or that, in its opinion, all three conditions for the eventual grant of a licence are likely to be satisfied.

We consider the proposal will not be detrimental to the maintenance of the favourable conservation status (FCS) of any local populations of great crested newt present within the environs of the application site.

However, we advise that any subsequent consent is subject to planning conditions or obligation that address the following issues.

Condition 1: Submission and implementation of an avoidance based great crested newt conservation measures undertaken to the satisfaction of the local planning authority;

This advice applies to the proposal in its present form. If the plans are changed in ways that may affect GCN on this site, please consult us again. Furthermore, the above advice is based on the implementation of avoidance based conservation measures. If great crested newts are subsequently found within working areas, we advise that works immediately stop and may only resume on receipt of a valid derogation licence issued by NRW under Regulation 55 of the Conservation of Habitats and Species Regulations 2017

Biosecurity

We consider biosecurity to be a material consideration owing to the nature and location of the proposal. In this case, biosecurity issues concern invasive non-native species (INNS) and diseases. We therefore advise that any consent includes the imposition of a biosecurity risk assessment.

Condition 2: Submission and implementation of a Biosecurity Risk Assessment undertaken to the satisfaction of the LPA.

We consider that this assessment must include

(i) appropriate measures to control any INNS on site; and

(ii) measures or actions that aim to prevent INNS being accidentally or deliberately introduced to the site for the duration of construction and landscaping phases of the scheme.

Our comments above only relate specifically to matters that are included on our checklist "Natural Resources Wales and Planning Consultations" (March 2015) which is published on our website: (<https://naturalresources.wales/planning-and-development/planning-and-development/?lang=en>). We have not considered potential effects on other matters and do not *rule out the potential for the proposed development to affect other interests, including environmental interests of local importance*. The applicant should be advised that, in addition to planning permission, it is their responsibility to ensure that they secure all other permits/consents relevant to their development.

Please do not hesitate to contact us if you require further information or clarification on any of the above.

Yn gywir / Yours' faithfully,

Ruth Prichard

Ymgynghorydd Cynllunio Datblygu / Development Planning Advisor

Ebost/Email: Ruth.Prichard@cyfoethnaturiolcymru.gov.uk

Deialu uniongyrchol/Direct dial: (0300) 065 3787 **Siaradwr Cymraeg / Welsh Speaker**



cc:

Kirsty Williams

From: Thomas, Colin <Colin.Thomas@cyfoethnaturiolcymru.gov.uk>
Sent: 11 April 2017 14:45
To: Kirsty Williams
Subject: FW: ATI-12575a-Land off Bedwell Road, Cross Lanes, Wrexham, LL13 0TR

Follow Up Flag: Follow up
Flag Status: Completed

Dear Kirsty,

I have been informed that we don't hold any detailed information for this site:

Self Service and use of Open Data: You can now make the most of open data provided **free** online. You can

- create and **export an A4 or A3 PDF map** using our the [NRW Flood Risk Map](#), from the NRW Website. Here you will find many spatial risk layers, and be able to produce a map up to scale on 1:10000 (to be increased to 1:5000 in future updates). **Or**
- **download** FloodMap layers and other spatial flood datasets from "[Lle](#)" the Welsh Government Portal for [Open GIS data](#). Spatial data is free to download, view and use within your own GIS system. You will be able to find Flood Zones, Flood Defences, Recorded Flood Outline, Areas Benefiting Defences and more. More datasets will be released in the coming year.
- download the Extreme Tide level report and data from the [Coastal Flood Boundary Conditions for the Mainland UK Coasts and Islands \(SC060064\)](#), covering still water levels for the whole Welsh Coastline. Wave overtopping is **not** covered.

Please Note The Following:

** All information supplied will need to be verified by the recipient PRIOR to using in a Flood Consequences Assessment (FCA). We would expect to see a review of the hydrology, in-channel survey, and floodplain topography etc. to demonstrate the data is suitable for the purposes of producing an FCA. Please contact the Flood Risk Analysis Team for further advice.*

** As of 1st of December, 2016 you will need to apply climate change allowances carefully to ensure compliance with Welsh Government climate change clarification letter.*

Kind Regards
Colin

Colin Jason Thomas
Swyddog Cymorth Busnes/Business Support Officer
Cyfoeth Naturiol Cymru/Natural Resources Wales
Maes y Ffynnon
Penrhosgarnedd
Bangor
LL57 2DW

Ffon/Tel: 03000 655267
E bost/E-mail:
Colin.Thomas@cyfoethnaturiolcymru.gov.uk

Colin.Thomas@naturalresourcescymru.gov.uk

Gwefan/Website:

www.cyfoethnaturiolcymru.gov.uk/ www.naturalresourceswales.gov.uk

Ein pwrpas yn sicrhau fod adnoddau naturiol Cymru yn cael eu cynnal, gwella a'u defnyddio yn cynnal, gwella a'u defnyddio yn gynaliadwy, yn awr ac i'r dyfodol.

Our purpose is to ensure that the natural resources of Wales are sustainably maintained, used and enhanced, now and in the future

From: Data Distribution

Sent: 28 March 2017 10:18

To: Enquiries <enquiries@cyfoethnaturiolcymru.gov.uk>

Subject: ATI-12575a-Land off Bedwell Road, Cross Lanes, Wrexham, LL13 0TR

Hi Seren,

Thanks for this, we will log the request for historical flooding and water levels as a data request.

I think the sentence "If there are any specific requirements that you require in a scope of works for this site please can you advise at this stage so that it can be fully incorporated into the works at an early stage" is asking for our advice on the FCA. Could you therefore please also send this to Planning.

Thank you,
Rachel

From: Enquiries

Sent: 28 March 2017 10:03

To: Data Distribution <datadistribution@cyfoethnaturiolcymru.gov.uk>

Subject: NRW:02940084

Hi team,

I have forwarded this email to yourselves in the hope that you could advise Kirsty with her query.

Kind regards,

Seren Metcalfe

Ymgynghorydd Gofal Cwsmer/Customer Care Advisor

Cwsmeriaid, Cyfathrebu a Gwybodaeth/Customer, Communications and Information Directorate

Cyfoeth Naturiol Cymru/Natural Resources Wales

Siaradwraig Cymraeg

----- Original Message -----

From: kirstywilliams@betts-associates.co.uk

Received: 28/03/2017

To: Enquiries Queue; HZW-005344; HZW-006866

Cc: Lucy Stephenson; Ryan Knowles

Subject: HYD217 Bedwell Road, Cross Lanes

To whom it may concern,

Land off Bedwell Road, Cross Lanes, Wrexham, LL13 0TR

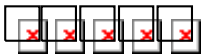
Please could you confirm whether you have any information that you feel would be valuable to a Flood Risk Assessment and Drainage Management Strategy for the above site (location plan attached), including details of historical flooding and any water levels; this would be greatly appreciated. If there are any specific requirements that you require in a scope of works for this site please can you advise at this stage so that it can be fully incorporated into the works at an early stage.

Please do not hesitate to contact me on the details below to discuss further should you require additional information or clarification.

Kind Regards

Kirsty Williams BSc(Hons)
Flood Risk Analyst

BETTS HYDRO
Specialists in Drainage and Flood Risk
Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire, CH5 2LY
CHESTER OFFICE - 01244 289041



kirstywilliams@betts-associates.co.uk
www.betts-associates.co.uk

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FLOOD RISK FROM RIVERS AND SEA
Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- Main Rivers
- Flood Defences
- Risk of Flooding from Rivers & Sea
 - High
 - Medium
 - Low
 - Very Low

Graddfa / Scale 1: 4,999

Dyddiad / Date
06/04/2017



FLOOD ZONE MAP

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- Main Rivers
- Flood Defences
- Floodmap Flood Zone 3
- Floodmap Flood Zone 2

Graddfa / Scale 1: 5,001

Dyddiad / Date
06/04/2017



FLOOD WARNING AREAS

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- Main Rivers
- Flood Defences
- Flood Warning Area
- Flood Alert Area

Graddfa / Scale 1: 4,999

Dyddiad / Date
06/04/2017



HISTORIC FLOODING

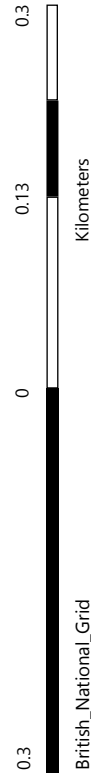
Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- Main Rivers
- Flood Defences
- Historic Flood Map

Graddfa / Scale 1: 4,999

Dyddiad / Date
06/04/2017



SURFACE WATER FLOOD RISK

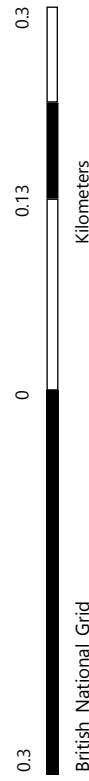
Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

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- Medium Surface Water Flood Risk - Extent
- Low Surface Water Flood Risk - Extent

Graddfa / Scale 1: 5,001

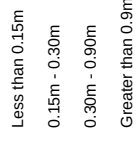
Dyddiad / Date
06/04/2017



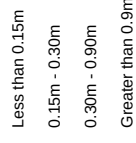
SURFACE WATER FLOOD RISK DEPTH
Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

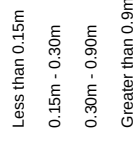
High Surface Water Flood Risk - Depth (m)



Medium Surface Water Flood Risk - Depth (m)

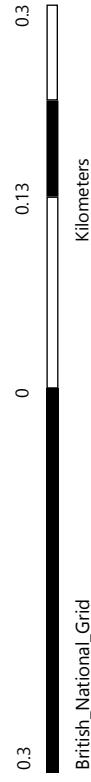
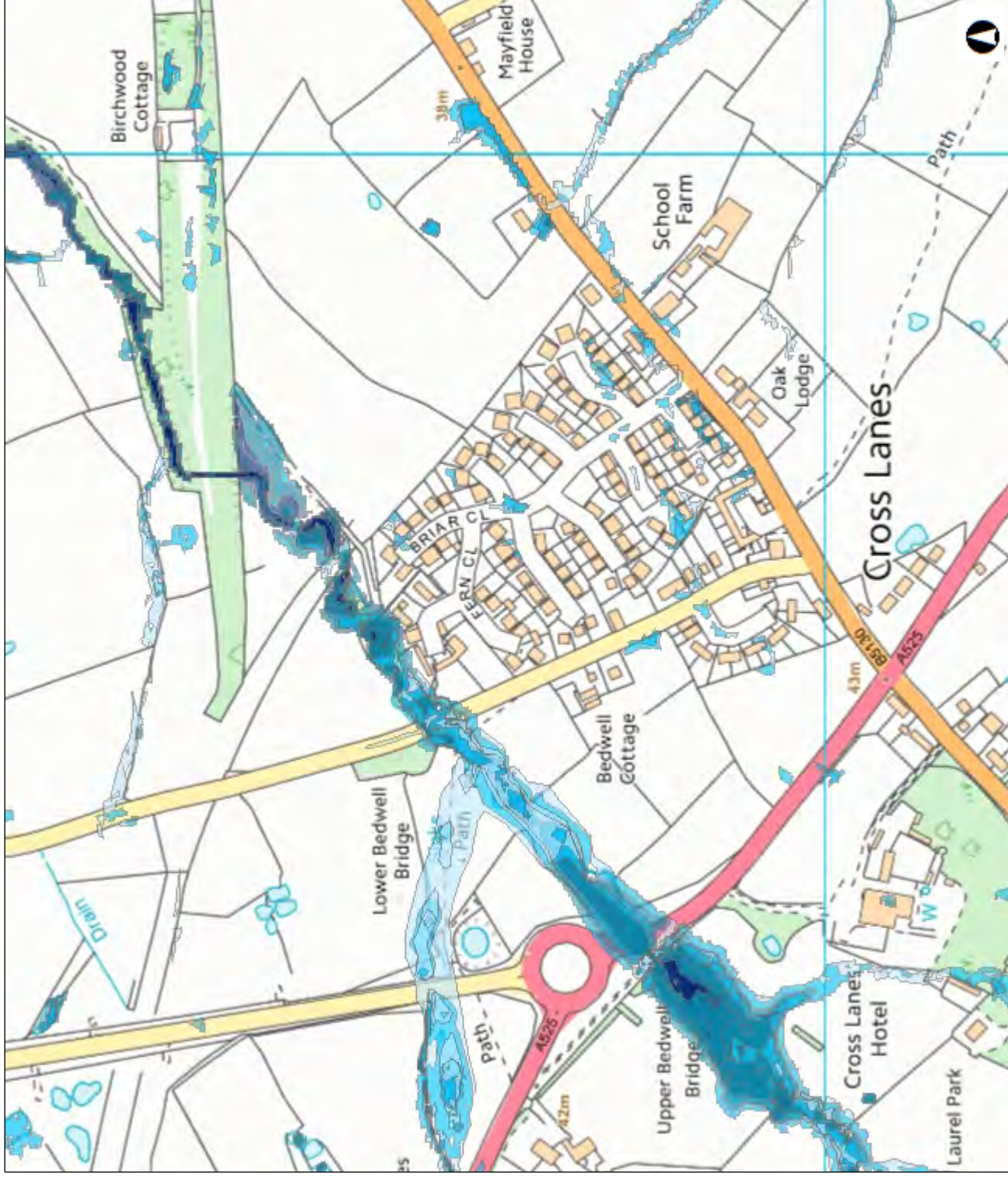


Low Surface Water Flood Risk - Depth (m)



Graddfa / Scale 1: 5,001

Dyddiad / Date
06/04/2017

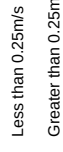


SURFACE WATER FLOOD RISK VELOCITY

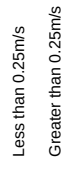
Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

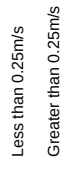
High Surface Water Flood Risk - Velocity (m/s)



Medium Surface Water Flood Risk - Velocity (m/s)



Low Surface Water Flood Risk - Velocity (m/s)



Graddfa / Scale 1: 5,001

Dyddiad / Date
06/04/2017



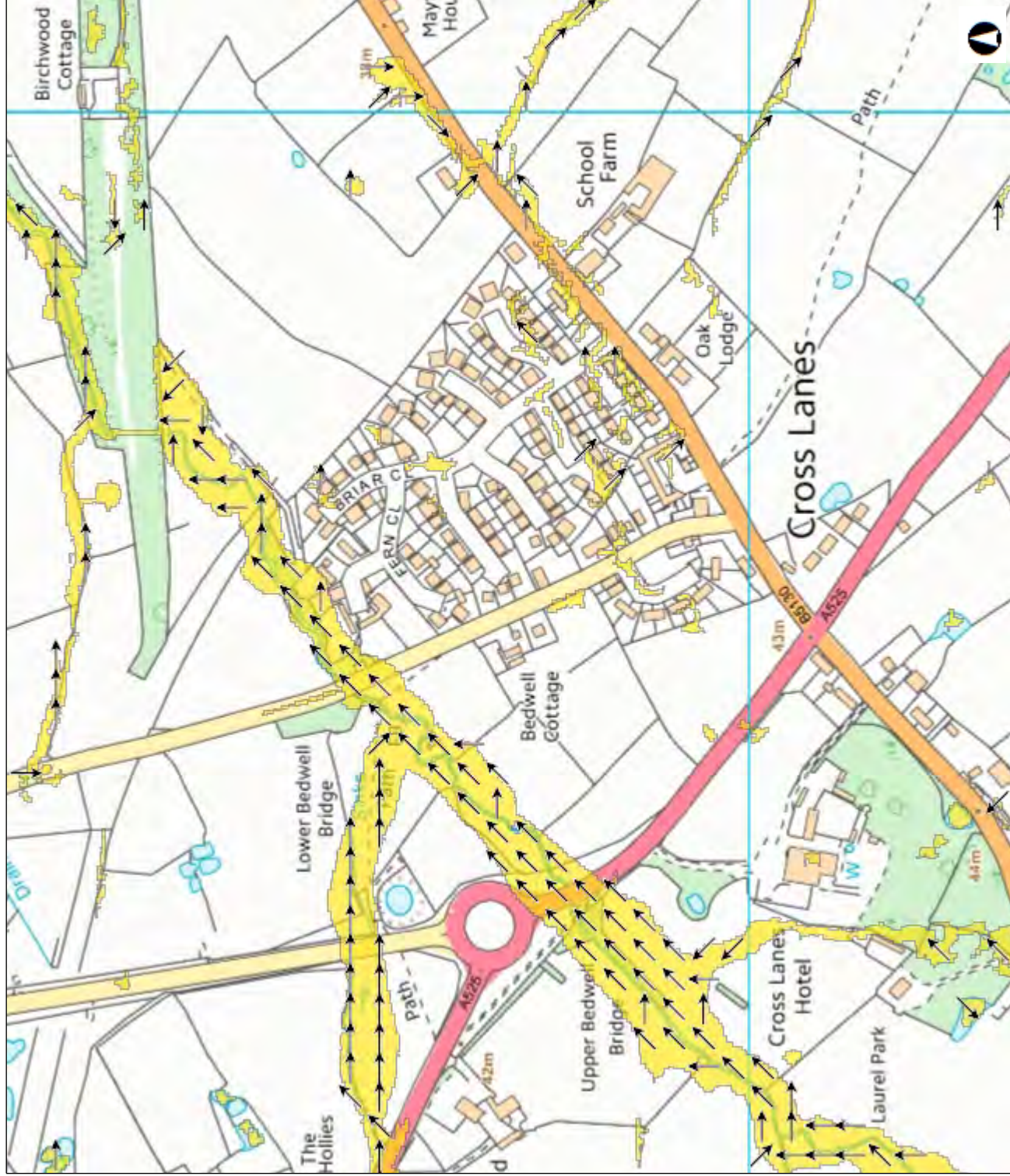
**SURFACE WATER FLOOD RISK
DIRECTION OF FLOW**
Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- ↑ Low Surface Water Flood Risk - Flow Direction
- Low Surface Water Flood Risk - Extent

Graddfa / Scale 1:5,001

Dyddiad / Date
06/04/2017



SURFACE WATER FLOOD RISK HAZARD
MAP
Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

High Surface Water Flood Risk - Hazard

- Low
- Danger for Some
- Danger for Most
- Danger for All

Medium Surface Water Flood Risk - Hazard

- Low
- Danger for Some
- Danger for Most
- Danger for All

Low Surface Water Flood Risk - Hazard

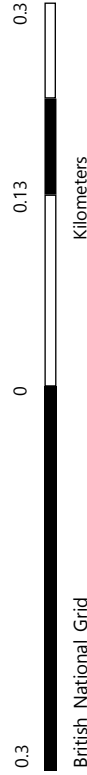
- Low
- Danger for Some
- Danger for Most
- Danger for All

Graddfa / Scale 1:5,001

Dyddiad / Date
06/04/2017



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British_National_Grid

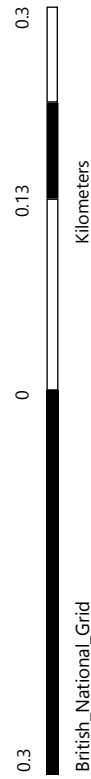
FLOODING FROM RESERVOIRS

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key
Reservoir Extents

Graddfa / Scale 1: 4,999

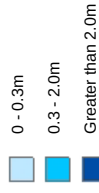
Dyddiad / Date
06/04/2017



FLOODING FROM RESERVOIRS DEPTH
Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

Reservoir Depths



Graddfa / Scale 1: 4,999

Dyddiad / Date
06/04/2017



FLOODING FROM RESERVOIRS

VELOCITY

Map Perygl Llifogydd / Flood Risk Map

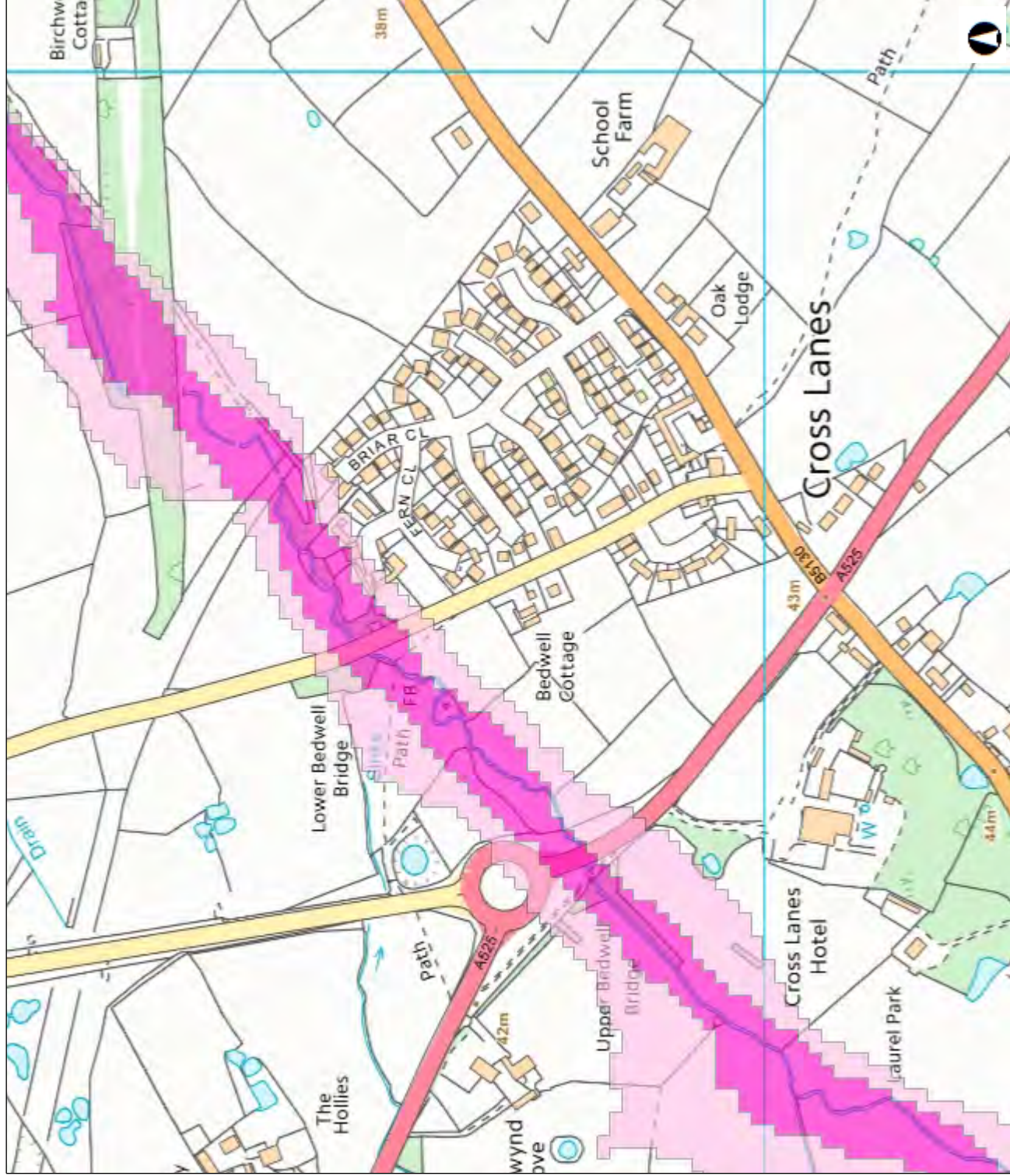
Allwedd / Map Key

Reservoir Velocities

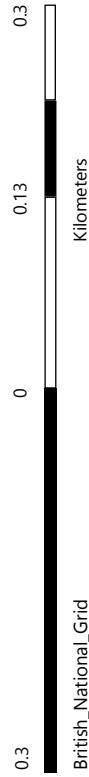
- 0 - 0.5m/s
- 0.5 - 2.0m/s
- Greater than 2.0m/s

Graddfa / Scale 1: 4,999

Dyddiad / Date
06/04/2017



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APPENDIX C: WW SEWER RECORDS & CORRESPONDENCE

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Kirsty Williams

From: Kirsty Williams
Sent: 28 March 2017 09:28
To: 'Jones-Hughes Henry'
Subject: HYD217 Bedwell Road, Cross Lanes
Attachments: LOCATION PLAN.pdf

Good Morning Henry,

Land off Bedwell Road, Cross Lanes, Wrexham, LL13 0TR

Please could you confirm whether you have any information that you feel would be valuable to a Flood Risk Assessment and Drainage Management Strategy for the above site (location plan attached), including details of historical flooding and any water levels; this would be greatly appreciated. If there are any specific requirements that you require in a scope of works for this site please can you advise at this stage so that it can be fully incorporated into the works at an early stage.

Please do not hesitate to contact me on the details below to discuss further should you require additional information or clarification.

Kind Regards

Kirsty Williams BSc(Hons)
Flood Risk Analyst

BETTS HYDRO
Specialists in Drainage and Flood Risk
Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire, CH5 2LY
CHESTER OFFICE - 01244 289041



kirstywilliams@betts-associates.co.uk
www.betts-associates.co.uk

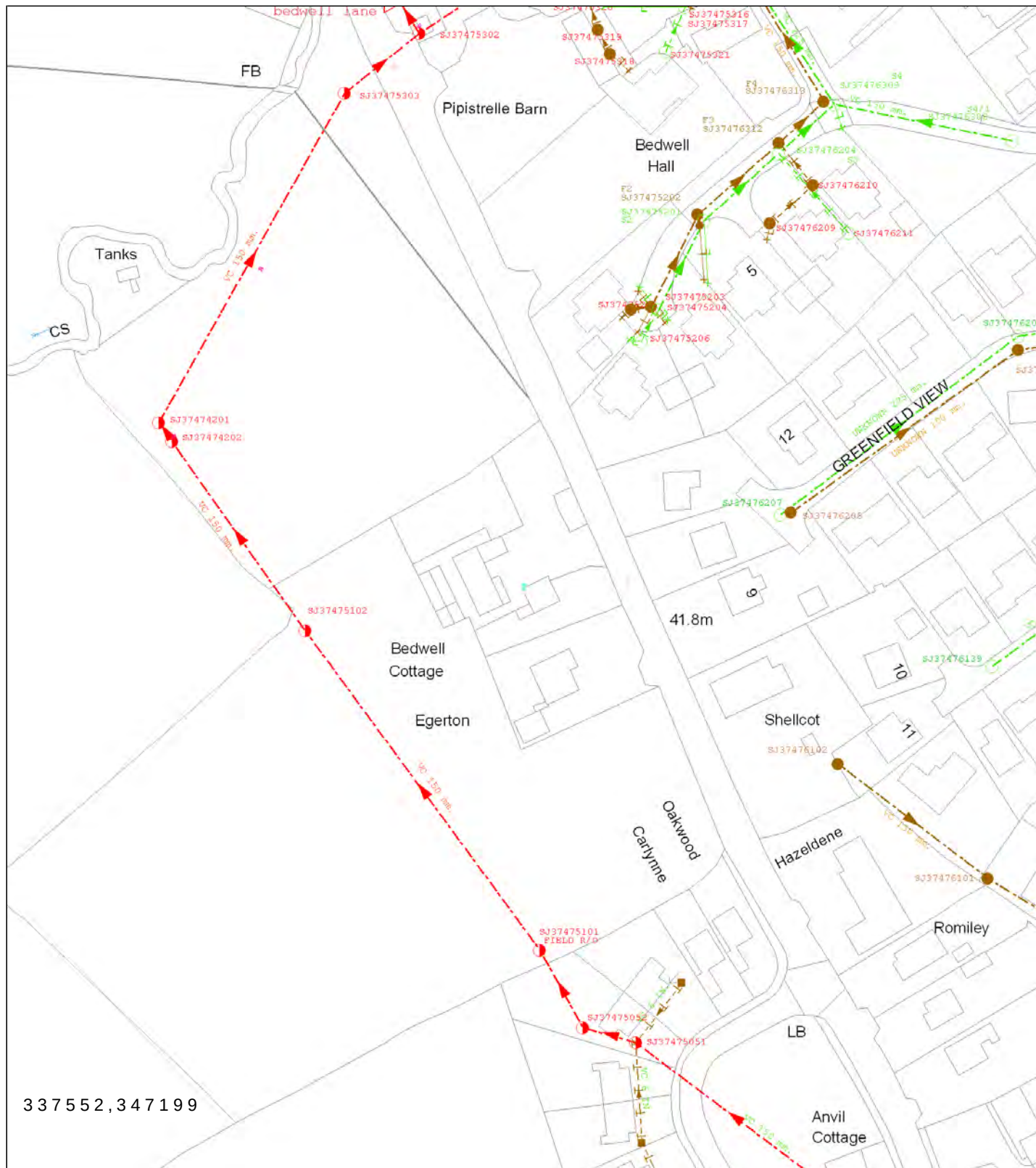
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Bedwell Road, Cross Lanes, Wrexham

Scale: 1:1250
07/04/2017

**EXACT
LOCATION OF
ALL APPARATUS
TO BE
DETERMINED ON
SITE**

Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets, there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF). It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation.

Dwr Cymru Cyfyngedig ('the Company') gives this information as to the position of its underground apparatus by way of general guidance only and on the strict understanding that it is based on the best information available and no warranty as to its correctness is relied upon in the event of excavations or other works made in the vicinity of the Company's apparatus and any onus of locating the apparatus before carrying out any excavations rests entirely on you. The information which is supplied hereby by the Company, is done so in accordance with statutory requirements of sections 198 and 199 of the Water Industry Act 1991 based upon the best information available and in particular, but without prejudice to the generality of the foregoing, it should be noted that the records that are available to the Company may not disclose the existence of a drain sewer or disposal main laid before 1 September 1989, or if they do, the particulars thereof including their position underground may not be accurate. It must be understood that the furnishing of this information is entirely without prejudice to the provision of the New Roads and Street Works Act 1991 and the Company's right to be compensated for any damage to its apparatus.

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LEGEND



- | | | | |
|--|----------------------------|--|-------------------------|
| | Sluice Valve | | Gravity Sewer |
| | Air Valve SINGLE | | Rising Main |
| | Tap | | Outfall |
| | Pressure Reducing Valve | | Pumping Station |
| | Meter | | Lamphole |
| | Bulk Meter | | Combined Sewer Overflow |
| | Fire Hydrant | | Special Purpose Chamber |
| | Cap | | Treatment Works |
| | Non Dwr Cymru | | Private Sewer Transfer |
| | Existing Distribution Main | | Lateral Drain |
| | Inspection Chamber | | |

NB: Sewer symbol colour indicates the sewer type.

RED - Combined
GREEN - Surface Water
BROWN - Foul

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APPENDIX D: LLFA CORRESPONDENCE

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Kirsty Williams

From: Carole Wright <Carole.Wright@wrexham.gov.uk>
Sent: 28 March 2017 14:26
To: Kirsty Williams
Subject: RE: HYD217 Bedwell Road, Cross Lanes

Hi Kirsty

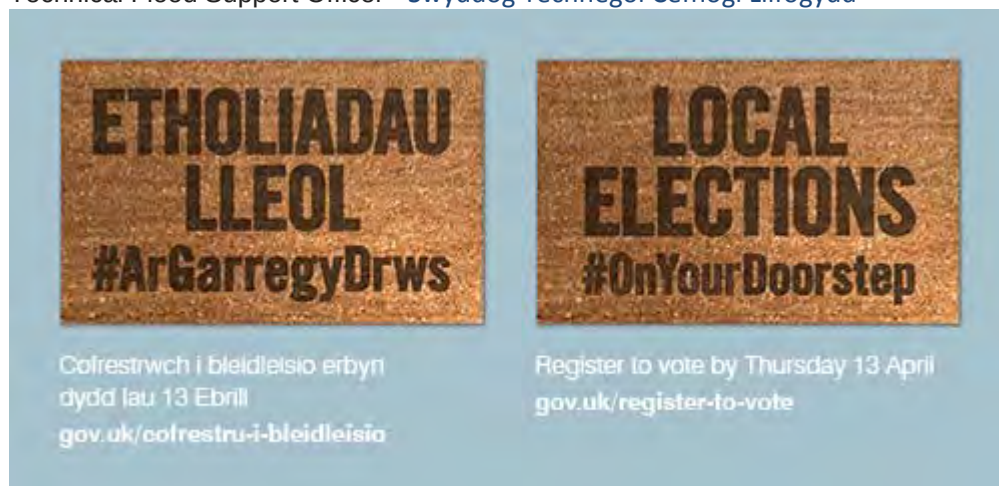
The report was submitted in 2007 to support the link road application and unfortunately we do not have the model. Our senior flood officer Neil Taunt will be happy to discuss any issues with you as your project progresses.

Kind regards

Carole Wright

Carole Wright - BA MBCS

Technical Flood Support Officer - Swyddog Technegol Cefnogi Llifogydd



01978 729735

Wrexham County Borough Council, Environment and Planning Department Abbey Road South Wrexham Industrial Estate Wrexham LL13 9PW

Cyngor Bwrdeistref Sirol Wreccsam, Amgylchedd a Chynllunio De Ffordd yr Abaty Ystâd Ddiwydiannol Wreccsam Wreccsam LL13 9PW

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facebook.com/wrexhamcouncil | facebook.com/cyngorwreccsam

From: Kirsty Williams [mailto:kirstywilliams@betts-associates.co.uk]

Sent: 28 March 2017 14:19

To: Carole Wright

Cc: Neil Taunt

Subject: RE: HYD217 Bedwell Road, Cross Lanes

Many Thanks Carole for your swift and comprehensive response.

The team may be in touch again as the project progresses in terms of the hydraulic assessment you sent though as it appears there should be an existing hydraulic model that may be of use if we need to look at the more up to date climate change aspects. I don't suppose you have access to the actual model do you ? also could you find out the date of the report you sent through please so at least we have an idea of how recent the dataset is. Thank you

Kind Regards

Kirsty Williams BSc(Hons)
Flood Risk Analyst

BETTS HYDRO

Specialists in Drainage and Flood Risk

Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire, CH5 2LY

CHESTER OFFICE - 01244 289041



kirstywilliams@betts-associates.co.uk

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From: Carole Wright [<mailto:Carole.Wright@wrexham.gov.uk>]

Sent: 28 March 2017 13:47

To: Kirsty Williams <kirstywilliams@betts-associates.co.uk>

Cc: Neil Taunt <Neil.Taunt@wrexham.gov.uk>

Subject: RE: HYD217 Bedwell Road, Cross Lanes

Hi again

My apologies, I omitted the surface water link.

http://www.wrexham.gov.uk/english/planning_portal/publications/surface_water.htm

kind regards

Carole Wright

Carole Wright - BA MBCS

Technical Flood Support Officer - *Swyddog Technegol Cefnogi Llifogydd*



01978 729735



Wrexham County Borough Council, Environment and Planning Department Abbey Road South Wrexham Industrial Estate Wrexham LL13 9PW



Cyngor Bwrdeistref Sirol Wrecsam, Amgylchedd a Chynllunio De Ffordd yr Abaty Ystâd Ddiwydiannol Wrecsam Wrecsam LL13 9PW



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From: Kirsty Williams [<mailto:kirstywilliams@betts-associates.co.uk>]

Sent: 28 March 2017 11:19

To: flooding

Subject: HYD217 Bedwell Road, Cross Lanes

To Whom It May Concern,

Land off Bedwell Road, Cross Lanes, Wrexham, LL13 0TR

Please could you confirm whether you have any information that you feel would be valuable to a Flood Risk Assessment and Drainage Management Strategy for the above site (location plan attached), including details of historical flooding and any water levels; this would be greatly appreciated. If there are any specific requirements that you require in a scope of works for this site please can you advise at this stage so that it can be fully incorporated into the works at an early stage.

Furthermore we have been advised that as the Lead Local Flood Authority you may have existing hydraulic/river models of the Ordinary Watercourse which bounds the northern portion of the development site. NRW have requested that we review the potential flood risks from this source and as it is Ordinary they cannot provide any specific modelling data. Any assistance you can provide would be greatly appreciated. Please do not hesitate to contact me on the details below to discuss further should you require additional information or clarification.

Kind Regards

Kirsty Williams BSc(Hons)
Flood Risk Analyst

BETTS HYDRO
Specialists in Drainage and Flood Risk

Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire, CH5 2LY

CHESTER OFFICE - 01244 289041



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Mae'r neges e-bost hon ac unrhyw atodiadau wedi eu bwriadu ar gyfer yr unigolyn neu'r sefydliad y?i cyfeirir atynt yn unig. Am yr amodau llawn yngl?n â chynnwys a defnyddio'r neges e-bost hon, ac unrhyw atodiadau, cyfeiriwch at www.wreccsam.gov.uk/top_navigation/disclaimersw.htm

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Mae'r neges e-bost hon ac unrhyw atodiadau wedi eu bwriadu ar gyfer yr unigolyn neu'r sefydliad y?i cyfeirir atynt yn unig. Am yr amodau llawn yngl?n â chynnwys a defnyddio'r neges e-bost hon, ac unrhyw atodiadau, cyfeiriwch at www.wreccsam.gov.uk/top_navigation/disclaimersw.htm

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APPENDIX E: LOCATION PLAN

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LOCATION PLAN

Land off Bedwell Road, Cross Lanes, Wrexham, LL13 0TR



OS X (Easting)	337522
OS Y (Northings)	347194
Nearest Post Code	LL13 0TR
Lat (WGS84)	N53:01:06 (53.018381)
Long (WGS84)	W2:55:58 (-2.932803)
Lat, Long	53.018381, -2.932803
Nat Grid	SJ375471 / SJ3752247194

APPENDIX F: PHOTOGRAPHS

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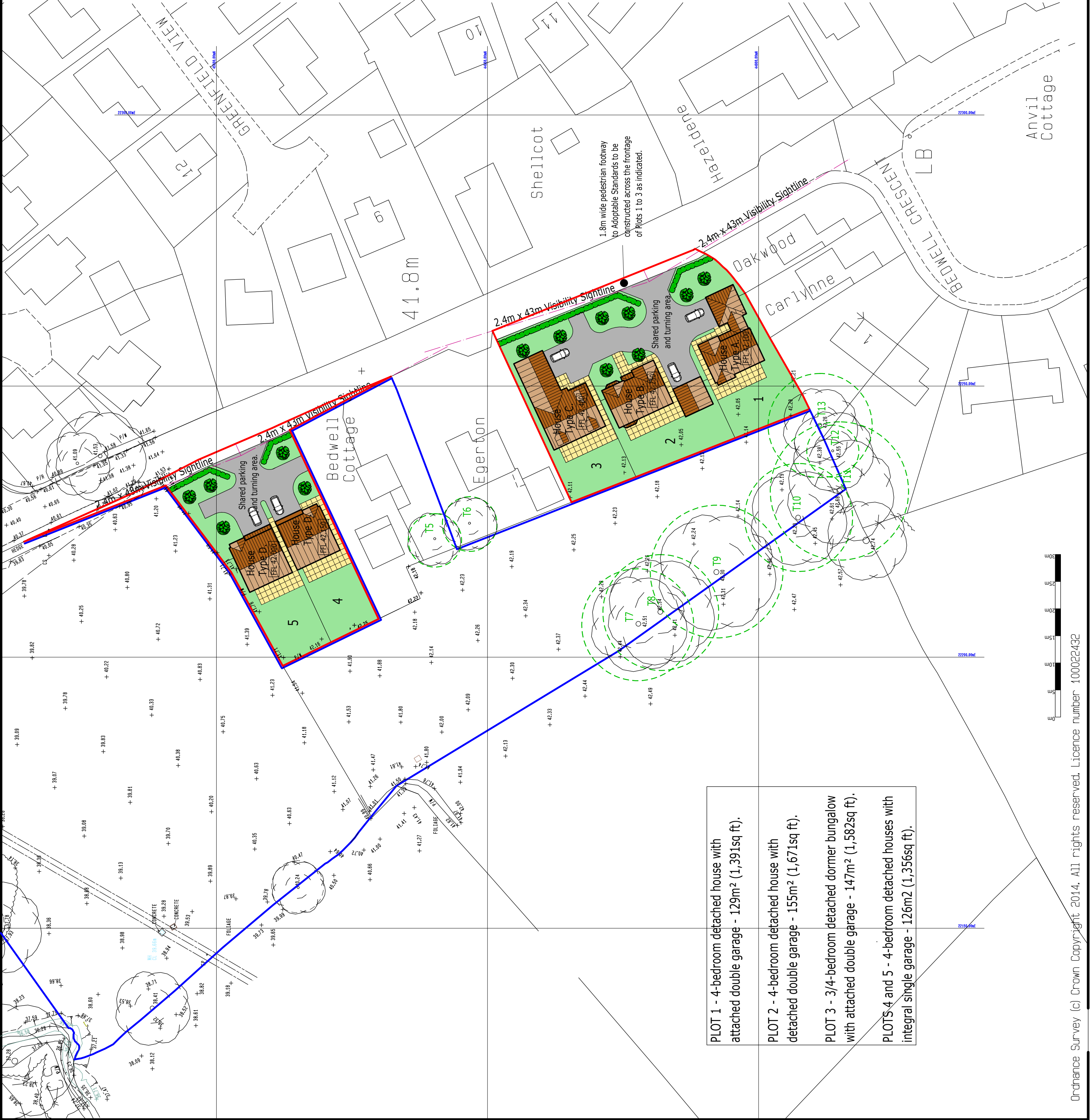


APPENDIX G: TOPOGRAPHIC SURVEY

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APPENDIX H: PLANNING LAYOUT

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SOFT LANDSCAPING.

Garden areas to be grassed front and rear with good quality turf with tree planting as indicated.

Tree planting is to be carried out as indicated. Trees to comprise selected standard stock, nursery cultivated specimens planted as indicated at an initial height of approximately 3000mm with a 100mm - 120mm girth. Tree species to be a selection of Silver Birch (betula pendula) - SB
Mountain Ash (sorbus aucuparia) - MA and
Wild Cherry (prunus avium) - WC as indicated.
Trees are to be adequately staked to provide protection after planting.
Landscaping proposals are to be completed during the first planting season following completion of development.

Existing hedge along the site frontage of Bedwell Road is to be retained as far as possible and is to be supplemented as necessary.
New hedge to be planted is to be planted in two staggered rows, 3000mm apart with plants at 450mm centres. Existing grass and weed cover is to be removed prior to planting and hedge plants are to be planted by notch planting. Hedges should be planted between November and March but planting in very cold weather should be avoided. A "mulch mat roll" of 1000mm wide is to be provided for the length of the hedge prior to planting.
Provide 75mm deep bark mulch over the mat. Hedging plants are to be planted through the mulch mat roll. The following hedge plant species are to be incorporated into the proposed hedge to the specification and percentages indicated.

%	Botanical Name	Height	Root	Habit	Branches
75	Corylus avellana - Hazel	40-60cm	Bare root	Branched	2 min
25	Crataegus monogyna - Hawthorn	40-60cm	Bare root	Branched	2 min

Shared private drives / parking / turning areas are to be surfaced with tarmacadam with 10% red stone chippings to top wearing course.

Pathways to perimeters of dwellings to be finished with concrete paving slabs laid with a gravelled channel immediately adjacent to the dwellings.

Screen fences between private rear gardens to comprise 1.8m high timber close boarded fence panels supported on timber rails and posts which are to be set in concrete bases all to details supplied.

Existing pedestrian footway to the west side of Bedwell Road is to be extended across the frontage of Plots 1 to 3 as indicated. Footway is to be 1.8m wide and is to be constructed to adoptable standards to the approval of the Highway's Department.

- PLOT 1 - 4-bedroom detached house with attached double garage - 129m² (1,391sq ft).
- PLOT 2 - 4-bedroom detached house with detached double garage - 155m² (1,671sq ft).
- PLOT 3 - 3/4-bedroom detached dormer bungalow with attached double garage - 147m² (1,582sq ft).
- PLOTS 4 and 5 - 4-bedroom detached houses with integral single garage - 126m² (1,356sq ft).

Project.	PROPOSED RESIDENTIAL DEVELOPMENT on land at BEDWELL LANE, CROSS LANES, WREXHAM, LL13 0TR.		
Client.	RESIDENTIAL LAND PROMOTION LTD.		
Title.	PROPOSED SITE LAYOUT PLAN.		
Drawing No.	10110.04A.dsj		
Date.	Jan 2018.	Scale.	1:500@A2.
D.S. Jones & Co.			
Architectural & Planning Consultants. The Studio, Coedpoeth, Wrexham, LL11 3PE. Tel : 01978 750195 / 07880 874522. E : dsjonesandco@live.co.uk			

REVISION A. 03/2018. Tree root protection areas indicated with broken green lines / circles.

APPENDIX I: LLFA HYDRAULIC MODELLING REPORT

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Appendix 4 Hydraulic Study of the Clywedog Stream

CAPITA SYMONDS

Wrexham County
Borough Council

Wrexham Industrial Estate,
Southern Road

Hydraulic Modelling
Technical Report:
Clywedog Stream and
Hollies Stream

CS/000868/39

Capita Symonds Ltd, 24-30 Holborn, LONDON, EC1N 2LX
T: 02078709300 F: 02078709399

CONTENTS

1. INTRODUCTION..... 4
1.1 Aim 4
1.2 Flood Model Selection..... 4

2. DATA COLLECTION..... 4
2.1 Ground Survey 4
2.2 Hydrology 4

3. BASELINE MODEL SETUP..... 4
3.1 Model Extents..... 4
3.2 Mannings n..... 5
3.3 Hydraulic Structures..... 5
3.4 Model Boundaries 5

4. BASELINE MODELLING RESULTS 6

5. SOUTHERN ACCESS ROUTE MODEL SETUP 6

6. SOUTHERN ACCESS ROUTE MODELLING RESULTS 7

7. CONCLUSIONS..... 8

APPENDICES

- APPENDIX 1 Figures and Drawings
- APPENDIX 2 Photos
- APPENDIX 3 ISIS Model Results

1. INTRODUCTION

1.1 Aim

To assess the impact of the proposed Wrexham Industrial Estate Southern Access Road, including a new bridge, on flows in the Clywedog Stream and adjoining watercourse. The proposed southern access route will cross the Hollies Stream immediately north of Cross Lanes roundabout, and the Clywedog Stream immediately south of it.

The results from this modelling exercise will produce flood levels in the study area. These outlines will represent the extent of baseline flooding and expected flooding following the construction of the proposed access road.

1.2 Flood Model Selection

The hydraulic model was constructed using the one dimensional modelling program iSIS. This was decided due to the scale of the watercourses being modelled. Both streams are reasonably small, with the Clywedog Stream having a catchment area of less than 3.5km^2 at the site of the proposed access road and the Hollies Stream a catchment area of 0.5km^2 .

2. DATA COLLECTION

2.1 Ground Survey

Information on fifteen cross-sections along the study reach of the Clywedog Stream and Hollies Stream was obtained from a survey carried out by PM Surveys, Deeside in March 2007. The width of the cross-sections varies between 42m and 101m.

The information was provided to Capita Symonds as detailed drawings, for use in this hydraulic model.

The survey did not contain details of any structures on the Clywedog Stream or Hollies Stream. This information was gained from Wrexham County Borough Council and measurements taken during a site visit in March 2007.

2.2 Hydrology

A separate hydrological study was undertaken by Capita Symonds in 2007 to obtain flows in the Clywedog Stream. Estimates of peak flood flow and hydrograph shape from these analyses have been used to provide inflow to this hydraulic model.

3. BASELINE MODEL SETUP

3.1 Model Extents

The study area of the Clywedog Stream begins 80m upstream of Upper Bedwell Bridge (SJ 372471), finishing 450m downstream of this at Lower Bedwell Bridge (SJ 375473). This reach was chosen as it encompasses the flooding in the area and should produce accurate results representing the effects of the proposed southern access road.

The Clywedog Stream is a natural channel. Figure 1 shows that the river channel is fairly straight with a small area of meandering. Hollies Stream is a significant tributary of the Clywedog Stream and is also represented in Figure 1. The confluence between the Clywedog Stream and Hollies Stream is located 24m upstream of Lower Bedwell Bridge. A 480m stretch of Hollies Stream has been included within the model, which begins immediately downstream of Upper Bedwell Bridge (SJ 373471).

3.2 Mannings n

Details of the river channels were observed during the site visit conducted in March 2007. The study reaches of the Clywedog Stream and Hollies Stream are located in fields, which at the time of the site visit were overgrown with vegetation. The Clywedog Stream's channel is made up of earth and a Mannings n value of 0.02 was chosen. The Hollies Stream flows through an overgrown field and therefore its channel mainly consists of long grass, a Mannings n value of 0.05 was chosen. The Mannings n value selected for the floodplains within the model was 0.05 due to the extent of the overgrowth in the surrounding area. Sensitivity analysis has been conducted on these Mannings n values by increasing and reducing them by 10%. From the results of this analysis it was concluded that the model was not sensitive to changes in Mannings n.

3.3 Hydraulic Structures

There are six structures currently located within the vicinity of the study area. Three of these are bridges, one footbridge and two road bridges (the Upper and Lower Bedwell Bridges), and are all situated on the Clywedog Stream. The two road bridges are arched masonry bridges, and the footbridge is a flat-decked wooden bridge. The remaining three structures are culverts all located on Hollies Stream. Two of these culverts are in the field immediately upstream of the Clywedog Stream and the final culvert is at the confluence with the Clywedog Stream and Hollies Stream.

As previously stated the survey conducted by PM Surveys contained no details of any of these structures. The only dimensions of these structures are rough measurements made on a site visit in March 2007. Therefore extensive sensitivity analysis was conducted on them, which involved altering the diameter of the culverts by $\pm 25\%$ and the structure coefficients by $\pm 10\%$. These changes were analysed independently. The results of this analysis concluded that the model was not sensitive to these changes and therefore measurements taken during the site visit were used within the model.

3.4 Model Boundaries

The model contains two inflows, one at the upstream boundary of each watercourse. The inflow calculated during the hydrological assessment of the area for the Clywedog Stream, was at a point some distance downstream of the model's boundary, therefore combining the flows in the Clywedog Stream and Hollies Stream. This point was chosen to ensure that a conservative flow value was used in the model. This inflow could not easily be divided between the two streams as no level data was available in this area, and therefore catchment areas for the two streams could not easily be established. As a rough estimate, it was decided that 90% of the flow should be entered at the top of the Clywedog Stream with the remaining 10% into the Hollies Stream.

Due to the uncertainty surrounding these inflows a number of scenarios were run with varying proportions of this flow down Hollies Stream to examine the sensitivity of the model to this split in flow. The analysis showed that the model was not particularly sensitive to these varying scenarios and so the 90:10 split was retained within the model.

The downstream boundary conditions of the model were unknown in this area. Therefore the boundary was set at normal depth within the iSIS model 20m downstream of Lower Bedwell bridge. When this type of boundary is specified within iSIS, a flow-head relationship, based on normal depth, is automatically generated at this point.

4. BASELINE MODELLING RESULTS

The model has been run for 1%, 1% plus climate change and 0.1% AEP flood event for the baseline scenario and proposed scenario. The results of these runs are presented in Table 1. The locations of the cross-sections for which results are reported can be seen in Figure 1.

Location		% Annual Probability Flood Event		
Clywedog (CS)	Stream	1	1 + CC	0.1
CS0409		Predicted Flood Level (mAOD)	Predicted Flood Level (mAOD)	Predicted Flood Level (mAOD)
CS0373		39.51	39.58	39.81
CS0322		39.38	39.47	39.78
CS0313		39.32	39.45	39.76
u/s proposed bridge		39.32	39.45	39.76
d/s proposed bridge		38.91	38.98	39.10
CS0228		38.82	38.89	39.01
CS0175		38.30	38.36	38.47
CS0138		37.79	37.85	37.96
CS0014		37.56	37.61	37.73
Footbridge		36.66	36.68	36.79
CS0000		36.78	36.85	36.94
		36.75	36.81	36.91
Hollies Stream (HS)				
HS0474		41.27	41.32	41.41
HS0366		40.93	40.98	41.07
HS0243		40.26	40.31	40.39
u/s proposed culvert		39.98	40.00	40.05
d/s proposed culvert		39.73	39.75	39.79
Culvert in field 01		36.90	36.97	36.97
Culvert in field 02		36.79	36.85	36.95
Culvert in field 03		36.78	36.85	36.94
CS0007d2 (confluence of HS and CS)		36.78	36.85	36.94

Table 1 Predicted Flood Levels Prior to the Construction of the Proposed Road Bridge

During the 1% AEP plus climate change (20%) event both the Clywedog Stream and the Hollies Stream flowed slightly out of bank for the majority of the study reach. All structures modelled surcharged during this event, except the Upper Bedwell Bridge. The culverts located on Hollies Brook significantly surcharge with water spilling out at depths varying between 200 and 600mm. Water flows over the footbridge crossing the Clywedog Stream at depths reaching 300mm, with the stream also flowing around the bridge into the surrounding fields at this point. The culvert beneath the Lower Bedwell Bridge surcharges causing water to flow onto the road.

5. SOUTHERN ACCESS ROAD MODEL SETUP

The access road will cross Hollies Stream immediately north of Cross Lanes roundabout and will involve the introduction of a circular culvert with a diameter of 900mm.

The access road will cross the Clywedog Stream immediately south of Cross Lanes roundabout and will involve the introduction a rectangular culvert (Middle Bedwell Bridge) with a cross-section of 3.4m by 1.6m and length of 15m. The proposed road deck was incorporated into the model by using its elevation in the spillways for these two culverts.

6. SOUTHERN ACCESS ROAD MODELLING RESULTS

The model was run for the 1%, 1% plus climate change and 0.1% AEP events. Table 2 shows the predicted flood levels with the proposed bridge at the same cross-section locations as for the baseline case in Table 1. The locations of the cross-sections listed in the table are shown in Figure 1.

Location	Stream	% Annual Probability Flood Event		
		1	1 + CC	0.1
Clywedog (CS)		Predicted Flood Level (mAOD)	Predicted Flood Level (mAOD)	Predicted Flood Level (mAOD)
CS0409		39.55	39.73	39.90
CS0373		39.40	39.48	39.78
CS0322		39.34	39.47	39.76
CS0313		39.34	39.47	39.76
u/s proposed bridge		38.93	39.01	39.14
d/s proposed bridge		38.82	38.89	39.01
CS0228		38.30	38.36	38.47
CS0175		37.79	37.85	37.96
CS0138		37.56	37.61	37.73
CS0014		36.66	36.68	36.79
Footbridge		36.78	36.85	36.94
CS0000		36.75	36.81	36.91
Hollies Stream (HS)				
HS0474		41.25	41.30	41.39
HS0366		40.97	41.04	41.13
HS0243		40.22	40.25	40.32
u/s proposed culvert		39.98	40.04	40.15
d/s proposed culvert		39.74	39.76	39.80
Culvert in field 01		36.91	36.97	36.97
Culvert in field 02		36.79	36.85	36.95
Culvert in field 03		36.78	36.85	36.94
CS0007d2				
(confluence of HS and CS)		36.78	36.85	36.94

Table 2 Predicted water levels following the Construction of the Proposed Southern Access Road

The water level on the upstream side of the proposed Middwell Bridge will be 38.93mAOD and 39.01mAOD during the 1% and 1% plus climate change events. The soffit of the bridge is 39.57mAOD, therefore the freeboard is 0.64m and 0.56m respectively.

The difference in predicted flood levels between the baseline and proposed case have been calculated at three cross-sections upstream and one downstream of the proposed bridge (Clywedog Stream) and culvert (Hollies Stream). These values are stated in Table 3. Positive difference values indicate an increase in flood level as a result of the proposed access road and crossing.

Location	% Annual Probability Flood Event			
	1	1 + CC		0.1
Clywedog Stream (CS)	Difference (m)	Difference (m)	Difference (m)	Difference (m)
CS0373	0.02	0.01		0
CS0322	0.02	0.02		0
CS0313	0.02	0.02		0
u/s proposed bridge	0.02	0.03		0.04
d/s proposed bridge	0	0		0
Hollies Stream (HS)				
HS0474	-0.02	-0.02		-0.02
HS0366	0.04	0.06		0.06
HS0243	-0.04	-0.06		0.09
u/s proposed culvert	0			0
d/s proposed culvert	0.01	0.01		0

Table 3 Changes in water levels following the Construction of the Proposed Southern Access Road.

7. CONCLUSIONS

With the exception of the Upper Bedwell Bridge the existing structures surcharge during the 1% AEP flood event. Middle Bedwell Bridge will not surcharge and has a freeboard of 0.64m during the 1% AEP event. The proposed southern access road and associated crossings will produce a small increase in water levels approximately 6mm upstream. Table 3 shows the difference in water level between the baseline and proposed scenarios, with the maximum increase being 9mm for the 1% AEP plus climate change, upstream of the proposed culvert on the Hollies Stream.

APPENDIX 1: Figures



WREXHAM INDUSTRIAL ESTATE ACCESS ROAD

Access to Wrexham Industrial Estate
Clywedog Stream Hydraulic
Model Cross-section

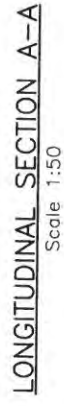
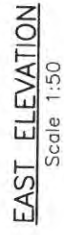
CAPITA SYMONDS

Penrhos Manor, Oak Drive, Colwyn Bay,
North Wales, LL29 7YW
Tel: 01492 539200
Fax: 01492 531333

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALE @ A3	ISSUING OFFICE	DRAWING NUMBER	REV
GAP	GJ	GJ	13/07/07	1:2,000	E.Grinstead		Figure 1

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TE 06934 | SCALES:
AS SHOWN | AMENDMENTS: | DATE | SCHEME TITLE:

WREXHAM INDUSTRIAL ESTATE
ACCESS ROAD |
| DADCIV GROUP:

BRIDGES | NATIONAL GRID REF:

RKD | | | |
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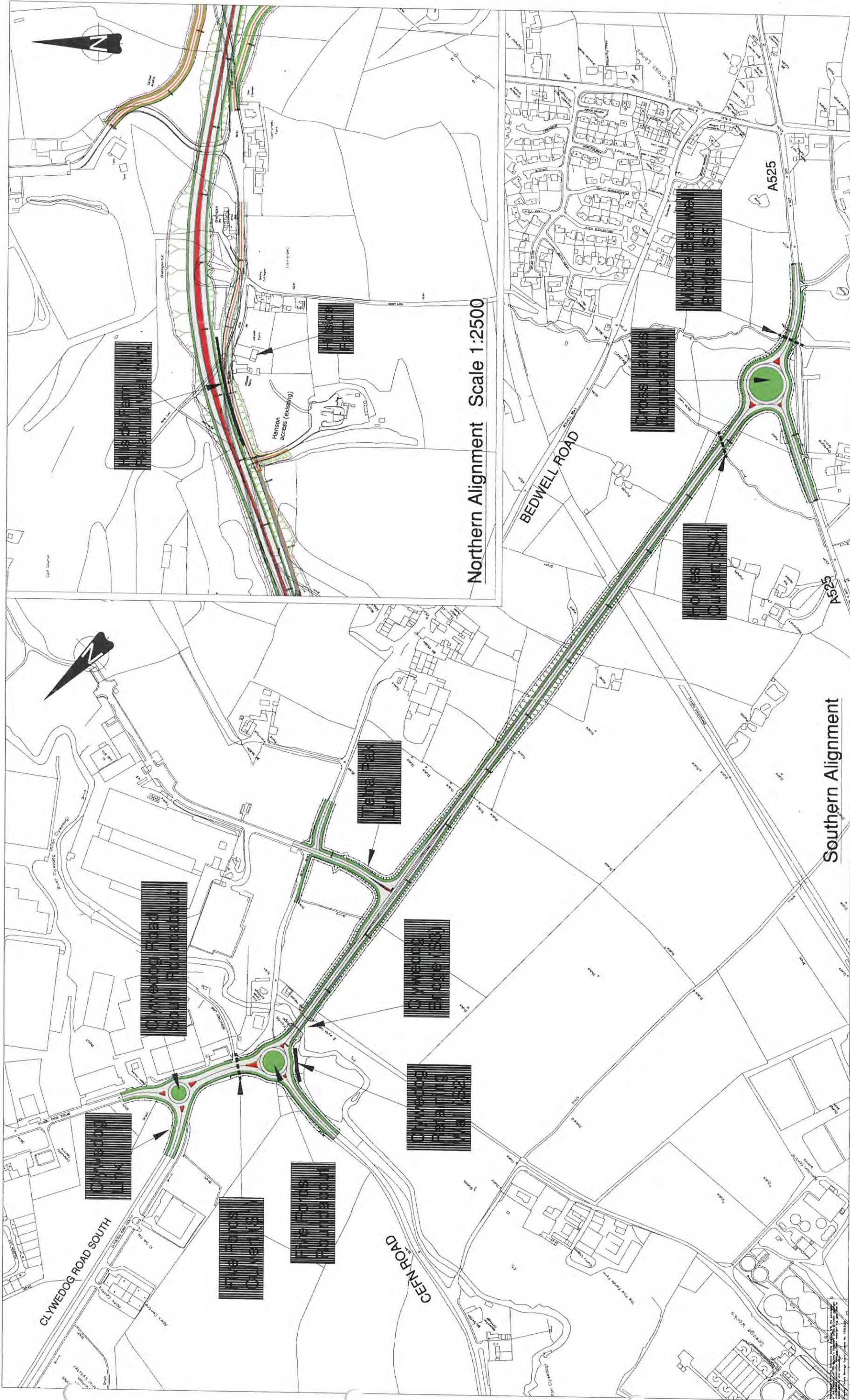
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GENERAL ARRANGEMENT |
| APPROVED BY: | STATUS: Preparatory | | DRAWING NUMBER: | |
| | | | TE/05934/ 02 A | |



Wrexham
COUNTY BOROUGH
BWRDEISTREF SIROL
wrecsam

MARTIN WRIGHT BSc(Hons) MRICS
CHIEF TRANSPORTATION AND ASSET MANAGEMENT OFFICER
Tel. (01978) 297102
Fax. (01978) 297103

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Northern Alignment Scale 1:2500

Southern Alignment

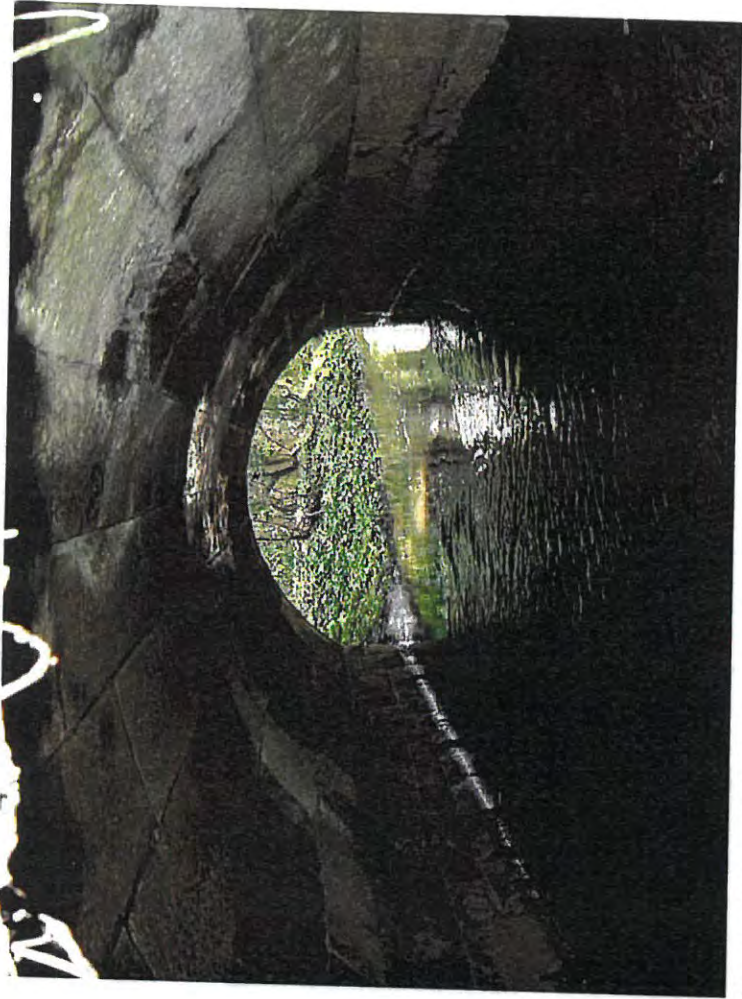
WREXHAM COUNTY BOROUGH COUNCIL
CROWN BUILDINGS,
WREXHAM LL13 8BG.



MARTIN WRIGHT BSC(Hons) MRICS
CHIEF TRANSPORTATION AND ASSET MANAGEMENT OFFICER
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JOB NUMBER: TE 02754		SCALES: 1:2500	AMENDMENTS:	DATE	SCHEME TITLE: Wrexham Industrial Estate Access Road
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DRAWN BY: RT	DESIGN	NATIONAL GRID REF:	DRAWING TITLE: Location of Structures		
CHECKED BY: AIS			DRAWING NUMBER: 02754/D/ 419 A		
APPROVED BY:					
STATUS: A1 Original Drawing 15/03/2007		Scheme			

APPENDIX 2: Photos



Upper Bedwell Bridge



Footbridge



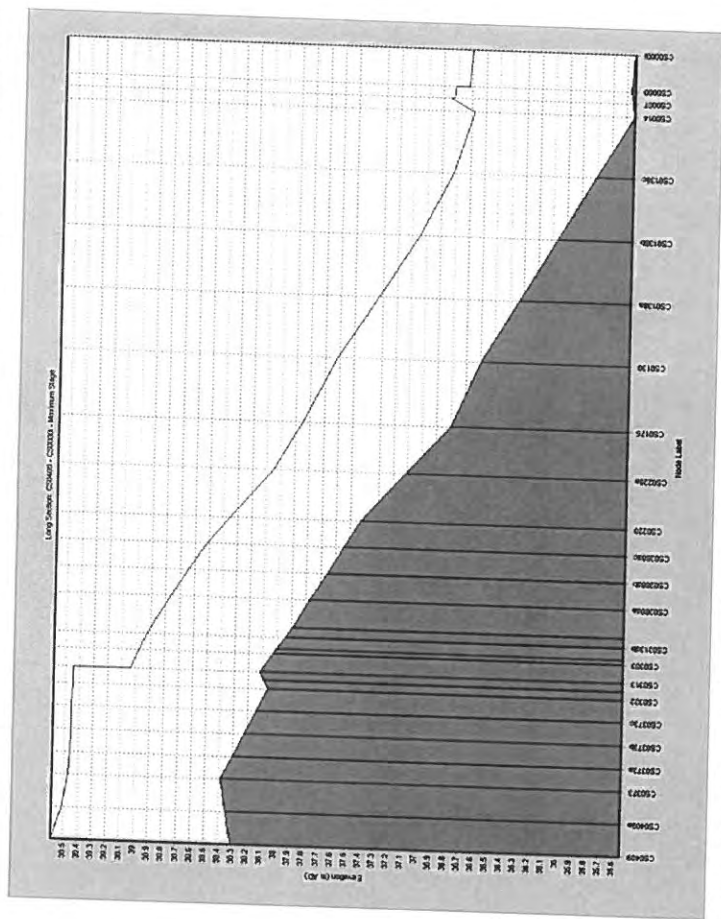
Lower Bedwell Brook



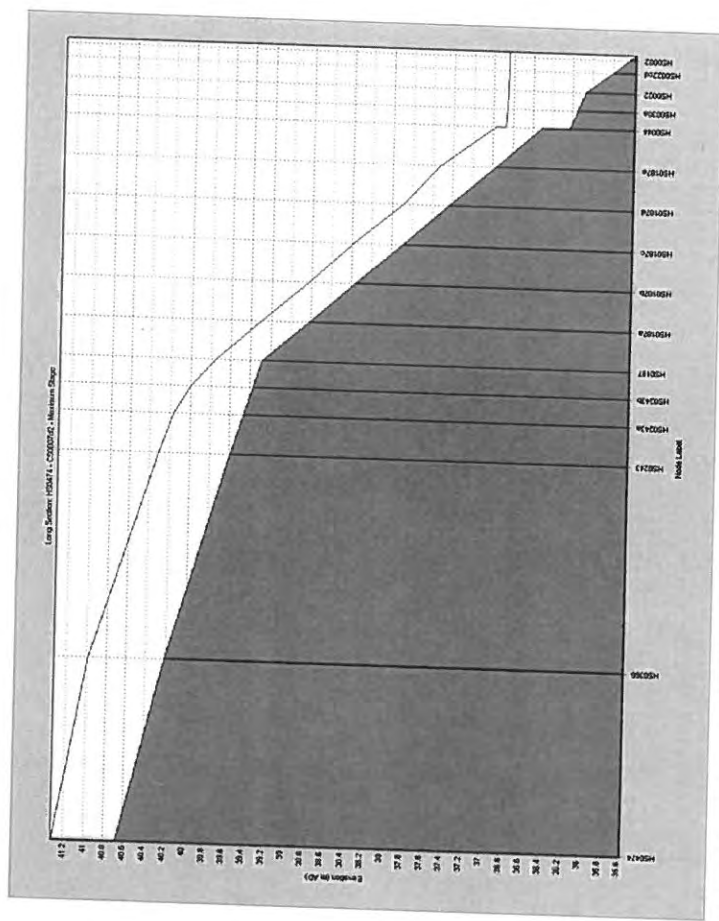
Culvert on Hollies Stream

APPENDIX 3: ISIS Model Results

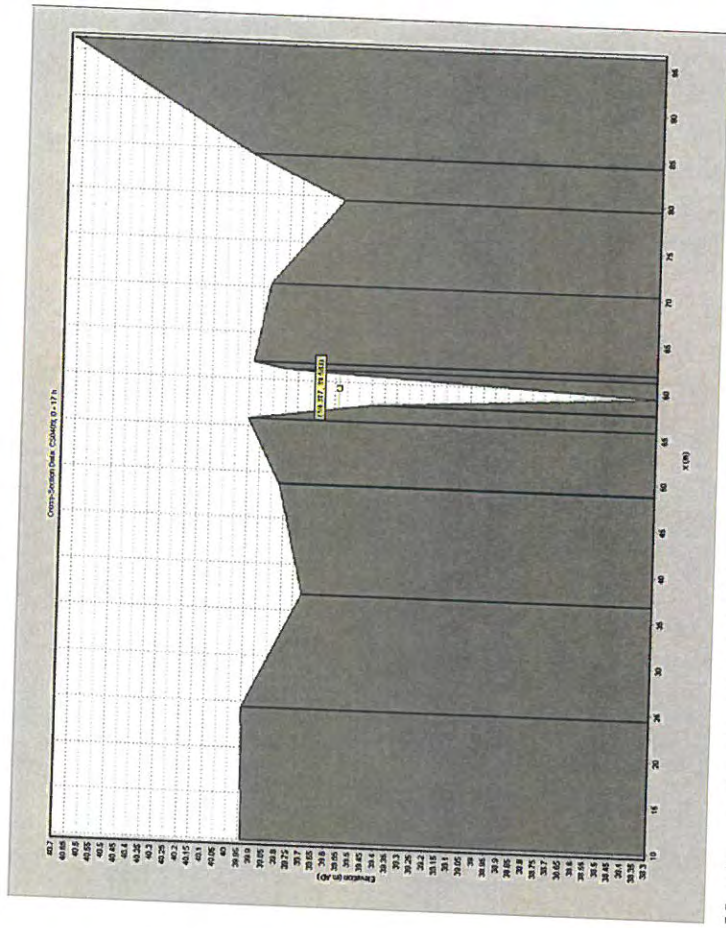
Baseline iSIS outputs representing Maximum Stage at Cross-sections



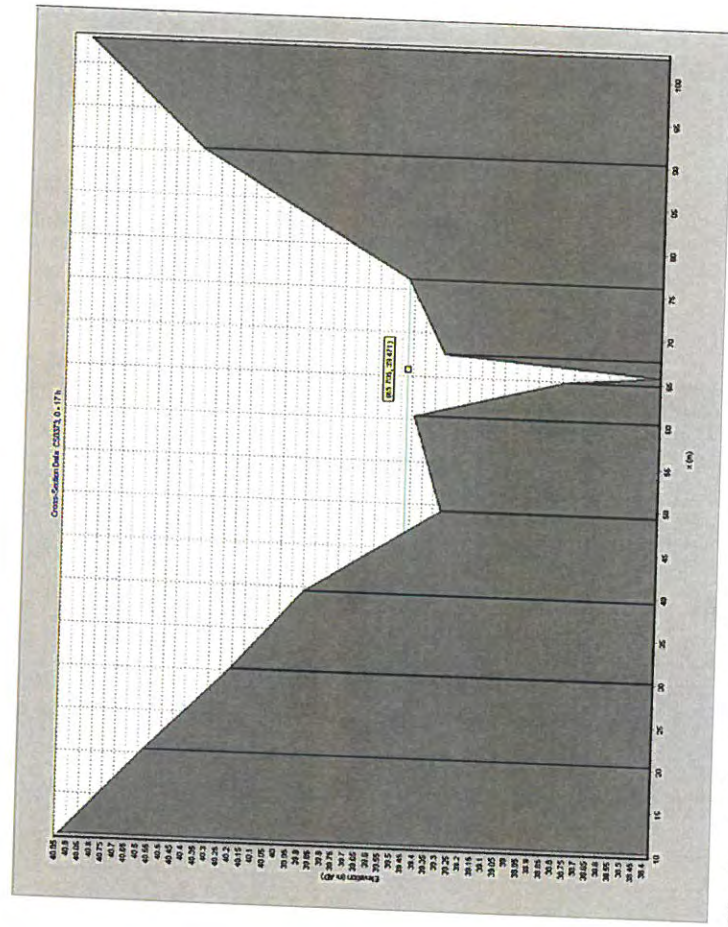
Long Section of Clywedog Stream



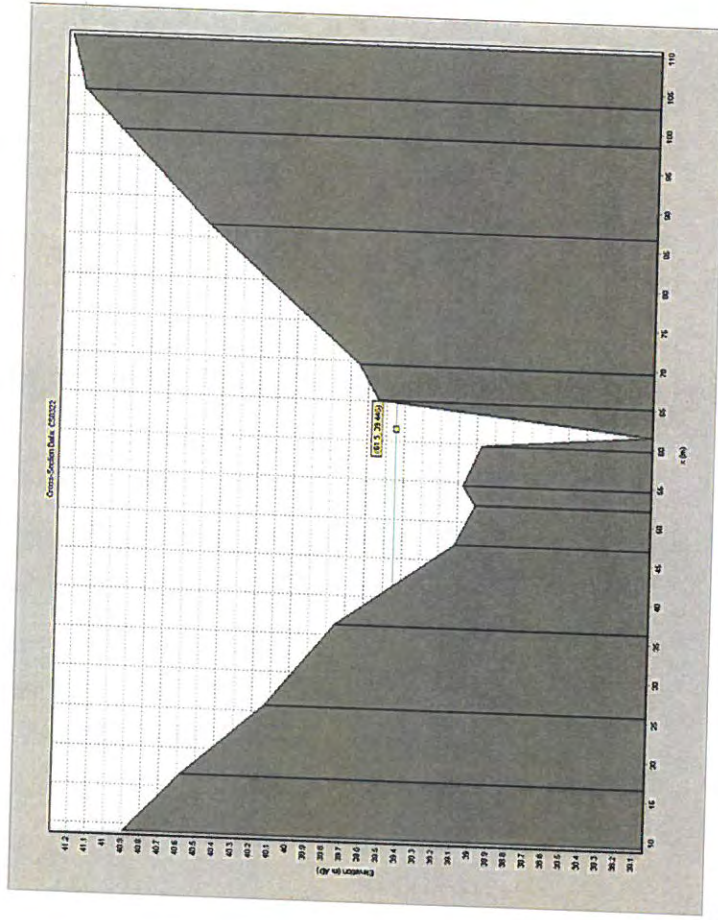
Long Section of Hollies Stream



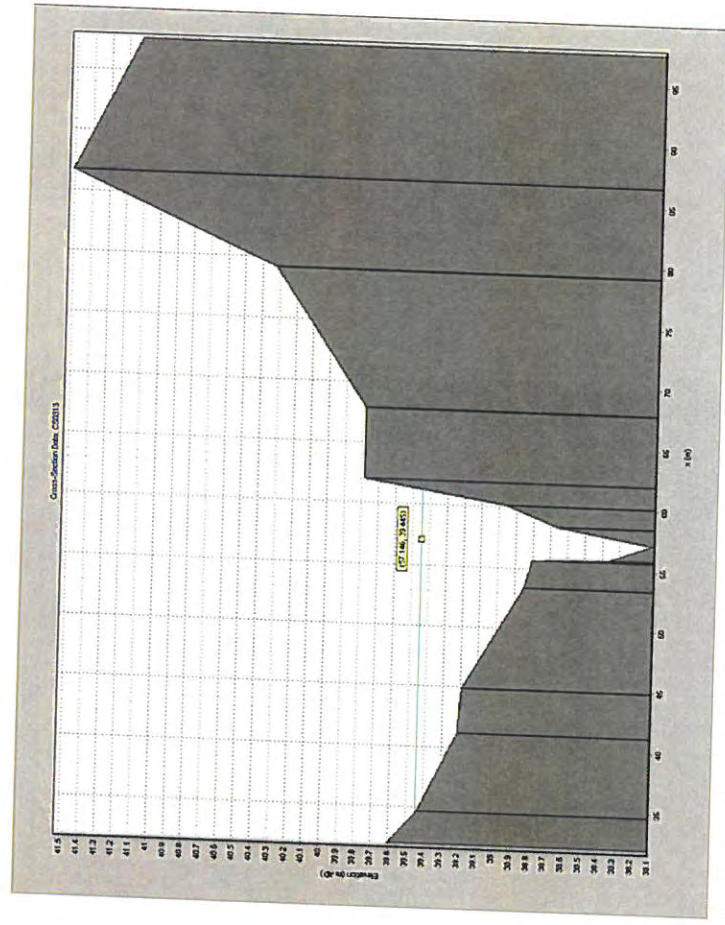
Maximum Stage at CS0409



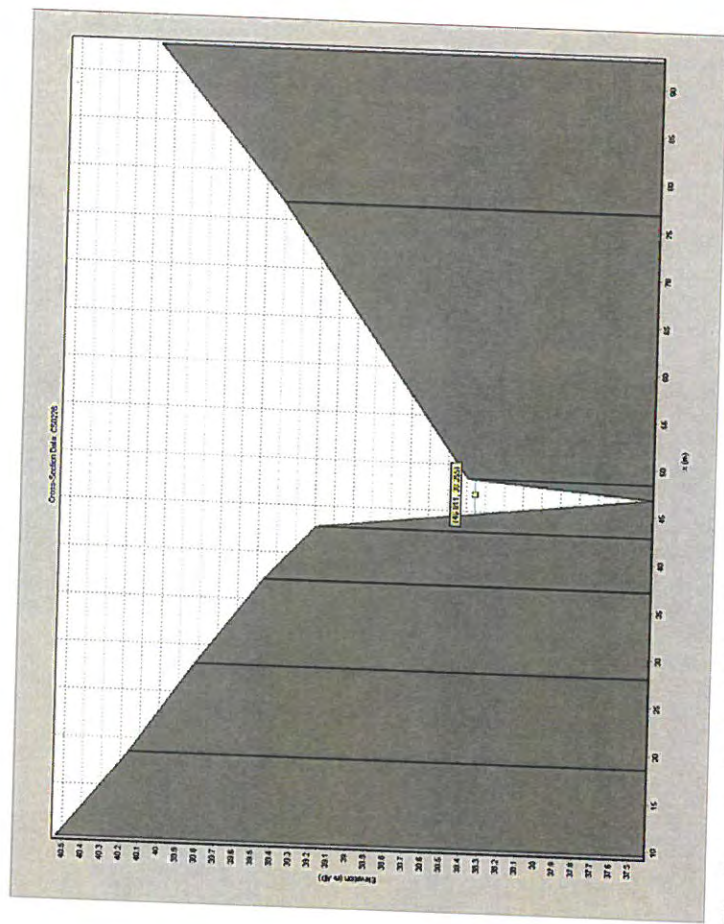
Maximum Stage at CS0373



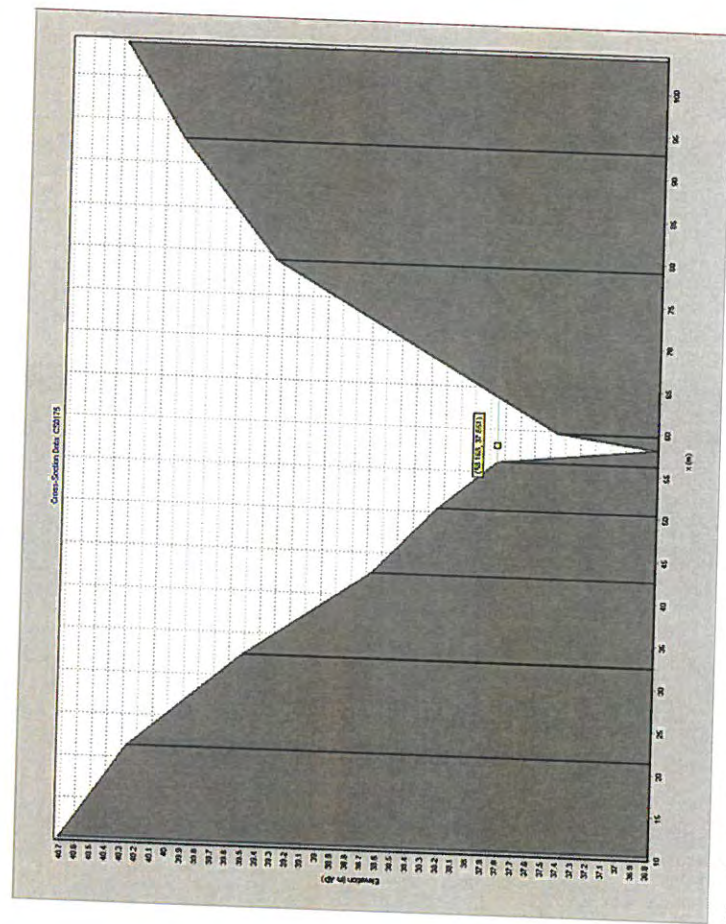
Maximum Stage at CS0322



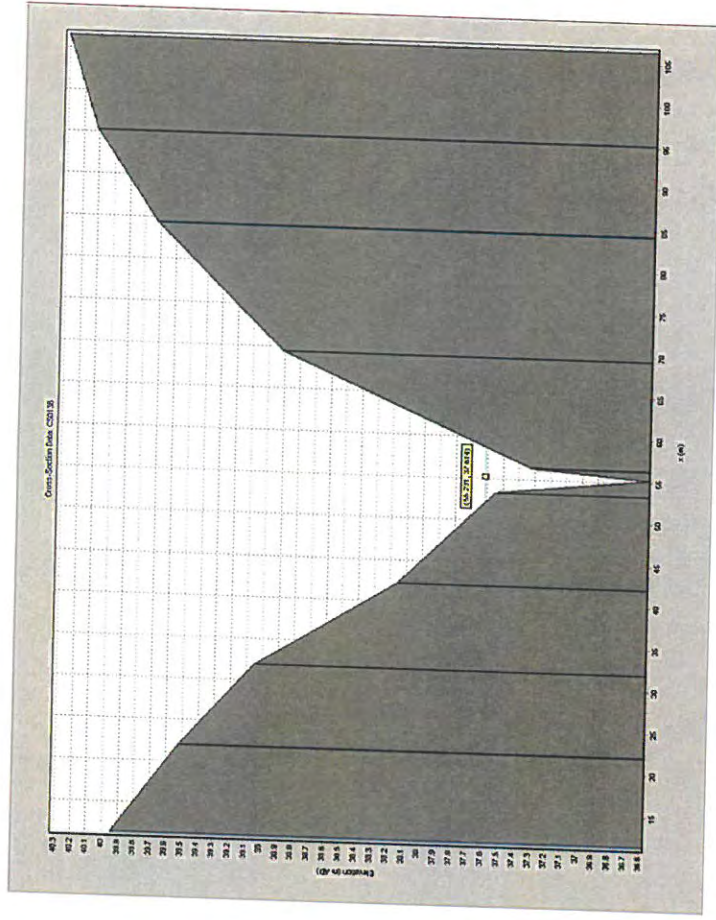
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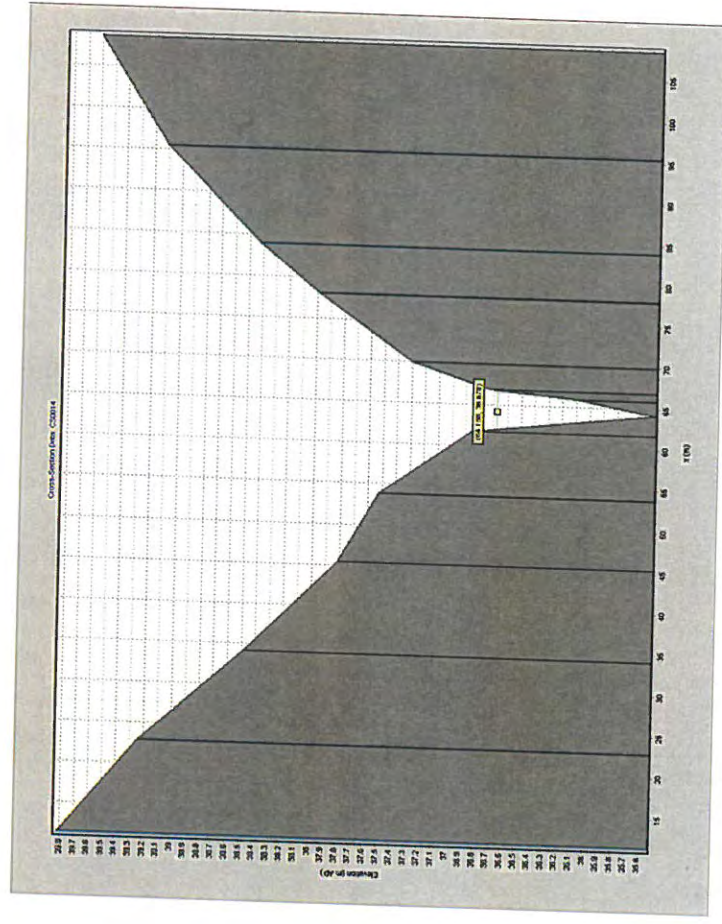
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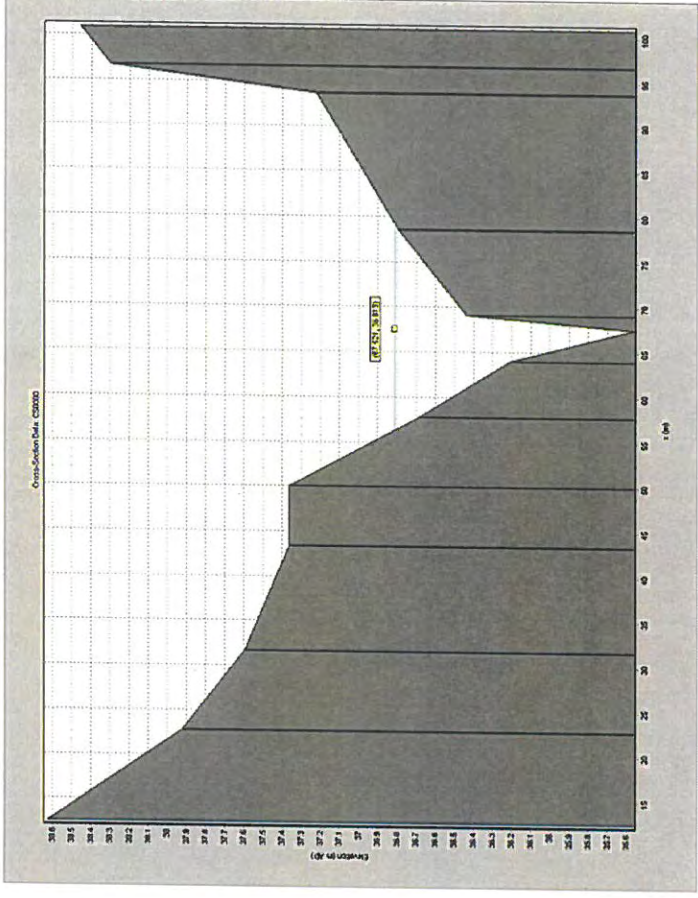
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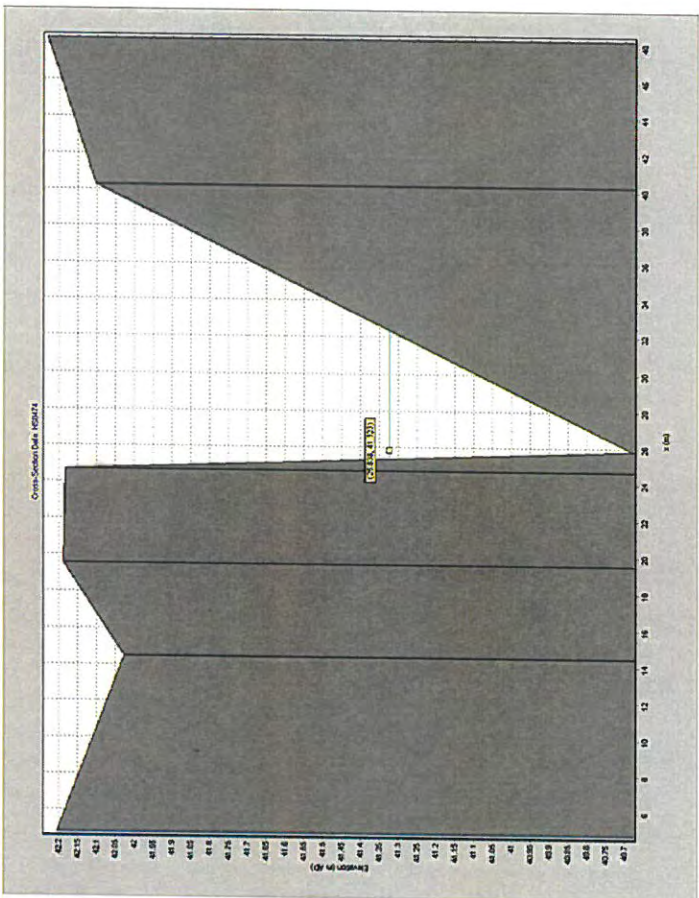
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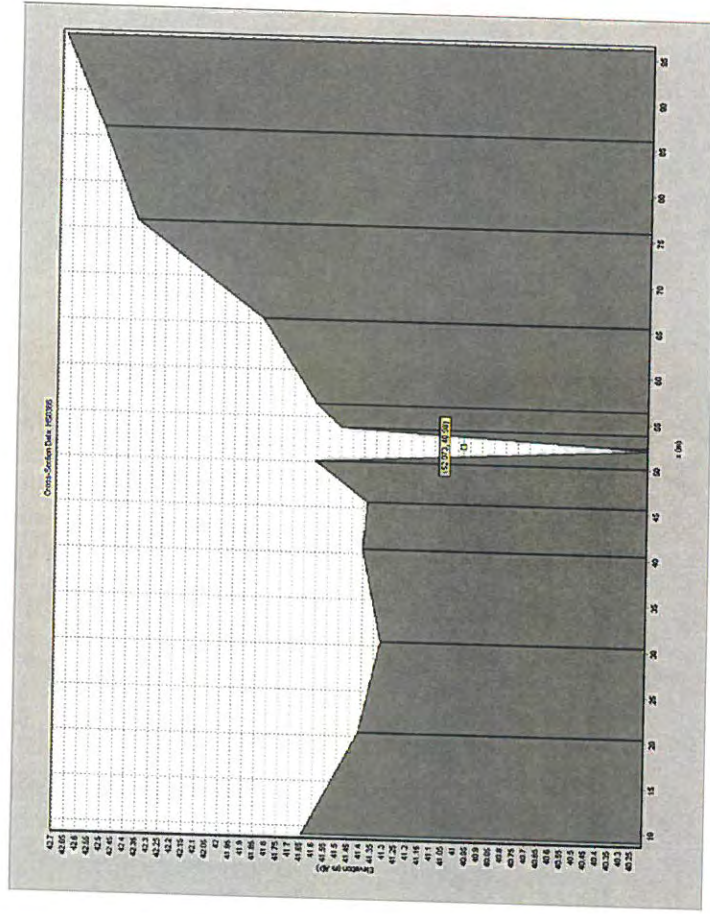
Maximum Stage at CS0014



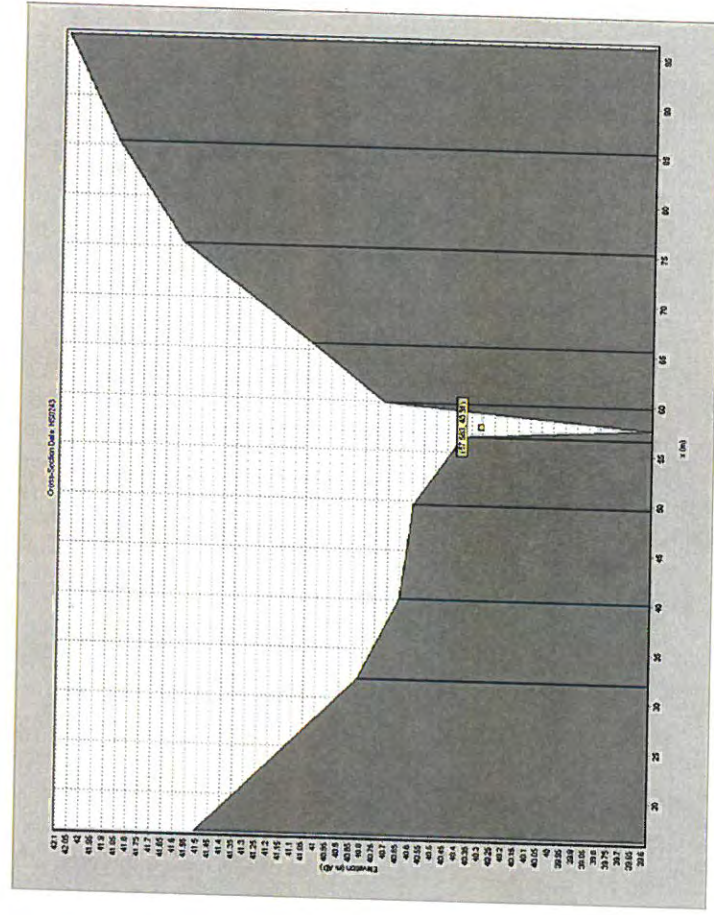
Maximum Stage at CS0000



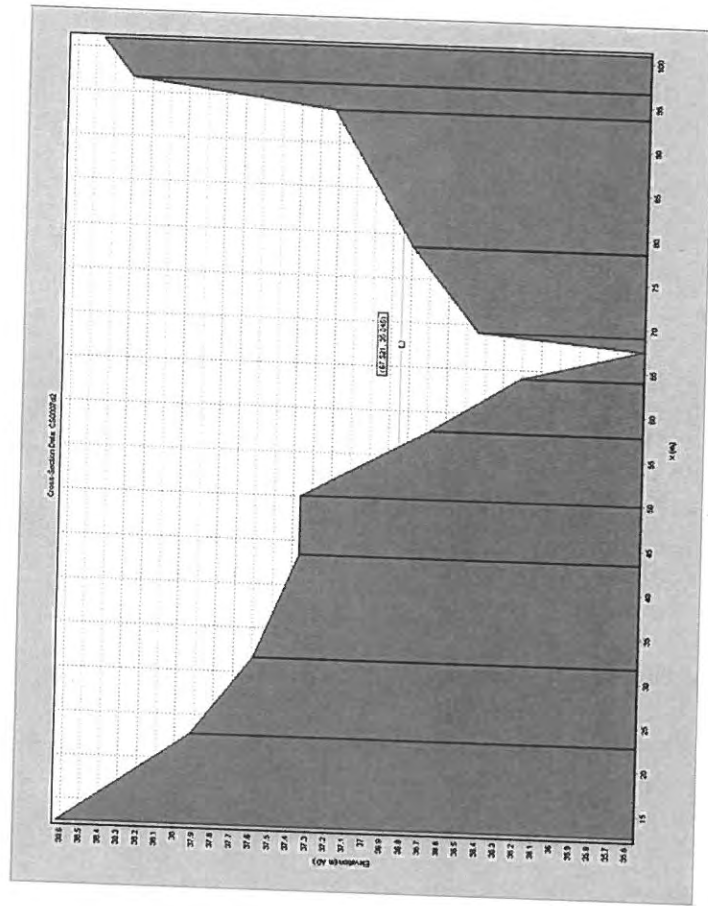
Maximum Stage at HS0474



Maximum Stage at HS0366

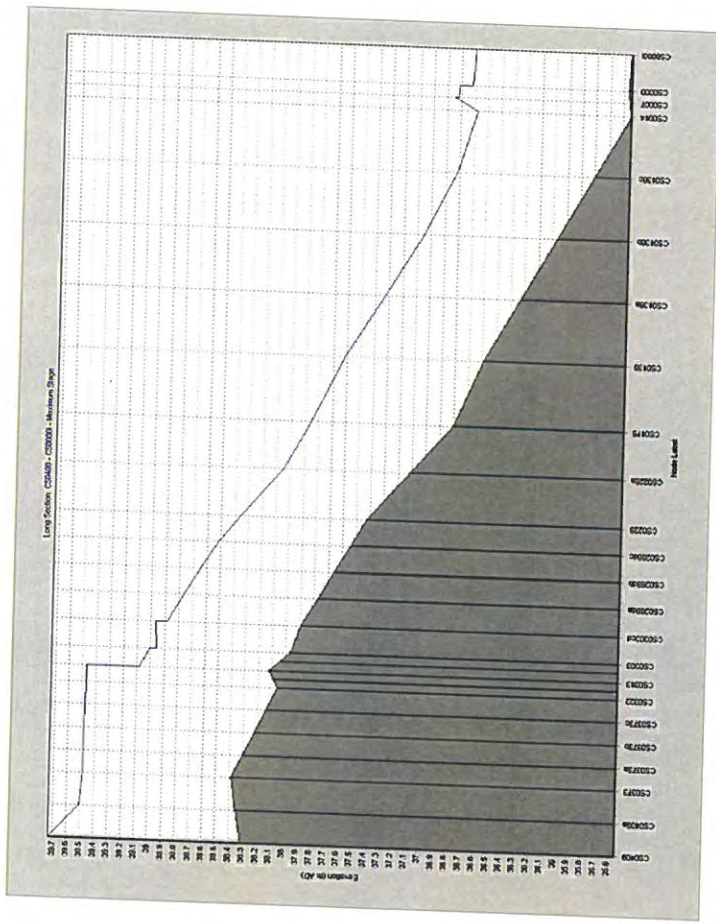


Maximum Stage at HS0243

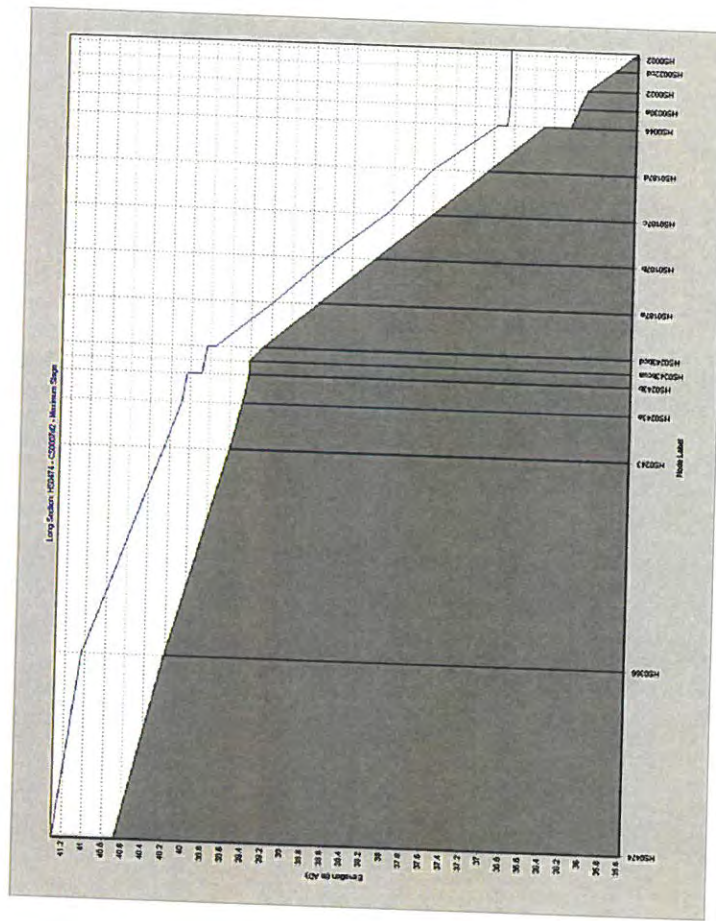


Maximum Stage at CS0007d2 (confluence of Clywedog Stream and Hollies Stream)

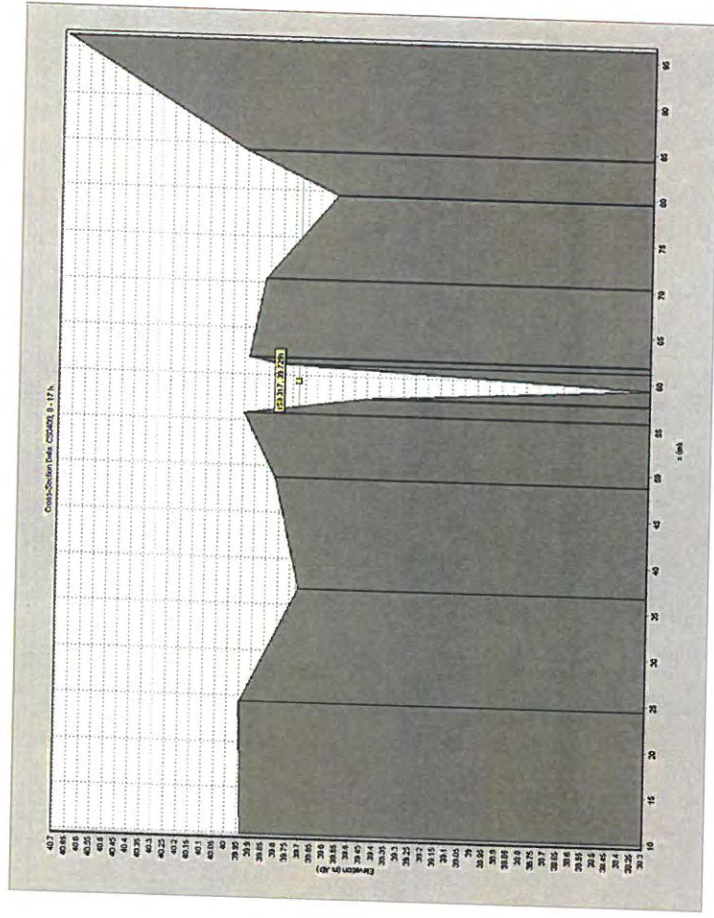
Proposed iSIS outputs representing Maximum Stage at Cross-sections



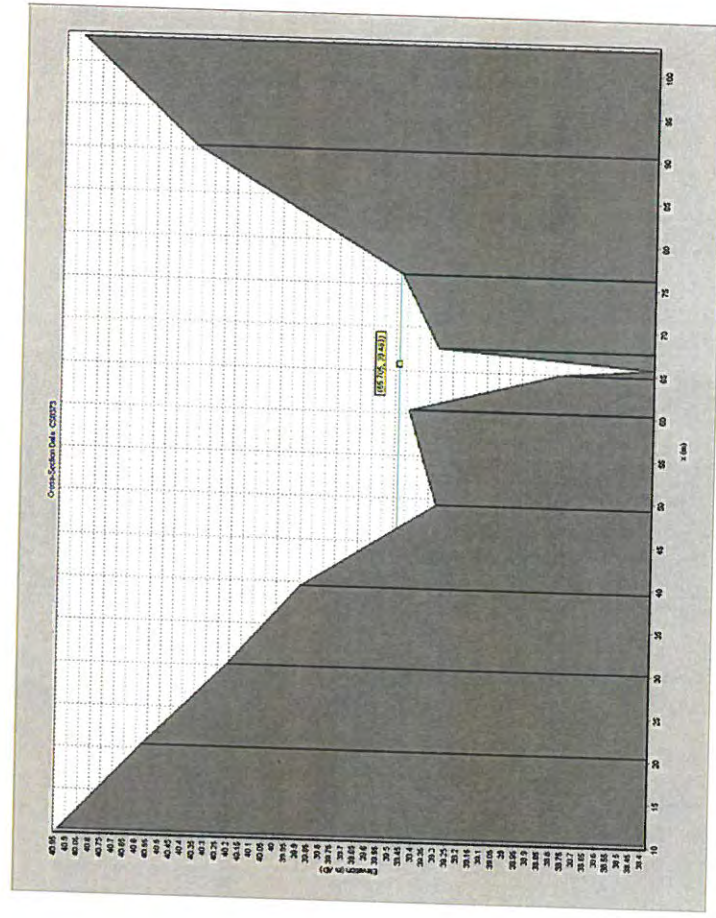
Long Section of Clywedog Stream



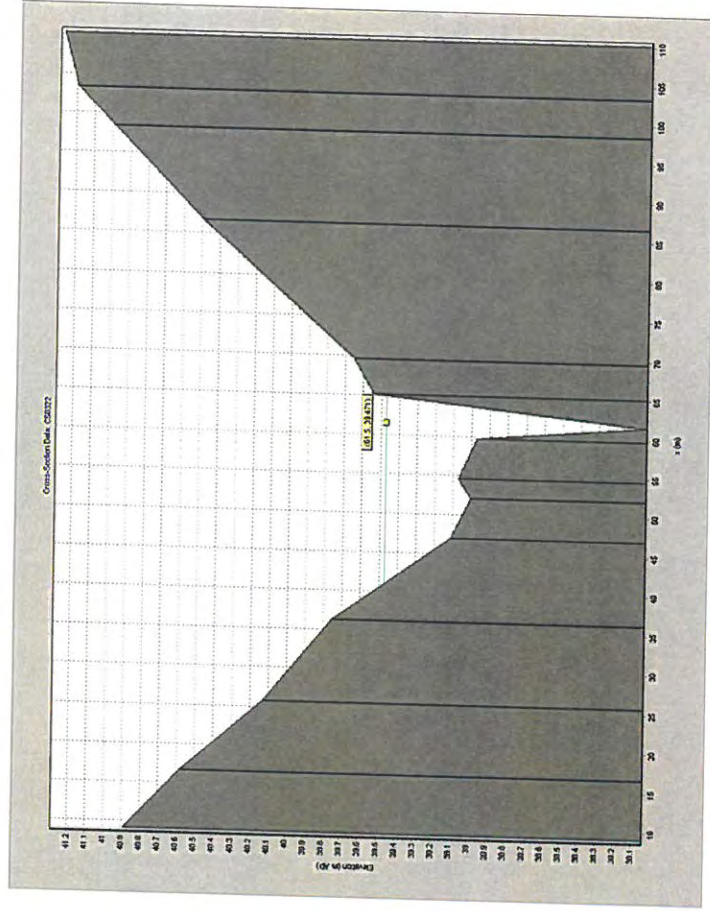
Long Section of Hollies Stream



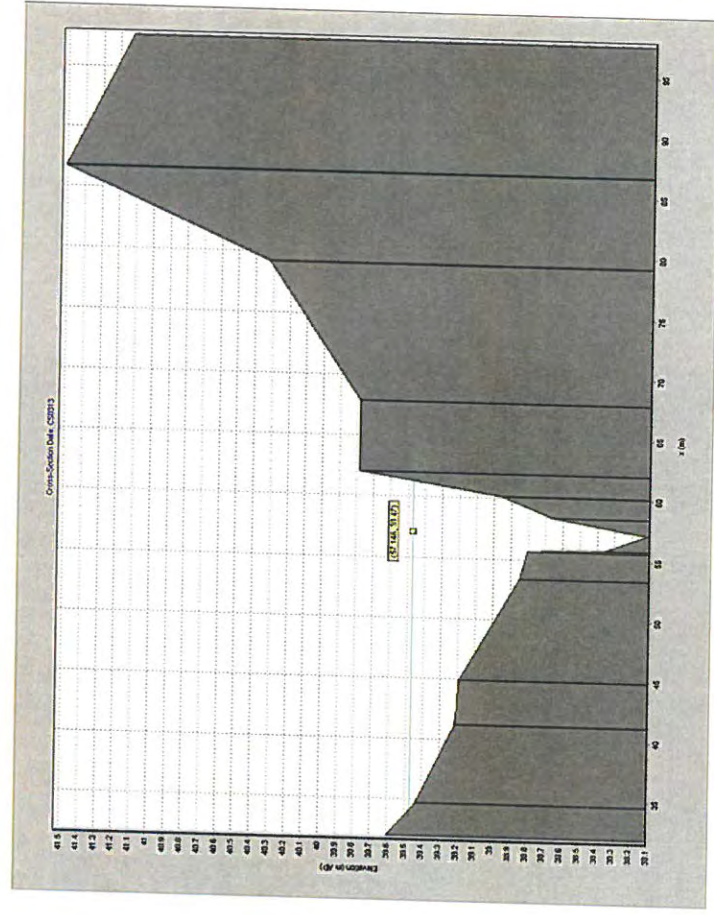
Maximum Stage at CS0409



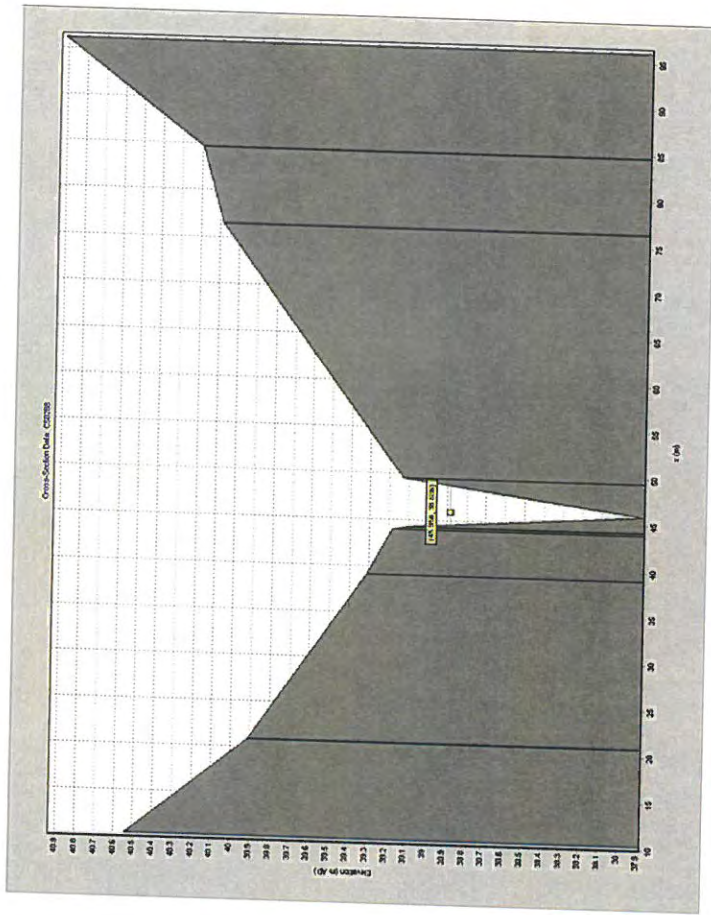
Maximum Stage at CS0373



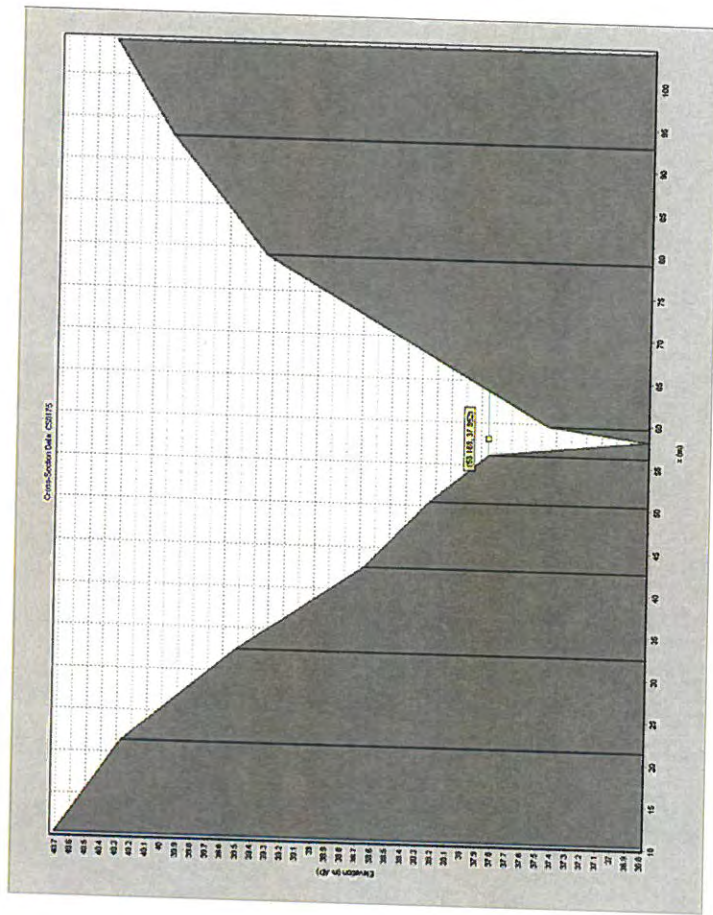
Maximum Stage at CS0322



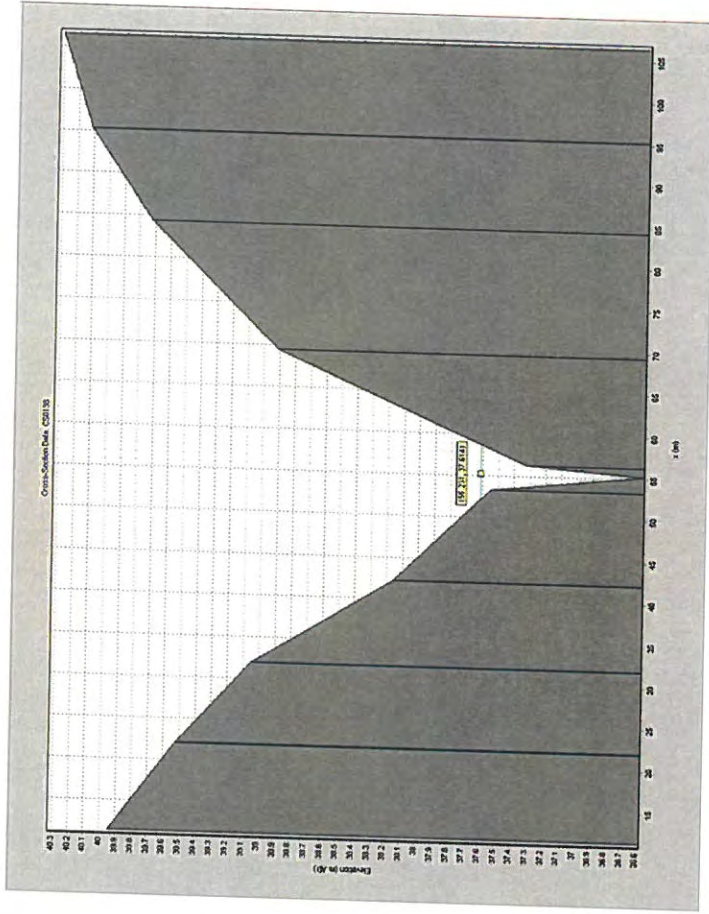
Maximum Stage at CS0313



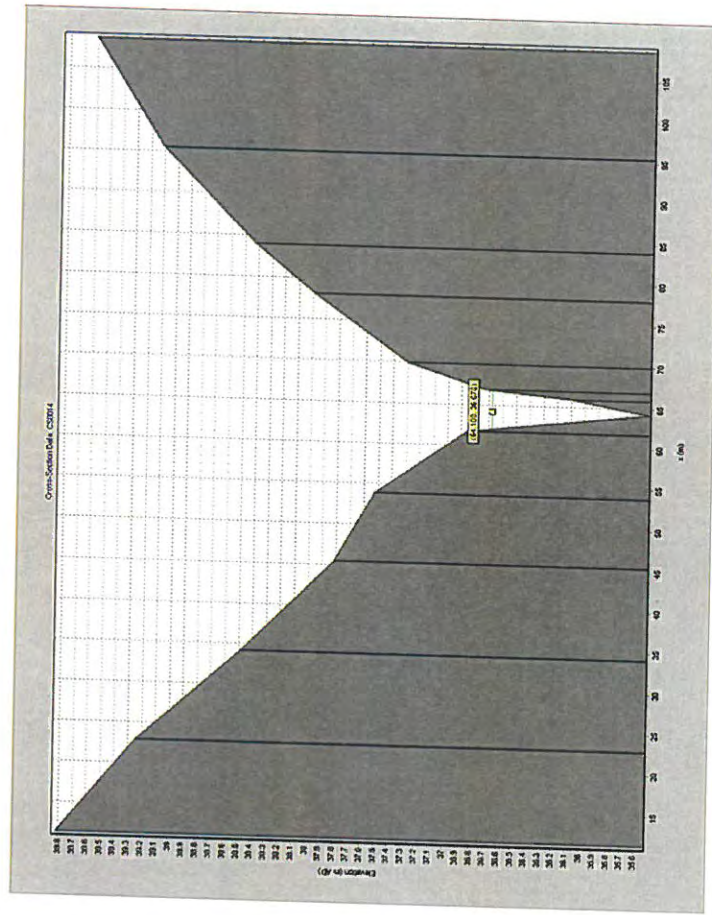
Maximum Stage at CS0228



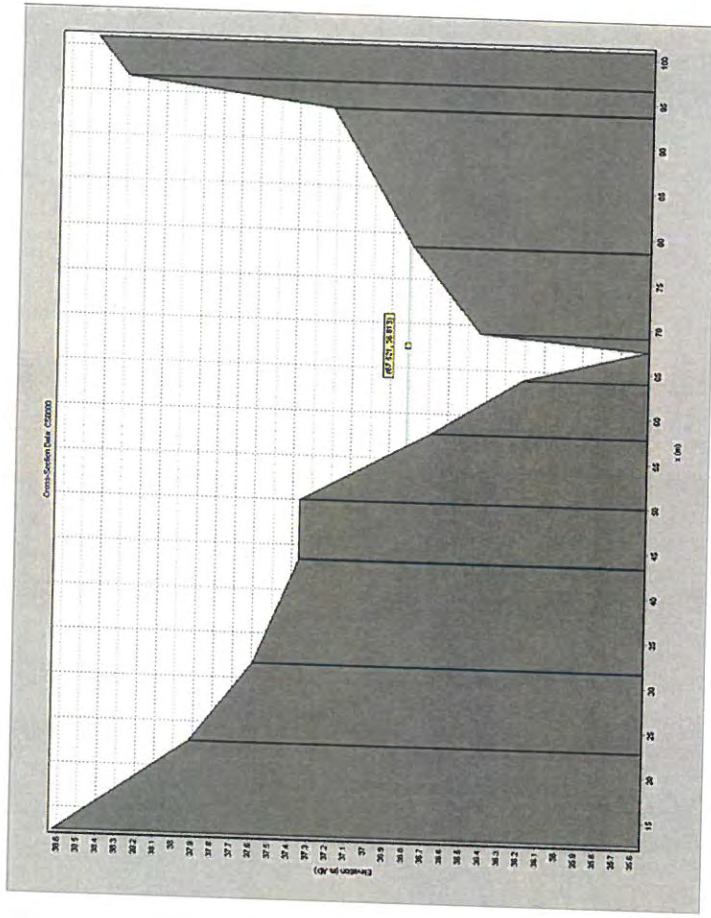
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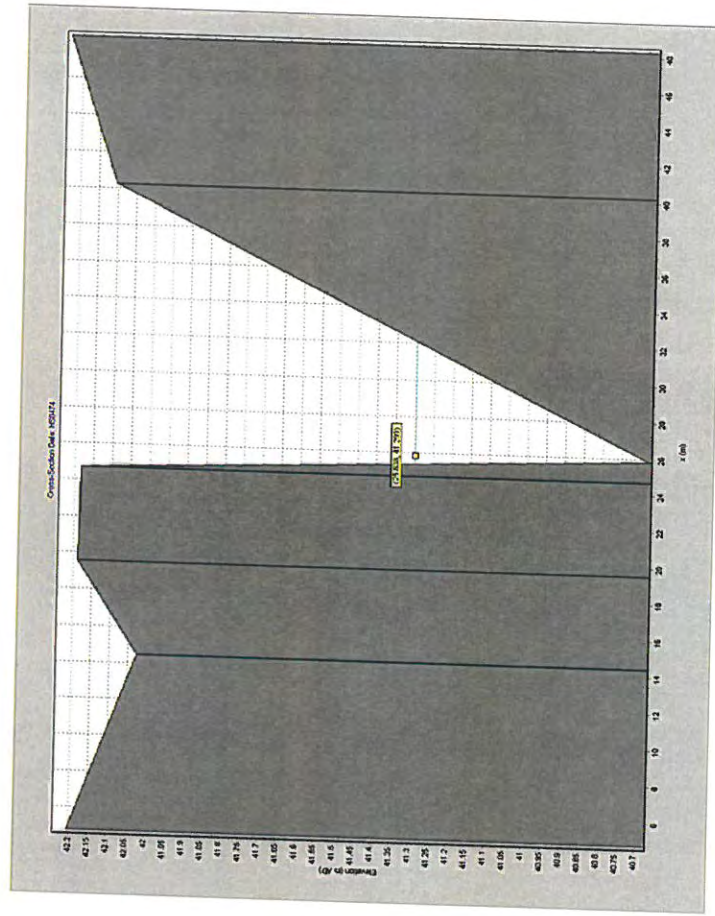
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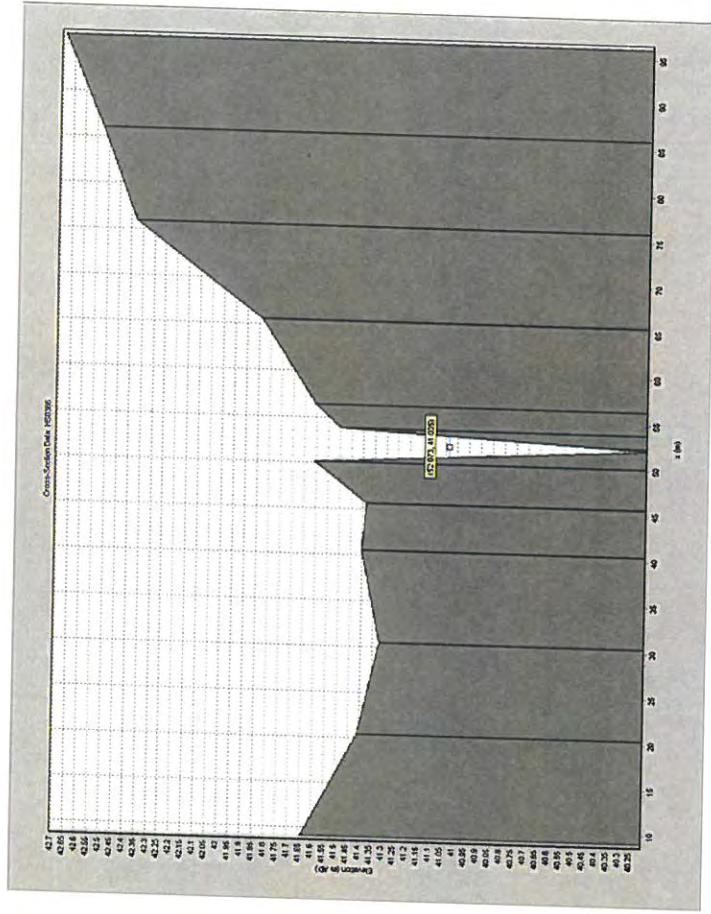
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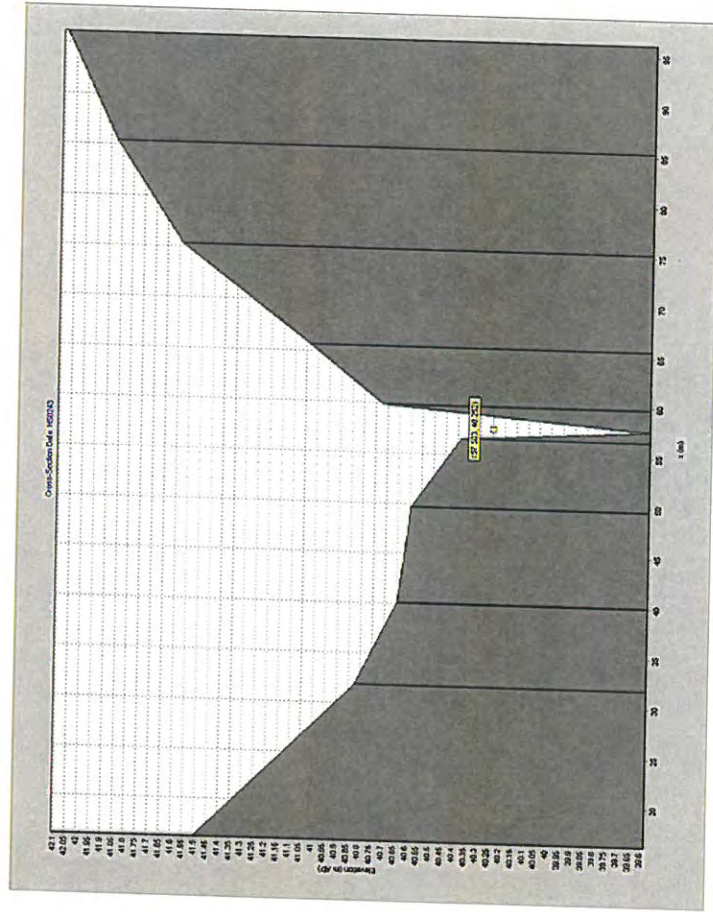
Maximum Stage at CS0000



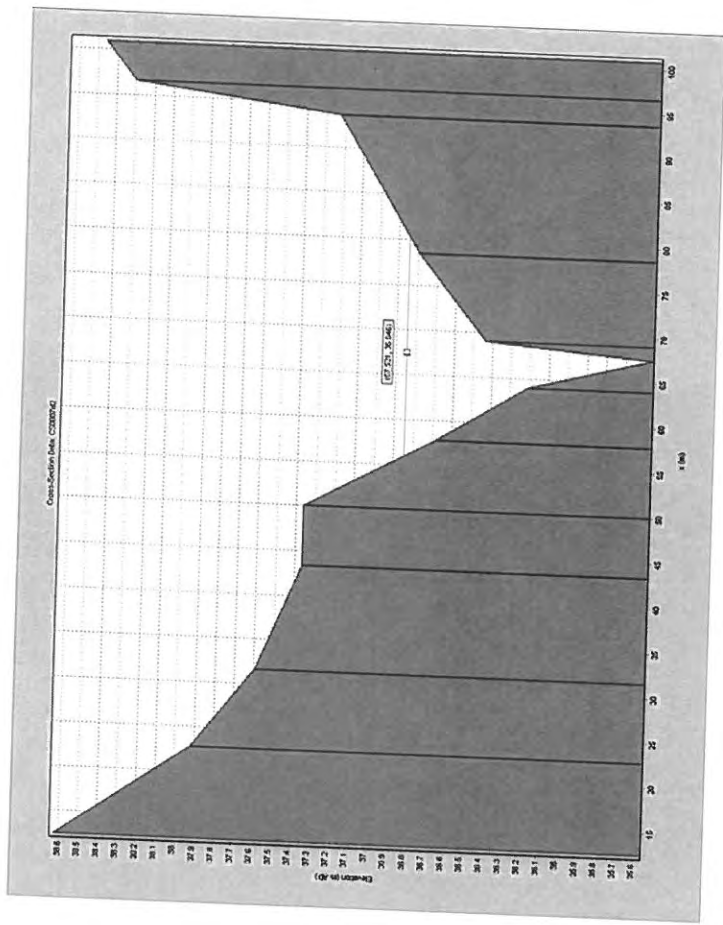
Maximum Stage at HS0474



Maximum Stage at HS0366



Maximum Stage at HS0243



Maximum Stage at CS0007d2 (confluence of Clywedog Stream with Hollies Stream)

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APPENDIX J: HYDRAULIC ASSESSMENT OUTPUTS

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Hydraulic Modelling

Hydrology

Flood Estimation Handbook (FEH) ReFH and statistical analyses were undertaken to determine peak design flows in the Clywedog Stream at a point upstream of Bedwell Road (refer to Appendix A Hydrological Analysis). The peak flows determined from both analyses are shown in Table 1.

Method	2	5	10	20	50	100	200	1000
Stats	1.16	1.60	1.94	2.31	2.88	3.40	4.00	5.85
ReFH	1.69	2.20	2.60	3.00	3.62	4.15	4.83	7.02

Table 1. Comparison of Flood Flows in the Statistical and ReFH analyses

The ReFH flows are consistently higher than the Statistical method flows but without any measured flood or flow data the choice of method is subjective. The policy of NRW is to select the Statistical Method unless any other method can be justified and therefore the Statistical Method has been chosen for the hydraulic analysis

River Model

A 1-dimensional ISIS river model of Clywedog Stream was constructed using a combination of newly obtained cross section data at the Upper and Lower Bedwell bridges and cross section data obtained from the Capita Symonds report *Hydraulic Modelling Technical Report: Clywedog Stream and Hollies Stream*. The model extended from upstream of Upper Bedwell bridge to downstream of Lower Bedwell bridge. The location of the cross sections from the Capita Symonds report is shown in Figure 1. The newly surveyed cross sections are provided in Appendix B – Survey Data)

The model was run in the 1 in 100 year and 1 in 100 climate change events. The amount added on for climate change was 45% which is the upper (90th) percentile for the River Dee catchment anticipated for the 2080s.

Two scenarios were considered:

-  Lower Bedwell Bridge unblocked
-  Lower Bedwell Bridge 95% blocked

The model predicted the peak water levels for both events and scenarios.

Results

The results of the modelling are shown in Table 2. The peak 1 in 100 year and 1 in 100 year plus climate change levels are quoted at the most relevant model nodes for the development site in both the blocked and unblocked scenarios.

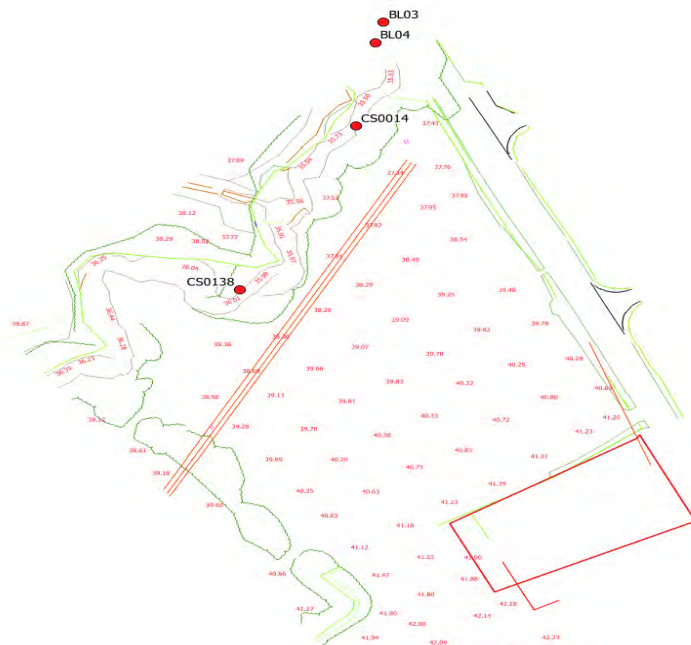


Figure 1: Location of cross section nodes

Model Node	1 in 100 year unblocked (mAOD)	1 in 100 year plus climate change unblocked (mAOD)	1 in 100 year blocked (mAOD)	1 in 100 year plus climate change blocked (mAOD)
CS0138	37.629	37.765	37.905	38.030
CS0014	36.891	37.158	37.842	37.979
BL04	36.828	37.100	37.835	37.967
BL03	36.858	37.123	37.838	37.971

Table 2. Peak water levels from 1-dimensional ISIS model

The ground levels on the development site range from approximately 37.40mAOD at Lower Bedwell Bridge to 38.12mAOD at the upstream boundary of the site (refer to site topographical survey in Appendix C). The results show that the peak water levels in the 1 in 100 year climate change 95% blockage scenario do not pose a flood risk to the site, as illustrated in Figure 3.



Figure 2. Extract from Capita Symonds report showing locations of cross sections

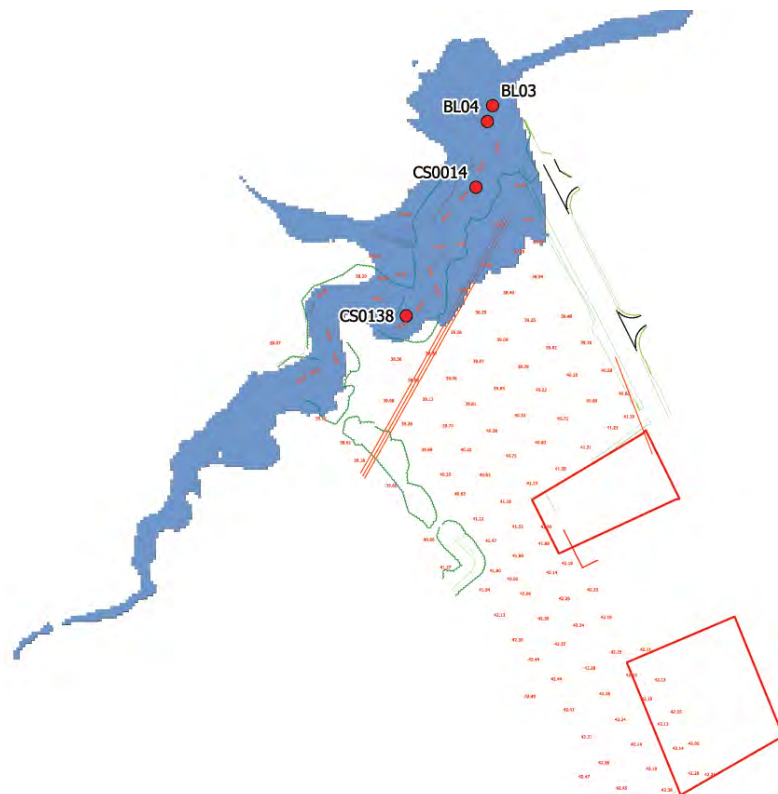


Figure 3. Flood Extent 1 in 100 year climate change levels with 95% blockage at Lower Bedwell Bridge in relation to development site ground levels.

Appendix A

Hydrological Analysis

1 INTRODUCTION

1.1 Site Location

As part of a Flood Study on the Clywedog Stream flood flows are required at Lower Bedwell Bridge (Figure 1.1) in Cross Lanes near Wrexham (SJ 3750 4731).

Figure 1.1 Flow Estimation Location



1.2 Methodology

Flood flows are provided for a range of return periods including the 2 year, 20 year, 100 year and the 1000 year events using methods detailed in the Flood Estimation Handbook (FEH)¹ and the NRW/EA's FEH Guidelines². Flow estimates for extreme events may be quite uncertain hence the approach is to use both (a) the FEH Revised Statistical Pooling Group approach and (b) the Revitalised Flood Hydrograph Method (ReFH) for comparison.

¹ The Flood Estimation Handbook, Centre for Ecology & Hydrology, 1999.

² Environment Agency's Flood Estimation Guidelines, Technical guidance 197_08, January 2015

2 FLOOD FLOW ESTIMATION

2.1 FEH Statistical Method

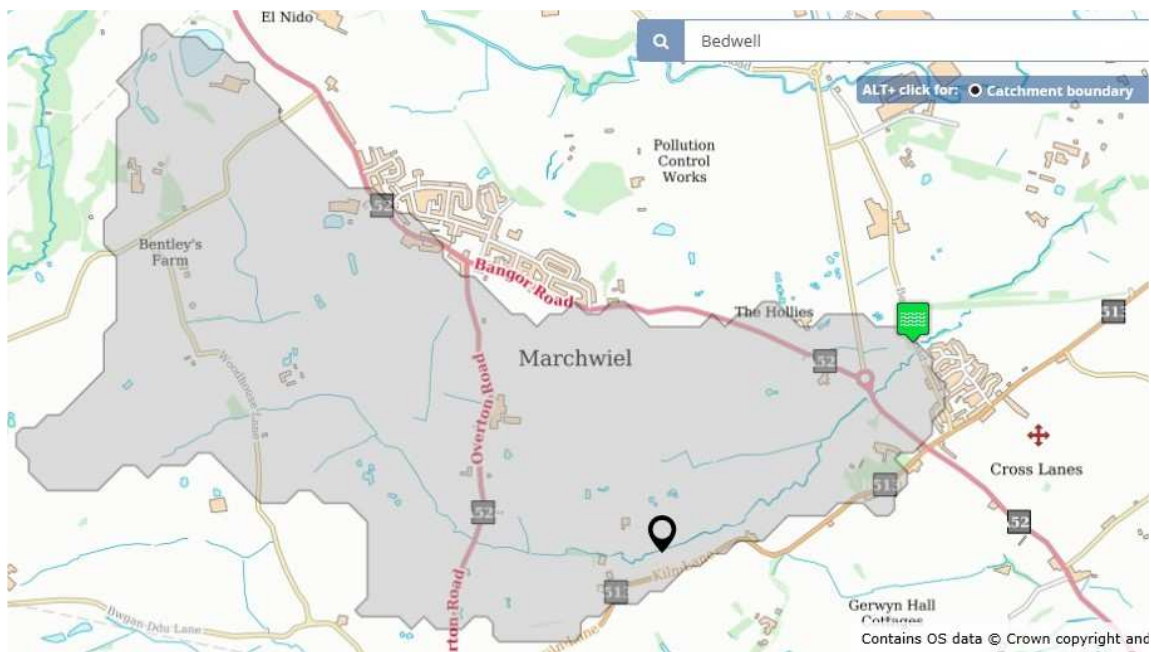
As the sites of interest are ungauged as a first approach it is convenient and appropriate to use the FEH Statistical method based on the FEH catchment descriptors.

2.1.1 Catchment Descriptors

The FEH on line version has been used to provide the catchment delineation (Figure 2.1) which has been checked against OS maps and appears reasonable. A manual adjustment of the FEH catchment area is therefore not required.

This FEH map confirms that the catchment has a simple structure with no lakes, reservoirs or major sub-catchments and hence a simple flood hydrograph response may be expected and as it is essentially rural FEH methods are considered suitable and used to derive flood flows at the location defined above.

Figure 2.1 Clywedog Stream FEH Catchment Delineation



The FEH catchment descriptors (Table 2.1) show the catchment is small (4.15km²) and rural (URBEXT1990 = 0.0056), with no lakes or ponds (FARL = 1.0) and with a high percentage runoff (SPRHOST 38.2%) which suggests no obvious reasons for not using the FEH methods for flood flow estimation. A full definition of these FEH parameters is given in FEH Volume 5.

Table 2.1 FEH Catchment Descriptors

Parameter	Lower Bedwell Bridge
Grid Ref	SJ 37500 47350
AREA	4.1525
FARL	1.0
PROPWET	0.51
BFIHOST	0.431
DPLBAR	2.74
DPSBAR	23.8
SAAR	717
SPRHOST	38.12
URBEXT1990	0.0056
URBEXT2000	0.0060

2.1.2 FEH Index Flood (QMED)

The FEH catchment descriptors are then used to derive QMED, the median annual flood (Table 2.2) using the Revised Stats Method QMED equation³. The EA's FEH guidelines recommend the urban adjusted QMED is used for consistency.

Table 2.2 QMED from Catchment Descriptors

Catchment	QMED RURAL (m ³ /s)	QMED URBAN (m ³ /s)
Lower Bedwell Bridge	1.155	1.162

The QMED-CD at an ungauged site is then adjusted using the ratio between QMED-CD and QMED-Flow data at a nearby local donor gauging station. The EA do not operate any flow or water level recorders on the Clywedog Stream catchment and the nearest stations are on the River Dee at Erbistock Rectory, the Alywn at Pont-y-Capel, the Dee at Maney Hall or the Clywedog further downstream at Bowling Bank (Table 2.3).

Table 2.3 EA Gauging Stations near Cross Lanes, Wrexham

CEH Ref	River	Location	Start Date	End Date	No Years	QMED ?	Pooling ?
67002	Dee	Erbistock Rectory	02-Mar-39	19-Oct-73	36	No	No
67008	Alyn	Pont-y-Capel	01-Oct-65	30-Sep-16	52	Yes	Yes
67015	Dee	Manley Hall	20-Feb-70	30-Sep-16	47	Yes	Yes
67025	Clywedog	Bowling Bank	29-Sep-76	30-Sep-16	41	No	No

The National River Flow Archive and HiFlows database (version 6) indicates:

- 67002, Dee at Erbistock Rectory. A velocity area station replaced by 67015 Manley Hall in 1970. Slight overspilling at very high flows and an unstable rating due to weed growth and natural river channel changes following floods which led to its replacement. QMED and high flow records are not considered suitable.

³ Improving the FEH statistical procedures for flood frequency estimation. CEH Science Report SC050050, July 2008

- 67008, Alyn at Pont-y-Capel. Asymmetrical compound crump weir with two crests. Rating is gauged above QMED which is in bank and with several high flow gaugings above AMAX3 so there is a good confidence in the rating at high flows.
- 67015, Dee at Manley Hal. Two crump weirs which drown above 200m³/s but no bypassing. Gaugings confirm the rating is accurate and flow records are suitable for QMED and pooling.
- 67025, Clywedog at Bowling Bank. A 6m wide Crump profile weir. The channel frequently blocks with debris from fallen trees and branches and the weir drowns at 8m³/s. A road bridge 150m downstream can act as a restriction particularly during high flows. Gauged above QMED but confidence in the rating is low above 8 m³/s and records are not suitable for QMED or pooling.

The timescale of this study does not allow for a detailed analysis of the high flow ratings at these four gauging stations but the flow data is considered suitable for QMED at two stations and hence these station data are used in the flood estimation process described below.

In selecting a suitable donor gauging station FEH also provides hydrological similarity criteria as follows;

- AREA – a factor of 4 or 5
- FARL – a difference of 0.05.
- BFIHOST – a difference of 0.18
- SAAR – a factor of 1.25
- SPRHOST – difference of 15

A comparison of the catchment descriptors at the two gauging stations with the subject site (Table 2.4) suggests both gauges are outside the bounds of hydrological similarity in terms of catchment area and 67015 in terms of FARL and SAAR but neither is ideal as a donor.

Table 2.4 Catchment Descriptors at Flow Estimate Site and Donor Gauging Stations

Site ID	AREA	FARL	BFIHOST	SAAR	SPRHOST	URBEXT90
Site	4.1525	1.0	0.431	717	38.12	0.0056
67008	225.65	0.990	0.591	917	29.84	0.0204
67015	1008.74	0.934	0.431	1367	42.69	0.0025

In the absence of any other stations these two gauges are considered for use as donor sites. A comparison suggests QMED from CDs overestimate that from flow data at both gauges and a reduction factor of 0.59 to 0.664 should be applied to the CD estimates. The Revised Stats method requires this donor ratio is further adjusted based on the distance between the catchment centroids and for the nearest gauge (67008) an adjustment of 0.843 should be applied (Table 2.5).

Table 2.5 QMED Ratio at Potential Donor Gauging Stations

Ref	Centroid Easting	Centroid Northing	QMED-AMAX	QMED-CDs	Distance (km)	Ratio	Revised Ratio
Site	335647	347205					
67008	323013	359066	21.91	37.12	17.33	0.590	0.843
67015	303097	340024	226.00	340.20	33.33	0.664	0.908

As these are not ideal as donor stations for the reasons given above the catchment descriptors estimates of QMED are adopted based on a donor adjustment factor of 1.0 to give final QMED estimates (Table 2.6) which is possibly a conservative estimate.

Table 2.6 Adopted and Adjusted QMED from Catchment Descriptors

Catchment	QMED RURAL (m ³ /s)	QMED URBAN (m ³ /s)	QMED Adjustment Ratio	Adopted QMED (m ³ /s)
Lower Bedwell Bridge	1.155	1.162	1.0	1.162

2.1.3 Flood Frequency Curve

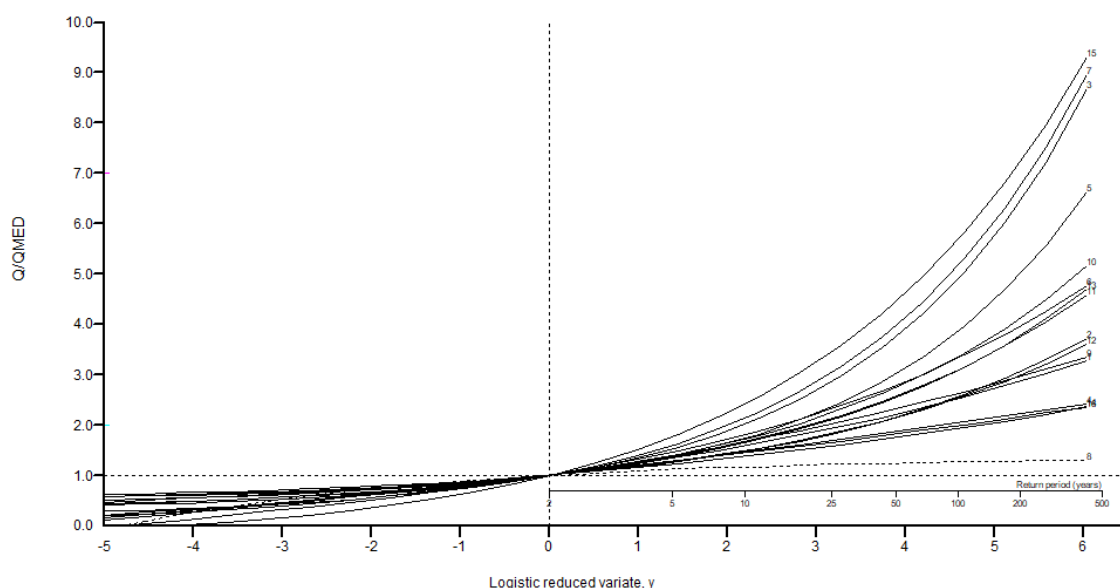
The calculation of a flood frequency curve and peak flows for a range of return periods then requires the construction of a pooling group and the fitting of an extreme value distribution to the annual maximum flow data from hydrologically similar sites (pooling group) using WINFAP4.

The initial pooling group contains 17 stations with 540 station years of record but one station was removed for having less than the required 8 years of data (Bollingey Stream @ Bollingey Cocks Bridge) leaving 16 stations with 534 station years of record. Examination of the pooling group indicates it is heterogeneous and a review considered desirable ($H_2 = 2.956$) but a review of this pooling group suggests no obvious or valid reason to remove any of the component stations. This discordancy arises as several of the component stations (Table 2.7) have relatively steep growth curve (Figure 2.2) and some very flat but there was no justification for removing any sites from the group.

Table 2.7 Component Stations of Pooling Group – Clywedog Stream

Station	Dist	Yrs data	QMED AMAX	L-CV	L-SKEW	Discord ancy
27051 (Crimple @ Burn Bridge)	1.418	44	4.539	0.223	0.156	0.475
76011 (Coal Burn @ Coalburn)	1.573	39	1.840	0.164	0.316	1.109
45816 (Haddeo @ Upton)	1.589	23	3.456	0.307	0.418	0.604
27073 (Brompton Beck @ Snainton Ings)	1.766	35	0.820	0.200	0.049	1.071
28033 (Dove @ Hollinsclough)	1.844	37	4.200	0.237	0.418	0.624
26802 (Gypsy Race @ Kirby Grindalythe)	2.042	17	0.116	0.274	0.240	0.132
25019 (Leven @ Easby)	2.049	38	5.333	0.338	0.391	1.065
49006 (Camel @ Camelford)	2.258	10	11.350	0.120	-0.269	3.023
47022 (Tory Brook @ Newnham Park)	2.295	23	7.123	0.262	0.115	0.902
25011 (Langdon Beck @ Langdon)	2.314	28	15.878	0.238	0.318	1.301
27010 (Hodge Beck @ Bransdale Weir)	2.434	41	9.420	0.224	0.293	0.130
25003 (Trout Beck @ Moor House)	2.441	43	15.164	0.170	0.288	0.616
71003 (Croasdale Beck @ Croasdale Flume)	2.468	37	10.900	0.212	0.323	0.314
203046 (Rathmore Burn @ Rathmore Brd)	2.491	34	10.788	0.146	0.136	0.588
44008 (Sth Winterbourne @ W Steepleton)	2.506	37	0.448	0.416	0.326	2.440
206006 (Annalong @ Recorder)	2.566	48	15.330	0.189	0.052	1.604

Figure 2.2 WINFAP Component Stations – Clywedog Stream



WINFAP4 is often found to provide discordant pooling groups and this arises because it uses the FEH parameters FARL and FPEXT to generate a pooling group, which are measures of flood storage and attenuation, whereas the original WINFAP was based on the soil or geology as reflected in BFIHOST. It is considered that WINFAP4 will always provide a more discordant pooling group as the shape of the growth curves of the component stations is more likely to be a function of the geology. However, the EA FEH Guidelines require the use of WINFAP4 and this method is therefore adopted in this report.

Two extreme value distributions are often used on the pooled group data (i) the Generalised Logistic (GL), and (ii) the General Extreme Value (GEV) distribution both fitted to the annual maximum data by the method of L-Moments. FEH indicates that the GL distribution can often provide the best fit to extreme value flood series and in this case WINFAP4 confirms the GL is the most acceptable distribution for this site and this is used to provide the estimated flood flows (Table 2.8). This gives a 100 year flood flow of 3.40m³/s and a 1000 year of 5.85m³/s.

Table 2.8 Estimated Flood Flows – Stats Method

Site	Return Period (Years)							
	2	5	10	20	50	100	200	1000
Lower Bedwell Bridge	1.16	1.60	1.94	2.31	2.88	3.40	4.00	5.85

2.2 Revitalised Flood Hydrograph Method (ReFH)

An alternative approach to flood estimation is to use the flood hydrograph methods. The original FSR/FEH rainfall runoff method (RR) underwent significant modification in 2006 taking advantage of new data and more advanced hydrological modelling techniques since the original method was developed. The improved or Revitalised Flood Hydrograph method (ReFH) retains the overall structure of the earlier FSR/FEH RR approach but with various improvements and

hence ReFH is now preferred to RR. ReFH is therefore used to derive peak flows for the specified design events based on the time to peak (T_p) and critical storm duration (Table 2.9) adjusted to be an odd multiple of the selected time step.

Table 2.9 ReFH Time to Peak and Critical Storm Duration

Site	T_p	C_{max}	BL	BR	Duration (hrs)	Time Step (hrs)	Critical Dur (hrs)
Lower Bedwell Bridge	2.41	315.3	29.8	1.186	4.13	0.25	4.25

The derived flows (Table 2.12) show that the ReFH flood flows are higher than the Stats Method with a 100 year flood flow of $4.15\text{m}^3/\text{s}$ and a 1000 year of $7.02\text{m}^3/\text{s}$ (Table 2.10).

Table 2.10 ReFH Flood Estimates (m^3/s)

Location	Return Period (Years)							
	2	5	10	20	50	100	200	1000
Lower Bedwell Bridge	1.69	2.20	2.60	3.00	3.62	4.15	4.83	7.02

The ReFH hydrographs can be generated within Flood Mapper or ISIS using the ReFH boundary unit.

3 DISCUSSION

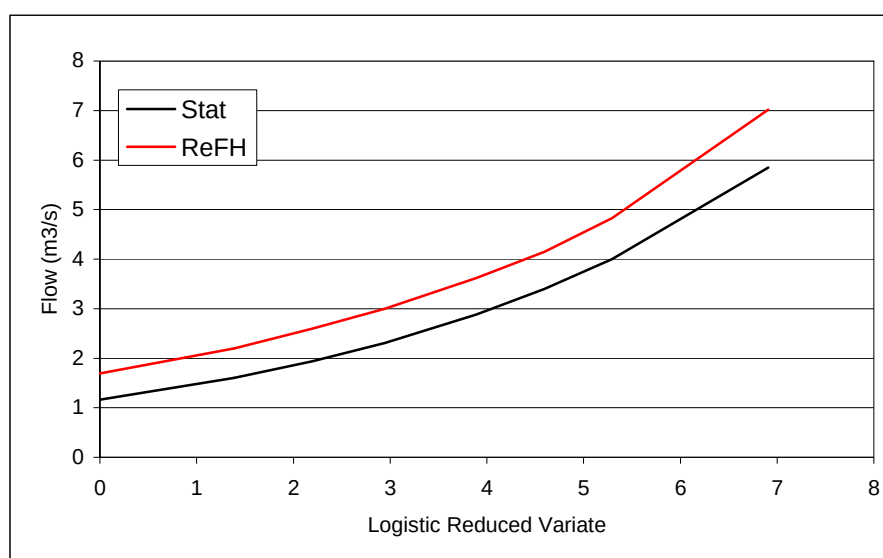
3.1 Comparison of Flood Estimates

As detailed above the QMED and the more extreme flood flows from ReFH are higher than the Stats method (Table 3.1) but there is no justification for preferring either method. The ReFH flows are consistently higher than the Stats method (Figure 3.1) but without any measured flood or flow data the choice of method is subjective.

Table 3.1 Comparison of Flood Flows

Method	2	5	10	20	50	100	200	1000
Stat	1.16	1.60	1.94	2.31	2.88	3.40	4.00	5.85
ReFH	1.69	2.20	2.60	3.00	3.62	4.15	4.83	7.02

Figure 3.1 Comparison of Flood Flow Estimates



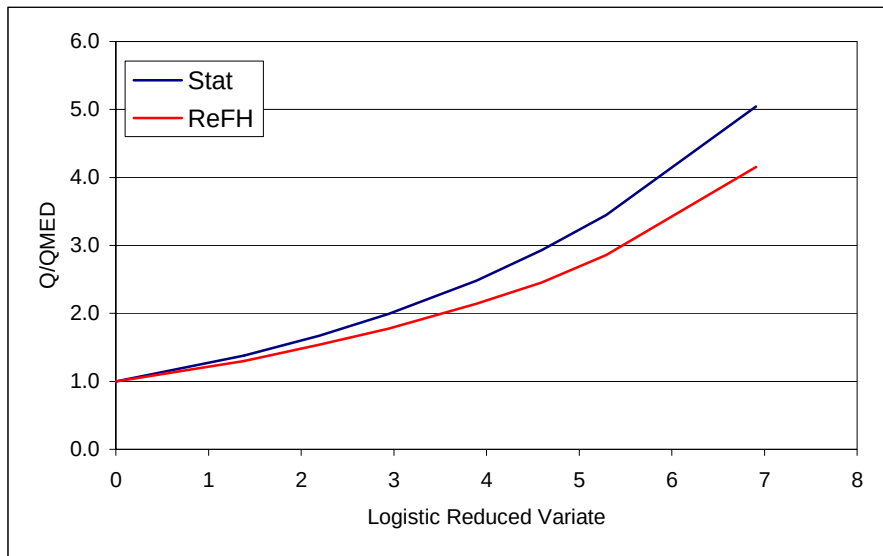
3.2 Comparison of Flood Growth Curve

The flood growth curves (Table 3.2) show that ReFH has a slightly flatter growth curve than the Stats method (Figure 3.2) but these are reasonably similar and it is the choice of QMED which is the main difference between the two methods.

Table 3.2 Comparison of Flood Growth Curves

Method	2	5	10	20	50	100	200	1000
Stat	1.0	1.379	1.672	1.991	2.483	2.931	3.448	5.043
ReFH	1.0	1.302	1.538	1.775	2.142	2.456	2.858	4.154

Figure 3.2 Comparison of Flood Growth Curves



The EA's FEH Guidelines emphasise that historical flood data can be particularly valuable as a guide to confirming extreme flood events but no such data are available on this catchment. In some cases, this can be used to confirm which of the estimated extreme flood flow methods are the more realistic. The statistical method estimates of QMED is normally preferred as this is based on measured flow data although in this case QMED is not adjusted using local flow data and as the pooling group is based on recorded flow data.

3.3 Hybrid Method

To incorporate these flood flows and generation of flood hydrographs can be achieved in ISIS or Flood Mapper using the ReFH boundary unit and importing the FEH catchment descriptors CSV file. Under Options the peak flood flow of the generated ReFH hydrograph can be forced to fit the peak flow given by the Stats method, referred to as the hybrid method.

3.4 Climate Change

A suitable allowance for increased river flow due to climate change should then be considered based on the EA's February 2016 guidance.

Appendix B

Survey Data

Appendix C

Topographical Survey

APPENDIX K: PFRA/SPRA INFORMATION

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4. Historic/Past Flood Risk

All records of previous flooding incidents in WCBC were collected from the data sets listed in Chapter 3, methodology, within Table 2. These flood events came from a range of flood sources, and in many cases the source of flooding was unknown or not recorded. A summary of information specific to each source of flooding considered as part of the PFRA are included below. The locally agreed surface water information was determined by combining a number of data sets from a range of organisations as described in Table 2 Chapter 3. The figure within this Chapter show the data sets used to determine the impacts of historic flood risk.

4.1. Surface Water Flooding

Surface Water Flooding (SWF) occurs following intense rainfall which, due to the large volume of water exceeds the ability of the drainage systems to cope. Due to its sudden nature there is no lead time as is often the case with pluvial and fluvial flooding. This sudden rise in water levels can cause localised flooding, often affecting individual streets and/or properties as the drainage network is unable to cope.

Within the WCBC area this was the most prominent cause of flooding from the three sources the LLFA is required to assess. The main source of flooding was predominantly from surface water run off from paved surfaces frequently becoming an issue as the flooded property was below the level of the road surface. Insufficient drainage or blockages of the drainage system was also a major cause of this surface water runoff. Figure 3 below shows the results of both the external questionnaire, as well as the internal data collection.

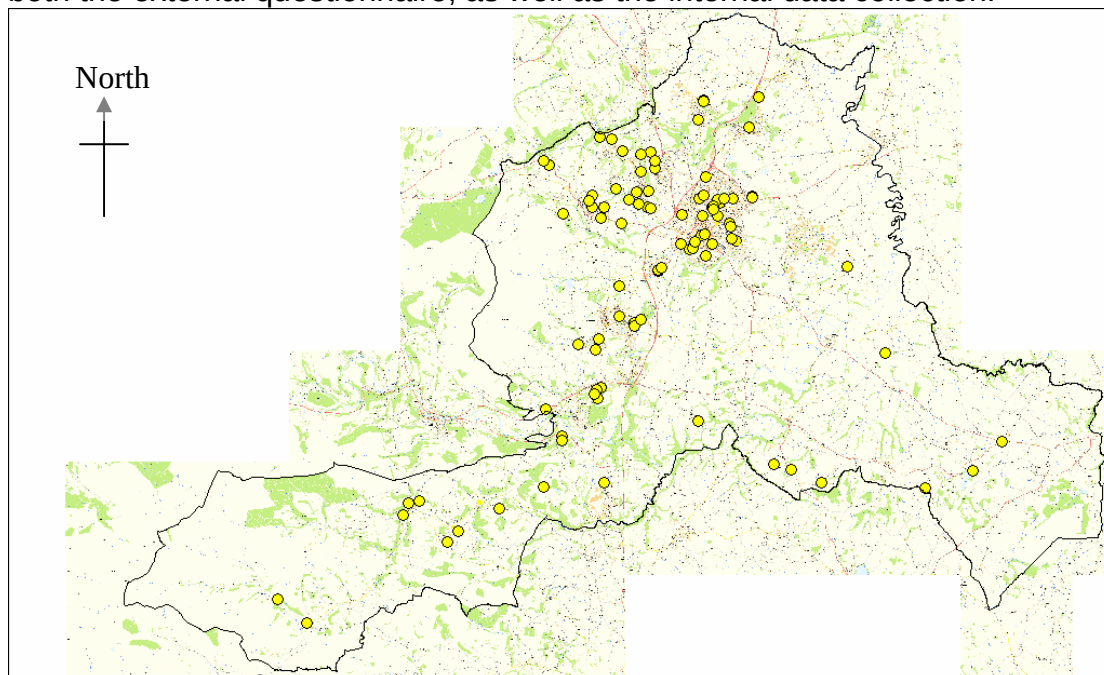


Figure 3 - Flooding Incidents within WCBC

still the case as with surface water none of the affected areas meet the requirements set by EA/WAG to be counted as an IFRA. Figure 4 below shows all sewer flooding incidents within the WCBC area over the last 10 years. This information was taken from the data set provided by WW/DC. Note that all flooding incidents in figure 4 are a combination of both internal and external flooding.

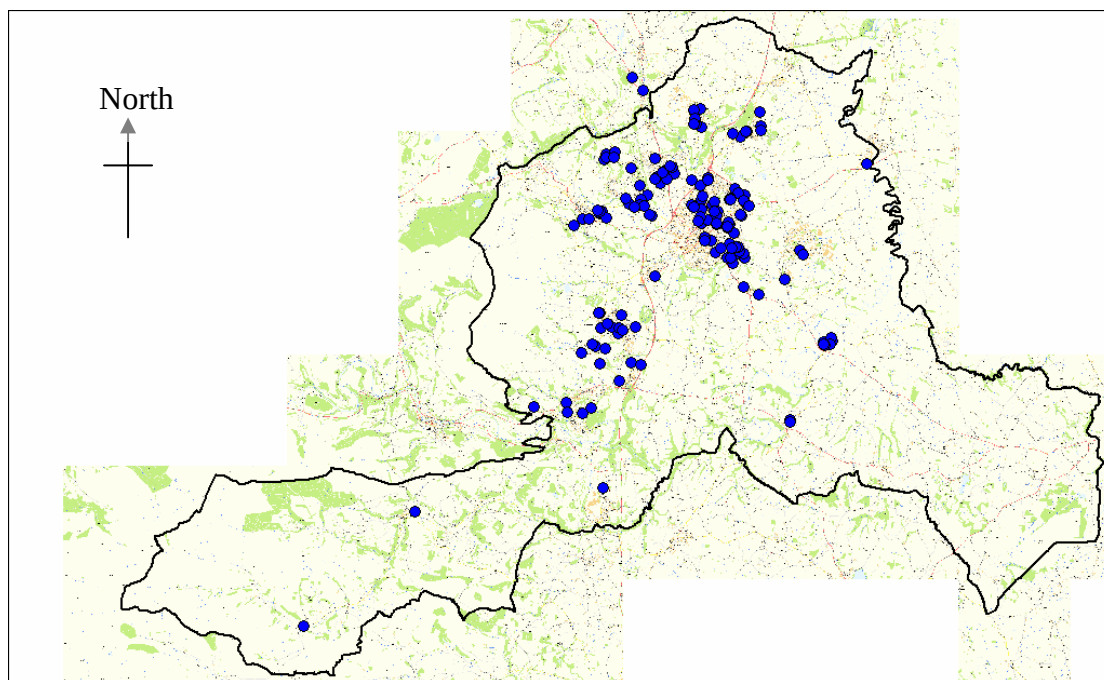


Figure 4 - Sewer Flooding Incident

4.4. Canal and Ordinary Watercourse Flooding

Information was obtained from British Waterways detailing the canal network throughout WCBC including the location of canals, weirs, sluices and locks. There are no historic records of canal overtopping or flooding issues from a canal within WCBC which meet the criteria for a significant flooding. There were a few events of canal breach/overtopping within the WCBC area which only affected rural areas and were caused by badgers burrowing under the canal in two cases. The first, in 2004, only flooded rural areas; the second in 2009 caused flooding and the evacuation of 1 property as well as causing water damage to a car. Both these incidents occurred around the village of Bettisfield. All incidents are shown on Figure 5 overleaf.

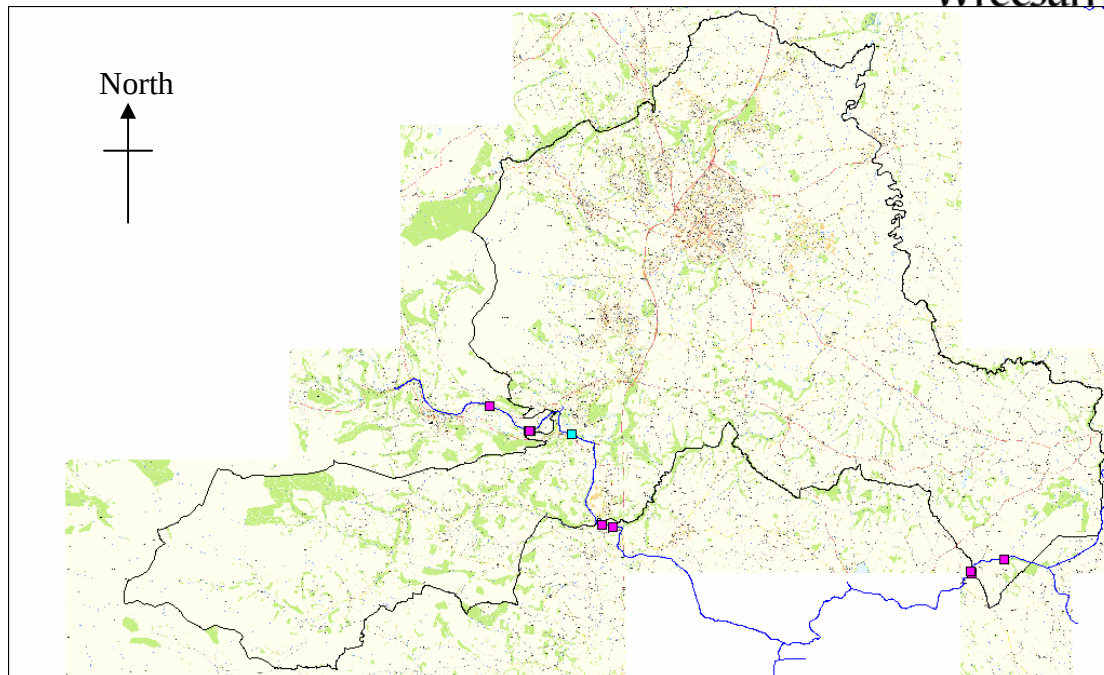


Figure 5 - Canal Flooding Incidents

4.5. Interaction with Main Rivers and the Sea

Insufficient data was available to draw definitive conclusions at this point. However, there is anecdotal evidence to suggest that surface water flooding is exacerbated in some areas, such as Bangor on Dee when the river is in flood. This occurred during the November 2000 floods when the one-way flap valves were unable to open due to the river level being above them, with the pressure of the river keeping the flap closed. As a consequence of this, High Volume Pumps (HVP's) pumps were brought in to extract the excess surface water in to the river system.

4.6. Consequence of Historic Flooding

As a result of the issues discussed in Chapter 3 methodology, insufficient data is available to draw definitive conclusions on the impacts and consequences of historic flood events on people, the economy and the environment. Due to the lack of information available, no historic flood events have been considered to have had 'significant harmful consequences' if the criteria set by the EA is used. Therefore Annex 1 of the Preliminary Assessment Report (PAR) which is the Spreadsheet containing information on past flood risk shall have a nil return. However, the information gathered and collated on past flood events shall be stored and used by WCBC in order to complete the LFRMS. Continuing to update this database at regular periods will allow a comprehensive picture of flooding in the WCBC area to be compiled, which will provide the foundations of the LFRMS.

flooding then the area is defined as an Indicative Flood Risk Area. The WCBC area has 20 locations above Flood Risk Thresholds (Signified by the red squares in figure 6 below), However the population of these squares is still below the threshold of 5000 people meaning that they are not classed as an IFRA.

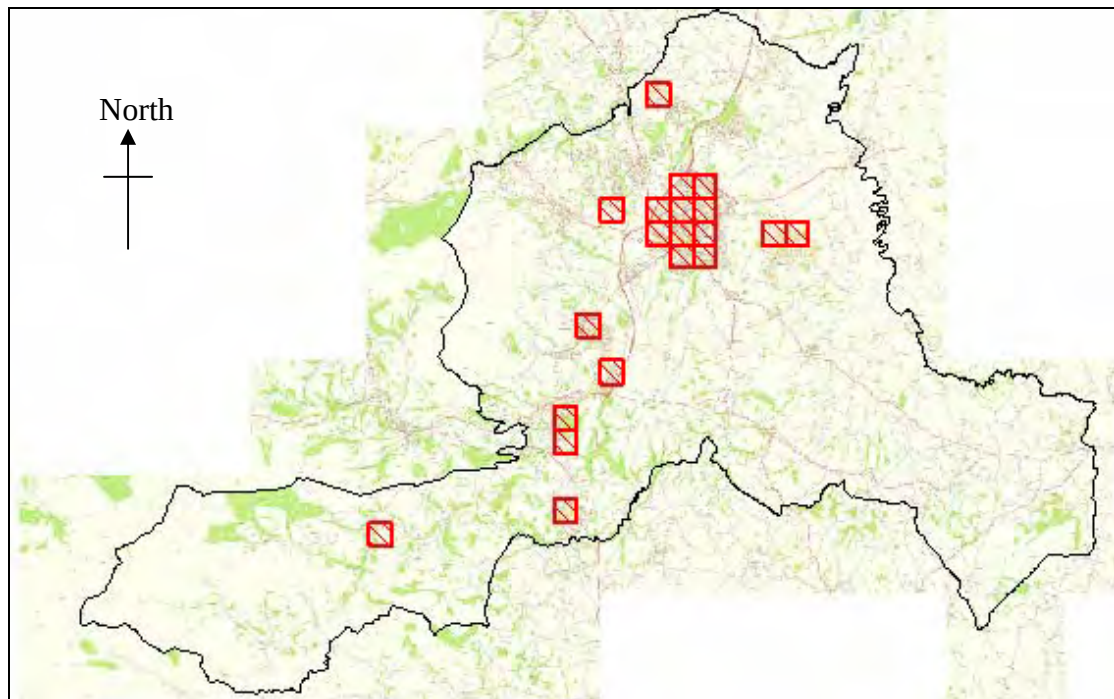


Figure 6 - Indicative Flood Risk Areas

6.3. Review of indicative Flood Risk Areas

As part of the PFRA process reviewing the areas defined by the EA as IFRA must be undertaken. Having collected, collated and assessed the numerous data sets from a range of organisations it is clear that there shall be no amendments to the IFRA as identified by the EAW, or the need to include any new ones as there are no areas that match the criteria set by DERFA/WAG. Due to this WCBC shall return a nil return for the spreadsheet for updating and reviewing of the IFRA.

For the future review of the PFRA, which shall be undertaken in 2017 there is likely to be a change to the indicative flood risk areas due to the expanding population and constraints they will place upon the local drainage infrastructure. It is predicted that the thresholds for what constitutes a flood risk area shall also be redefined for future work, which will also have an impact upon the areas defied as being at risk.

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APPENDIX L: SURFACE WATER RUN-OFF CALCULATIONS

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VERSION	FEH CD-RO Version	3 exported at	13:40:54 GMT	Thu	06-Apr-17
CATCHMENT	GB	337400	347250 SJ 37400 47250		
AREA	4.09				
ALTBAR	60				
ASPBAR	118				
ASPVAR	0.49				
BFIHOST	0.432				
DPLBAR	2.6				
DPSBAR	23.7				
FARL	1				
LDP	4.92				
PROPWET	0.51				
RMED-1H	9.2				
RMED-1D	29.3				
RMED-2D	36.9				
SAAR	718				
SAAR4170	752				
SPRHOST	38.09				
URBCONC1	0.25				
URBEXT199	0.0055				
URBLOC199	1.042				
C	-0.02482				
D1	0.32356				
D2	0.40463				
D3	0.3148				
E	0.28549				
F	2.37749				
C(1 km)	-0.025				
D1(1 km)	0.309				
D2(1 km)	0.419				
D3(1 km)	0.307				
E(1 km)	0.285				
F(1 km)	2.391				

DESIGN RAINFALL

Calculate : Design rainfall for

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☐ 1 km grid point 338000 347000 [SJ 38000 47000]
☐ Manually entered values ☐ for a point

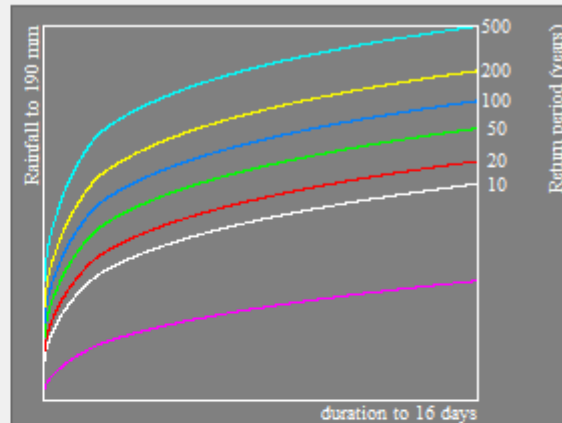
Area : km²

C : D3 :
 D1 : E :
 D2 : F :

Duration : Hours ☐ Fixed ☒ Sliding
 Return period : Years ☒ AM ☐ POT

Rainfall depth mm

 An areal reduction factor of 0.967 has been applied to a point rainfall of 11.7 mm to yield a catchment design rainfall of 11.3 mm.



Calculate : Design rainfall for

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☐ 1 km grid point 338000 347000 [SJ 38000 47000]
☐ Manually entered values ☐ for a point

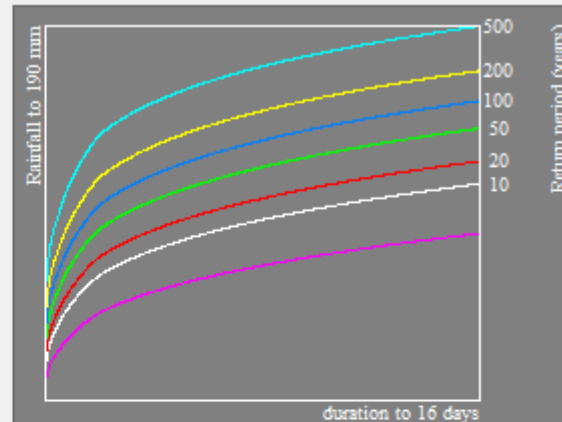
Area : km²

C : D3 :
 D1 : E :
 D2 : F :

Duration : Hours ☐ Fixed ☒ Sliding
 Return period : Years ☒ AM ☐ POT

Rainfall depth mm

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Calculate : Design rainfall for

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Area : km²

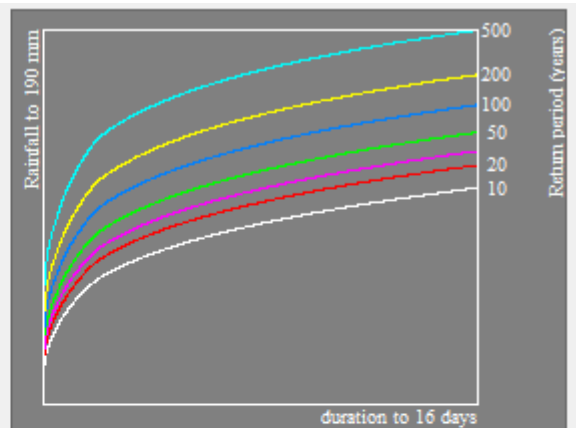
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 D1 : E :
 D2 : F :

Duration : Hours ☐ Fixed ☒ Sliding
 Return period : Years ☒ AM ☐ POT

Rainfall depth mm

Calculate... Export... Cancel

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Calculate : Design rainfall for

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☐ Manually entered values ☐ for a point

Area : km²

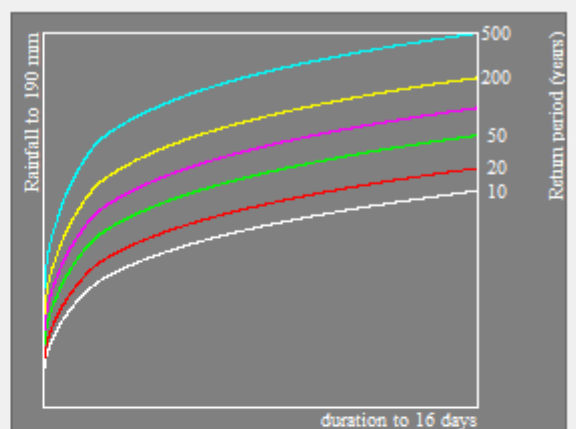
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 D2 : F :

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 Return period : Years ☒ AM ☐ POT

Rainfall depth mm

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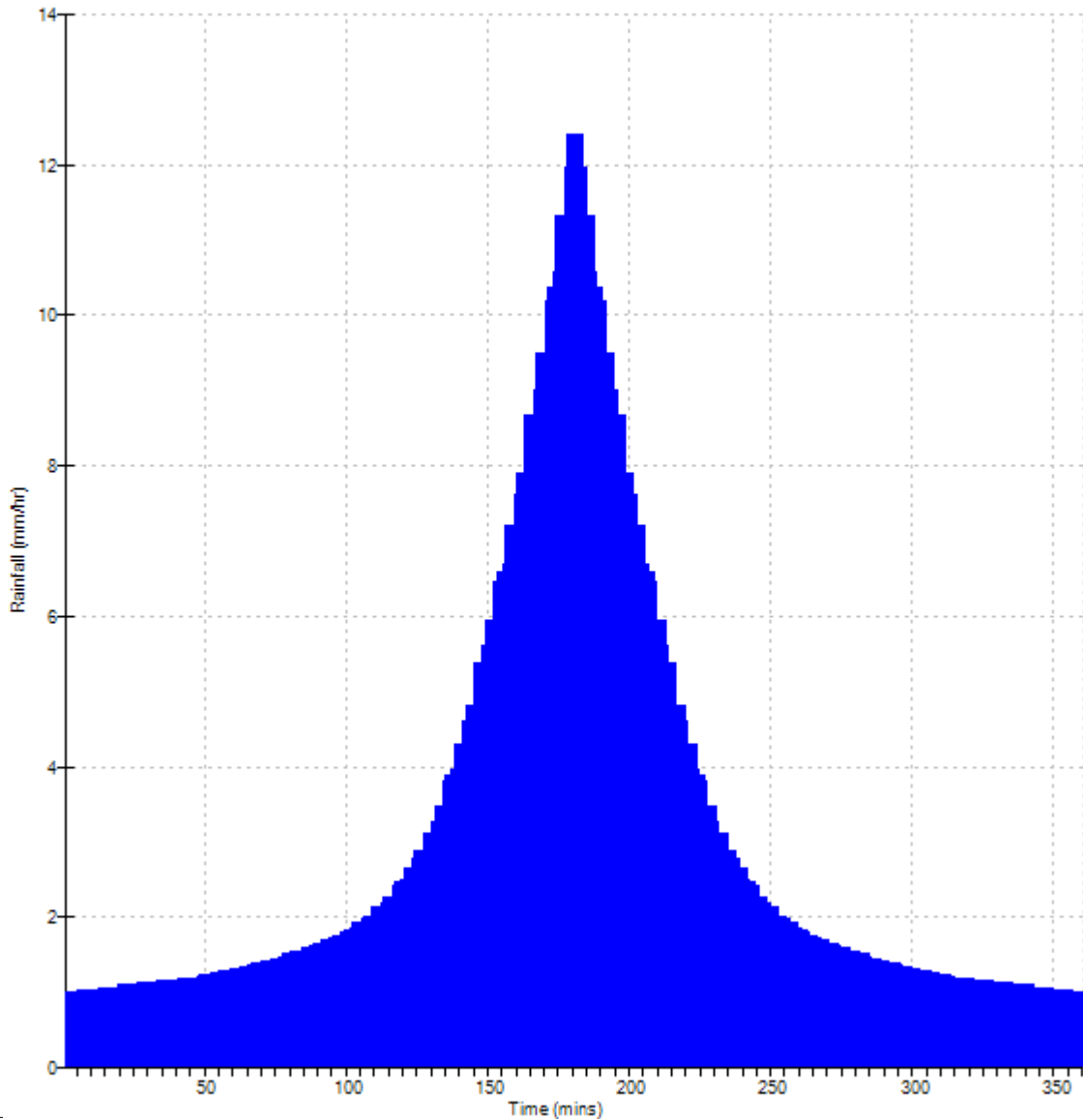
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Old Marsh Farm Barns Welsh Road Sealand Flintshire CH5 2LY		
Date 20/04/2017 17:18 File	Designed by patricktaylor Checked by	
Micro Drainage	Network 2014.1.1	

Rainfall profile

Storm duration (mins) 360

FEH Data

C (1km)	-0.025
D1 (1km)	0.309
D2 (1km)	0.419
D3 (1km)	0.307
E (1km)	0.285
F (1km)	2.391
Peak Intensity (mm/hr)	12.416
Ave. Intensity (mm/hr)	3.167
Return Period (years)	1



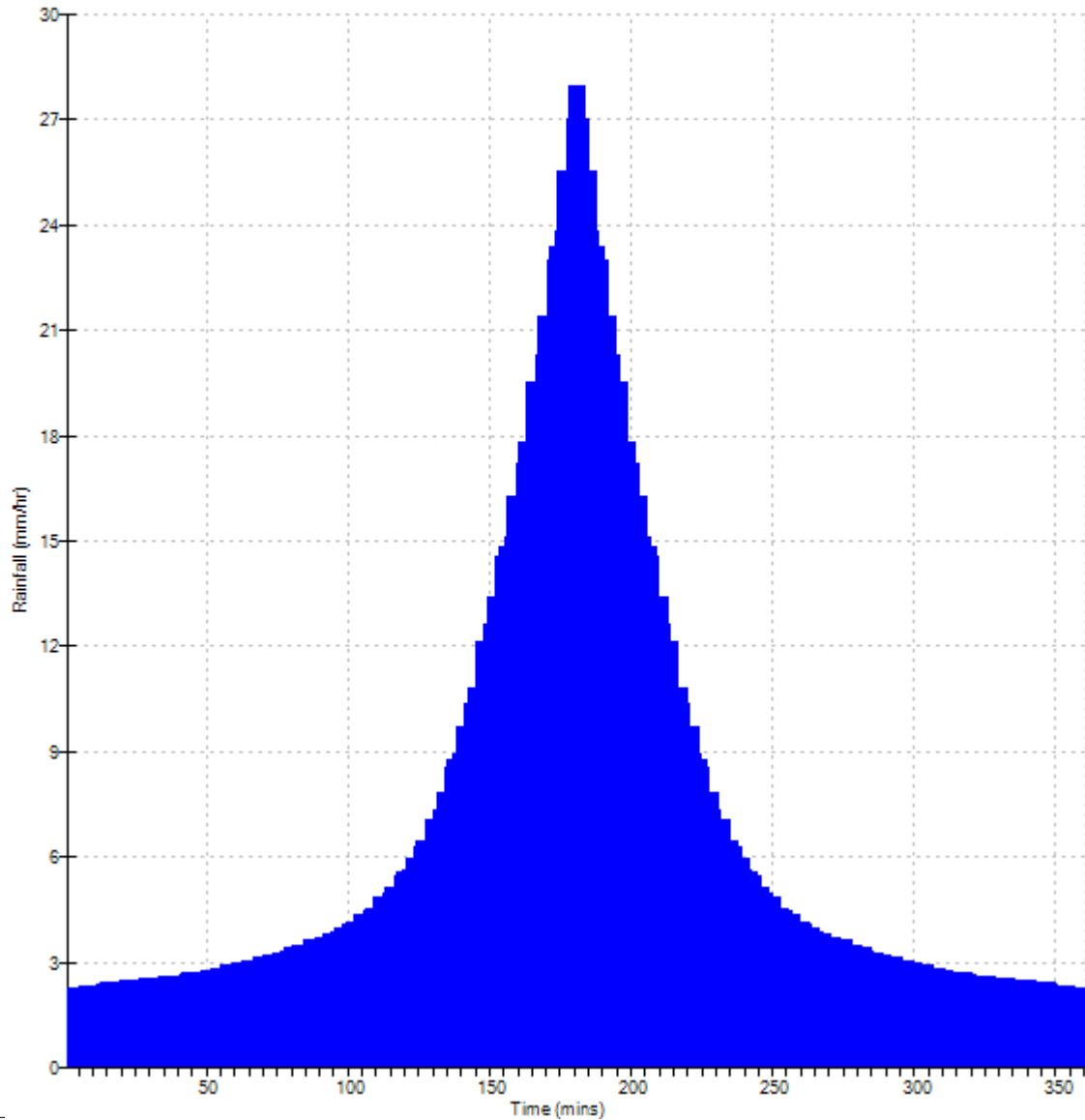
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Welsh Road		
Sealand Flintshire CH5 2LY		
Date 20/04/2017 17:18	Designed by patricktaylor	
File	Checked by	
Micro Drainage	Network 2014.1.1	

Rainfall profile

Storm duration (mins) 360

FEH Data

C (1km)	-0.025
D1 (1km)	0.309
D2 (1km)	0.419
D3 (1km)	0.307
E (1km)	0.285
F (1km)	2.391
Peak Intensity (mm/hr)	27.992
Ave. Intensity (mm/hr)	7.141
Return Period (years)	30



Old Marsh Farm Barns
Welsh Road
Sealand Flintshire CH5 2LY

Date 20/04/2017 17:19
File

Designed by patricktaylor
Checked by



Micro Drainage

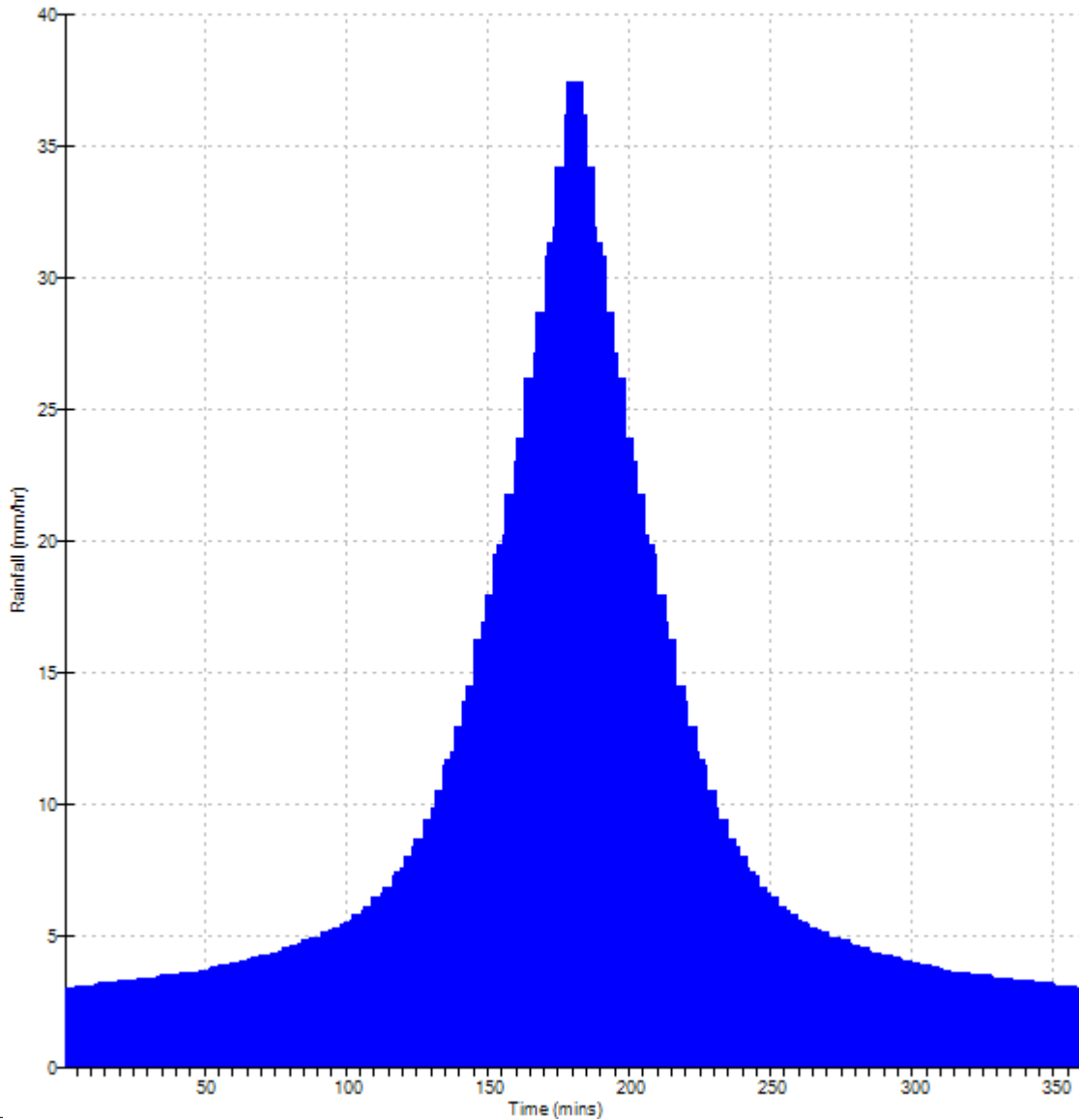
Network 2014.1.1

Rainfall profile

Storm duration (mins) 360

FEH Data

C (1km)	-0.025
D1 (1km)	0.309
D2 (1km)	0.419
D3 (1km)	0.307
E (1km)	0.285
F (1km)	2.391
Peak Intensity (mm/hr)	37.486
Ave. Intensity (mm/hr)	9.563
Return Period (years)	100



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©1982-2017 XP Solutions		

Betts Associates Limited		Page 1																																				
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Date 28/06/2018 09:36 File	Designed by KW Checked by DK																																					
XP Solutions Source Control 2017.1.2																																						
<u>Greenfield Runoff Volume</u> FEH Data <table> <tr> <td>Return Period (years)</td> <td>1</td> </tr> <tr> <td>Storm Duration (mins)</td> <td>360</td> </tr> <tr> <td>FEH Rainfall Version</td> <td>1999</td> </tr> <tr> <td>Site Location GB 337500 347350 SJ 37500 47350</td> <td></td> </tr> <tr> <td>C (1km)</td> <td>-0.025</td> </tr> <tr> <td>D1 (1km)</td> <td>0.309</td> </tr> <tr> <td>D2 (1km)</td> <td>0.419</td> </tr> <tr> <td>D3 (1km)</td> <td>0.307</td> </tr> <tr> <td>E (1km)</td> <td>0.285</td> </tr> <tr> <td>F (1km)</td> <td>2.391</td> </tr> <tr> <td>Areal Reduction Factor</td> <td>1.00</td> </tr> <tr> <td>Area (ha)</td> <td>0.242</td> </tr> <tr> <td>SAAR (mm)</td> <td>717</td> </tr> <tr> <td>CWI</td> <td>107.194</td> </tr> <tr> <td>SPR Host</td> <td>38.120</td> </tr> <tr> <td>URBEXT (1990)</td> <td>0.0056</td> </tr> </table> Results <table> <tr> <td>Percentage Runoff (%)</td> <td>33.79</td> </tr> <tr> <td>Greenfield Runoff Volume (m³)</td> <td>15.542</td> </tr> </table>			Return Period (years)	1	Storm Duration (mins)	360	FEH Rainfall Version	1999	Site Location GB 337500 347350 SJ 37500 47350		C (1km)	-0.025	D1 (1km)	0.309	D2 (1km)	0.419	D3 (1km)	0.307	E (1km)	0.285	F (1km)	2.391	Areal Reduction Factor	1.00	Area (ha)	0.242	SAAR (mm)	717	CWI	107.194	SPR Host	38.120	URBEXT (1990)	0.0056	Percentage Runoff (%)	33.79	Greenfield Runoff Volume (m³)	15.542
Return Period (years)	1																																					
Storm Duration (mins)	360																																					
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URBEXT (1990)	0.0056																																					
Percentage Runoff (%)	33.79																																					
Greenfield Runoff Volume (m³)	15.542																																					
©1982-2017 XP Solutions																																						

Betts Associates Limited		Page 1
6 Old Marsh Farm Barns Welsh Road Sealand CH5 2LY	BEDWELL ROAD CROSS LANES HYD331	
Date 28/06/2018 09:38 File	Designed by KW Checked by DK	
XP Solutions Source Control 2017.1.2		

Greenfield Runoff Volume

FEH Data

Return Period (years)	100
Storm Duration (mins)	360
FEH Rainfall Version	1999
Site Location GB 337500 347350 SJ 37500 47350	
C (1km)	-0.025
D1 (1km)	0.309
D2 (1km)	0.419
D3 (1km)	0.307
E (1km)	0.285
F (1km)	2.391
Areal Reduction Factor	1.00
Area (ha)	0.242
SAAR (mm)	717
CWI	107.194
SPR Host	38.120
URBEXT (1990)	0.0056

Results

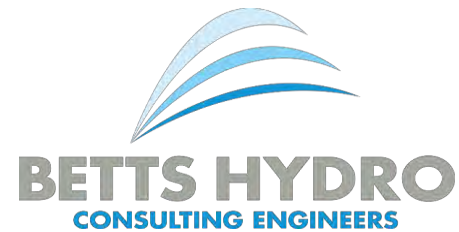
Percentage Runoff (%)	37.10
Greenfield Runoff Volume (m³)	51.517

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SURFACE WATER RUN-OFF CALCULATION SHEET

Development	Bedwell Road, Cross Lanes
Project No.	HYD331

Revision	0.0	Completed by	KW
Date	28.06.2018	Checked by	DK



Areas				Catchment Characteristics			
Total Site	0.242	ha		SAAR	718	mm	
Development Area (for SW Strategy)	0.242	ha		SPR	38	%	
Existing Impermeable	0.027	ha	11%	i ₁	12.4	mm/hr	
Existing Impermeable (for SW Strategy)	0.000	ha	0%	i ₃₀	27.9	mm/hr	
Existing Pervious	0.215	ha		i ₁₀₀	37.4	mm/hr	
Existing Pervious (for SW Strategy)	0.242	ha		d ₁	11.3	mm	
Proposed Impermeable (total)	0.123	ha	51%	d ₁₀₀	56.4	mm	

Run-off Rates				Volumes			
<i>Pre-development</i>				<i>Pre-development</i>			
Impermeable	1yr	0.0	l/s	Impermeable	1yr	0.0	cu.m
	30yr	0.0	l/s		100yr	0.0	cu.m
	100yr	0.0	l/s				
	50mm/hr	0.0	l/s	Pervious	1yr	15.5	cu.m
					100yr	51.5	cu.m
Pervious	1yr	1.1	l/s	Total	1yr	15.5	cu.m
	30yr	2.1	l/s		100yr	51.5	cu.m
	100yr	2.6	l/s				
	QBar	1.2	l/s	<i>Post-development</i>			
Total	1yr	1.1	l/s	Impermeable (total)	1yr	13.9	cu.m
	30yr	2.1	l/s		100yr+CC	90.2	cu.m
	100yr	2.6	l/s				
<i>Post-development</i>							
Impermeable (total)	1yr	4.2	l/s	Reduction (total)	-75%	-38.7	cu.m
	30yr	9.5	l/s				
	100yr+CC	16.6	l/s				

Quick storage Estimates		low	high	mean	Imp. Area (ha)	Max. Discharge (l/s)	Rainfall	CC
Return Period	1yr	2.3	6.3	4.3	0.123	5.0 *	FEH	0
Return Period	30yr	16	24	20	0.123	5.0 *	FEH	0
Return Period	100yr+CC	34	47	40.5	0.123	5.0 *	FEH	20%
Return Period	100yr+CC	41	57	49	0.123	5.0 *	FEH	40%

* Minimum Restraint Of A Flow Control Device (Based On The Standard Orifice Diameter Plate Constraints)

APPENDIX M: IMPERMEABLE AREAS PLANS

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DO NOT SCALE

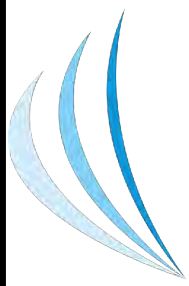
NOTES

- LAND IN CONTROL OF THE DEVELOPER - 1.269ha
- DEVELOPMENT AREA - 0.242ha
- PRE-DEVELOPMENT IMPERMEABLE AREAS - 0.027ha (2%)
- PRE-DEVELOPMENT PERVIOUS AREAS - 0.215ha



REV	DATE	BY	DESCRIPTION	CHK
B	22/06/18	KW	UPDATED TO SUIT COMMENTS	OK
A	05/04/18	MB	PRELIMINARY ISSUE FOR REVIEW	KW

DRAWING STATUS:



BETTS HYDRO
CONSULTING ENGINEERS

Unit 6, Old Marsh Farm Bldgs, Wash Road, Seabold, Fifehire CH45 2LY
01244 255773
01244 255773

D.S. Jones & Co.

PROJECT			
BEDWELL ROAD CROSS LANES			
TITLE			
PRE-DEVELOPMENT IMPERMEABLE AREAS PLAN			
DATE: JUN 2018	SCALE @ SITE: 1:750 @ A1	DRAWN: KW	CHECKED: DK
PROJECT NO: HYD331	DRAWING NO: 101	REV: B	

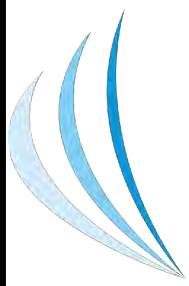


DO NOT SCALE

NOTES

- LAND IN CONTROL OF THE DEVELOPER - 1.269ha
- TOTAL SITE AREA - 0.2421ha
- POST-DEVELOPMENT IMPERMEABLE AREAS - 0.1231ha (51%)
- POST-DEVELOPMENT PERVIOUS AREAS - 0.1191ha

REV	DATE	BY	DESCRIPTION	CHECKED
1	22/06/18	KW	UPDATED TO SUIT COMMENTS	DK
2	05/07/18	KW	PRELIMINARY ISSUE FOR REVIEW	DK



BETTS HYDRO
CONSULTING ENGINEERS

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D.S. Jones & Co.

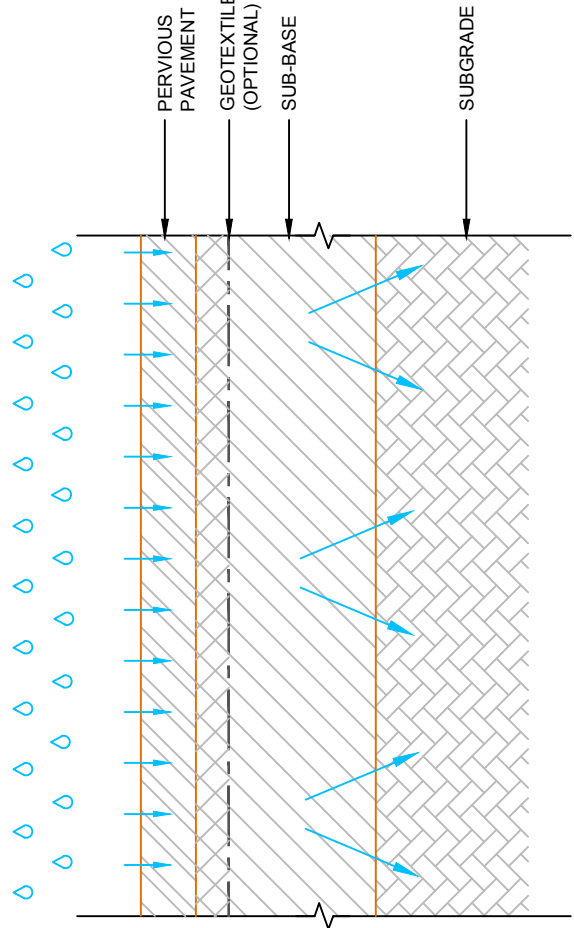
PROJECT		BEDWELL ROAD CROSS LANES	
TITLE		POST-DEVELOPMENT IMPERMEABLE AREAS PLAN	
DATE: JUN 2018	SCALE @ SITE: 1:750 @ A1	DRAWN: KW	CHECKED: DK
PROJECT NO: HYD331	DRAWING NO: 201	REV: B	

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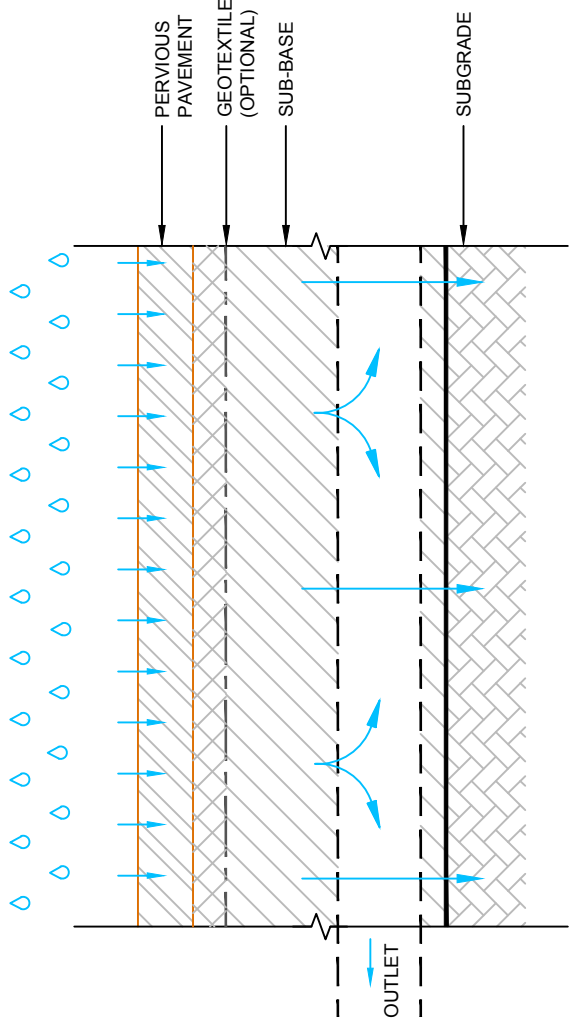
APPENDIX N: TYPICAL SUDS DETAIL

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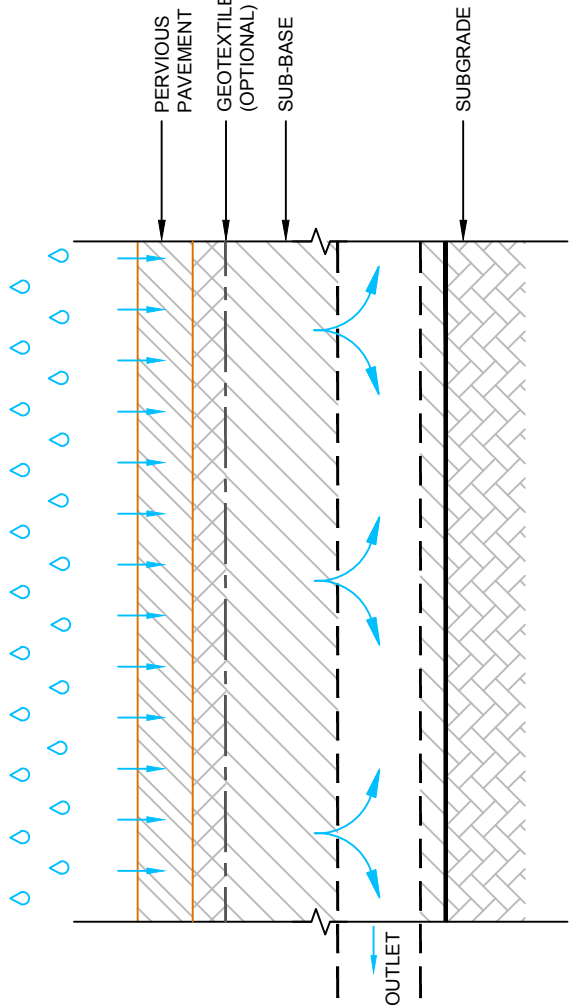
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TYPE A: TOTAL INFILTRATION

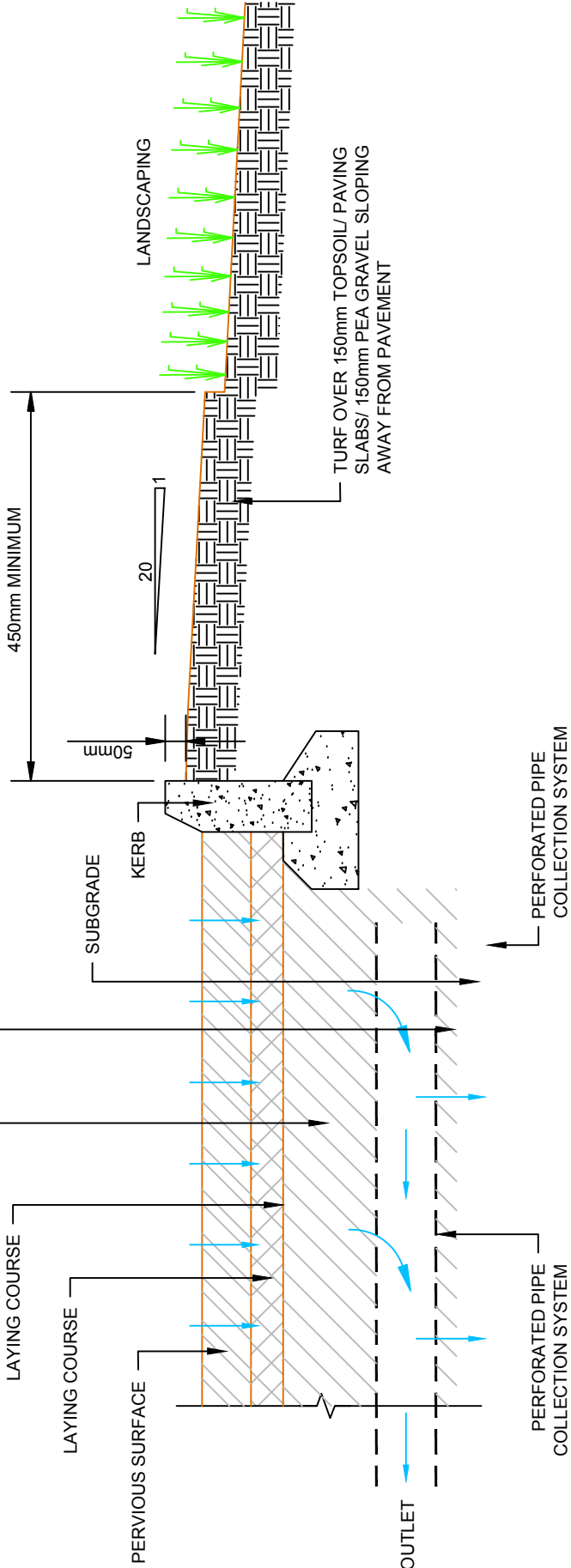


TYPE B: PARTIAL INFILTRATION



TYPE C: NO INFILTRATION

AGGREGATE SUB-BASE (MAY BE REPLACED WITH GEOCELLULAR BLOCKS)



LANDSCAPING DETAIL

REV	DATE	BY	DESCRIPTION	CHK
-----	------	----	-------------	-----

DRAWING STATUS: PRELIMINARY



BETTS ASSOCIATES
CIVIL AND STRUCTURAL ENGINEERS
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Tel: 01244 288178 Fax: 01244 288516 enquiries@betts-associates.co.uk

PROJECT:

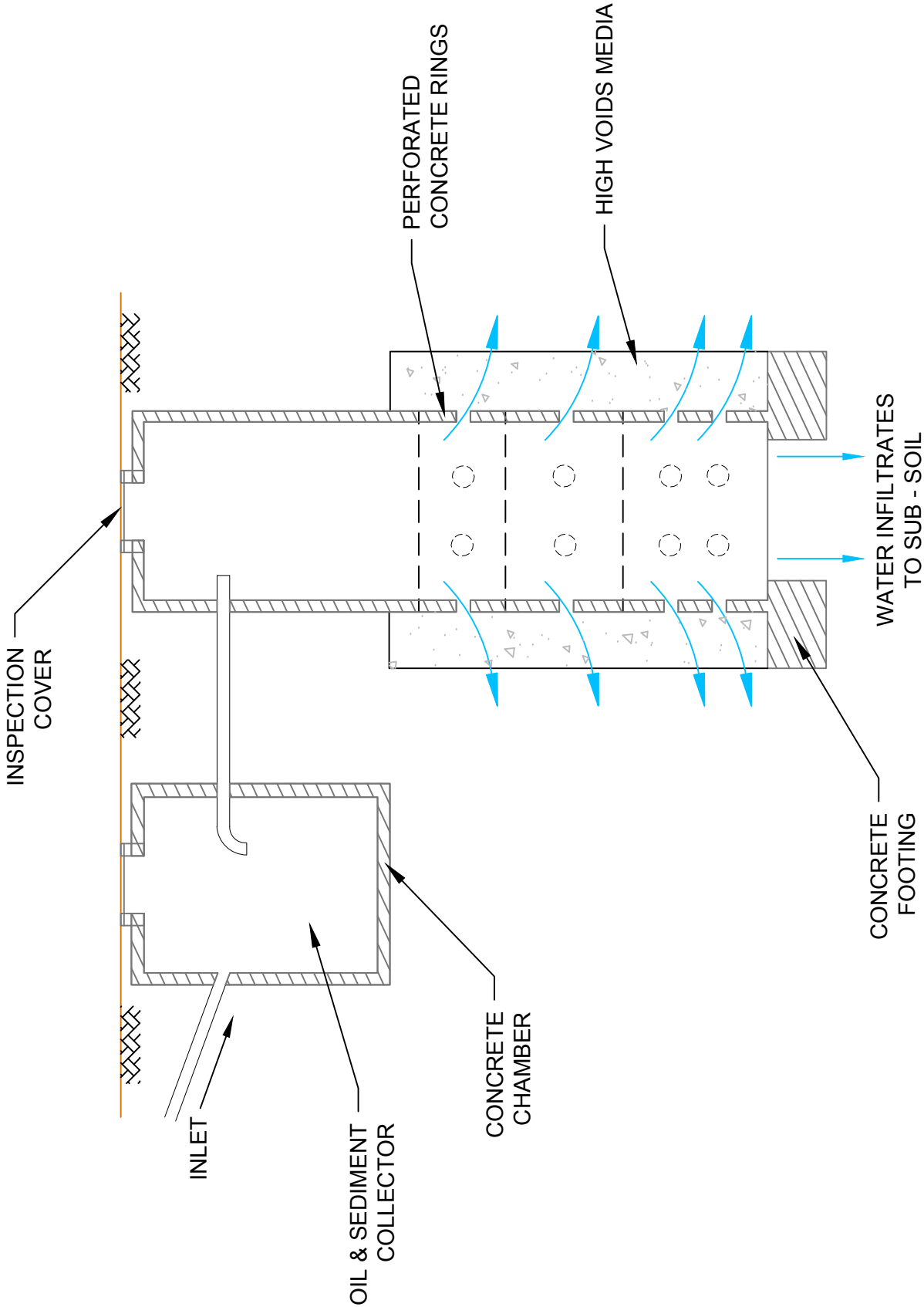
TYPICAL SUDS DETAIL

TITLE:

PERVIOUS PAVEMENTS

DATE: SEP 2014	SCALE @ SIZE: @ A3	DRAWN: CP	CHECKED: RDN
PROJECT No: BETTS	DRAWING No: 105	REV: A	

DO NOT SCALE



SOAKAWAY DETAILS
(INCLUDING PRE-TREATMENT DEVICE)

REV	DATE	BY	DESCRIPTION	CHK					
DRAWING STATUS:					PRELIMINARY				



BETTS ASSOCIATES

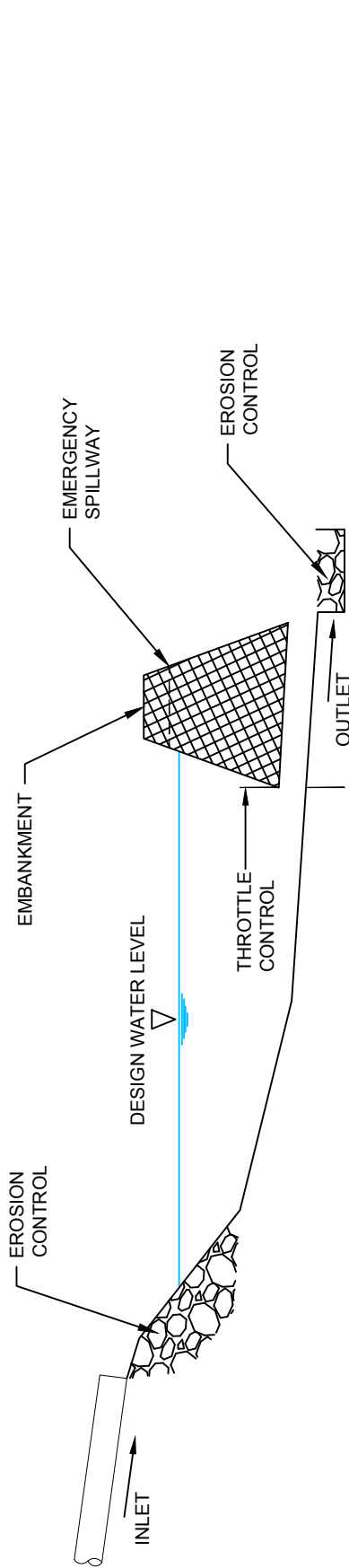
CIVIL AND STRUCTURAL ENGINEERS

Unit 6, Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire CH5 2LY

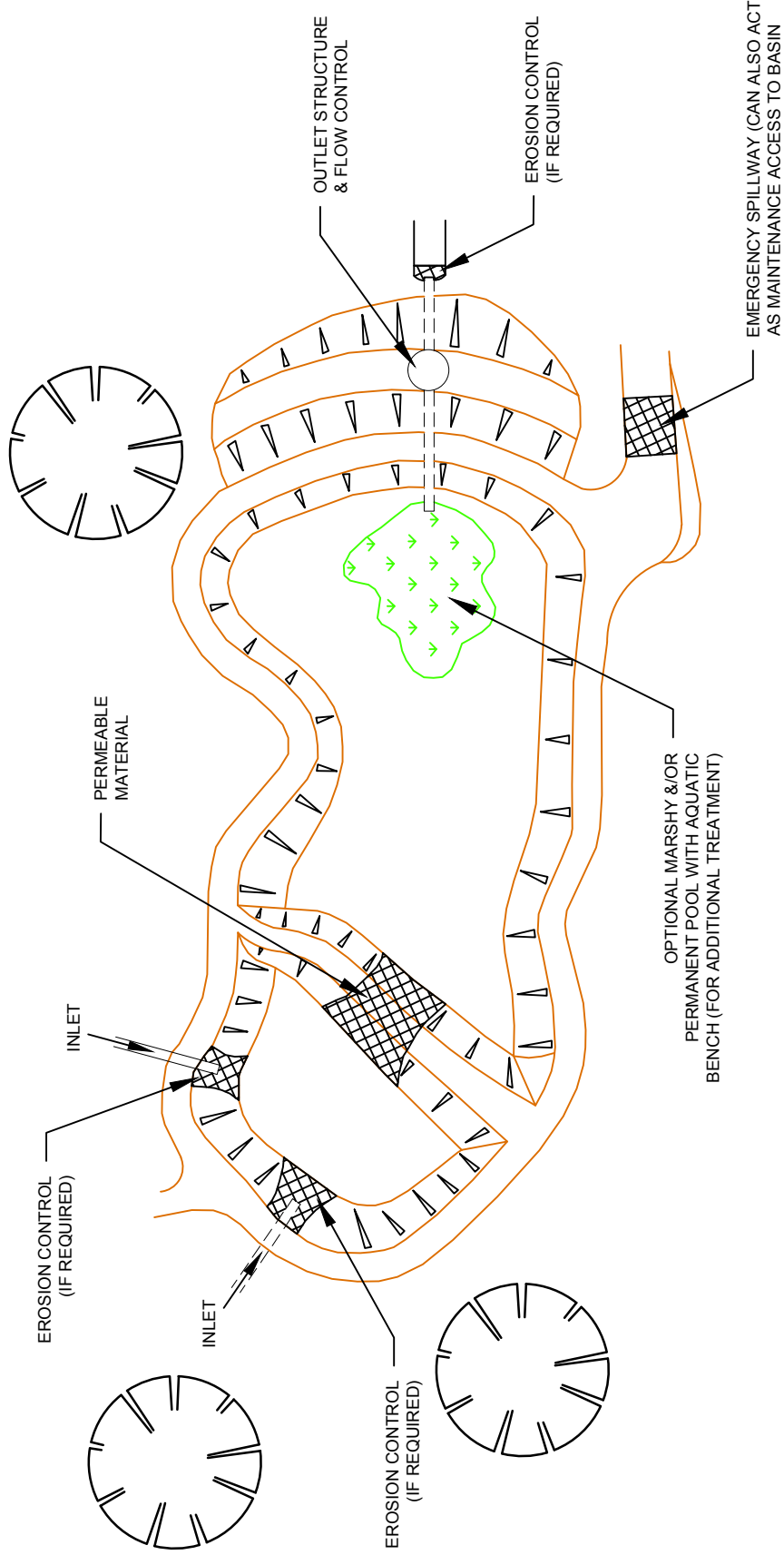
Tel: 01244 288178 Fax: 01244 288516 enquiries@betts-associates.co.uk

PROJECT:									
TYPICAL SUDS DETAIL									
TITLE:									
SOAKAWAYS									
DATE:	SCALE	@	SIZE:	DRAWN:	CHECKED:				
SEP 2014	@	A3		CP	RDN				
PROJECT No:					DRAWING No:		108	REV:	
BETTS								A	

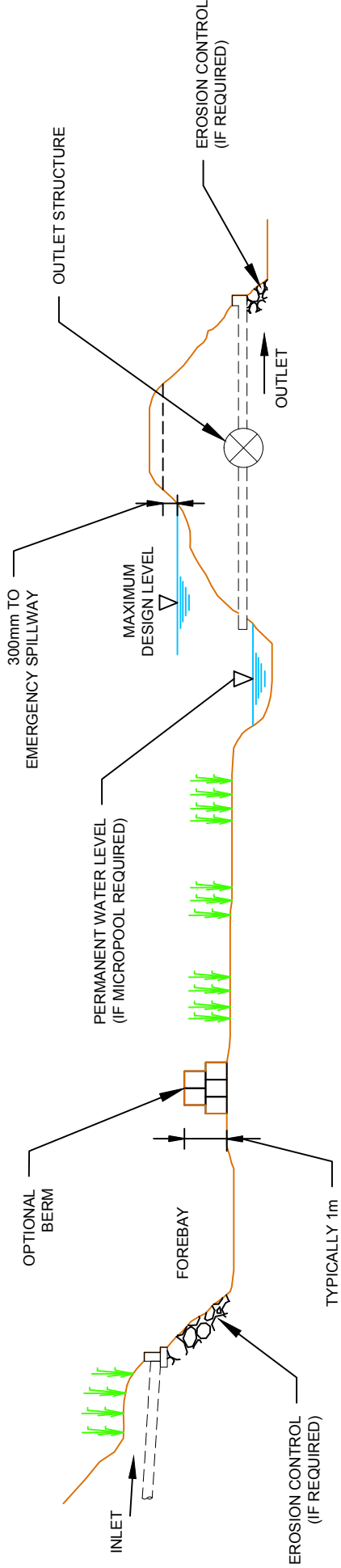
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SCHEMATIC OF DETENTION
BASIN PROFILE



PLAN VIEW



ELEVATION

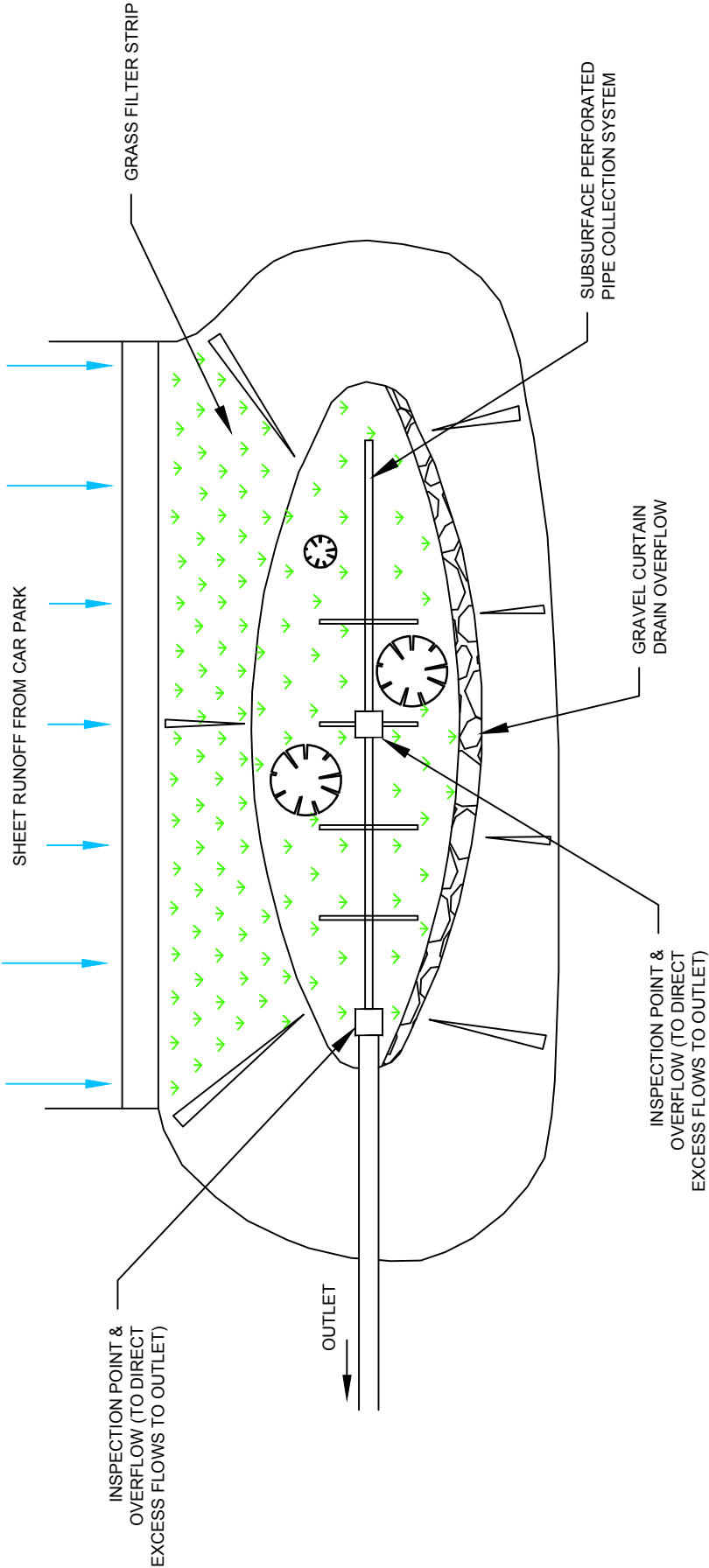
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DRAWING STATUS: PRELIMINARY				



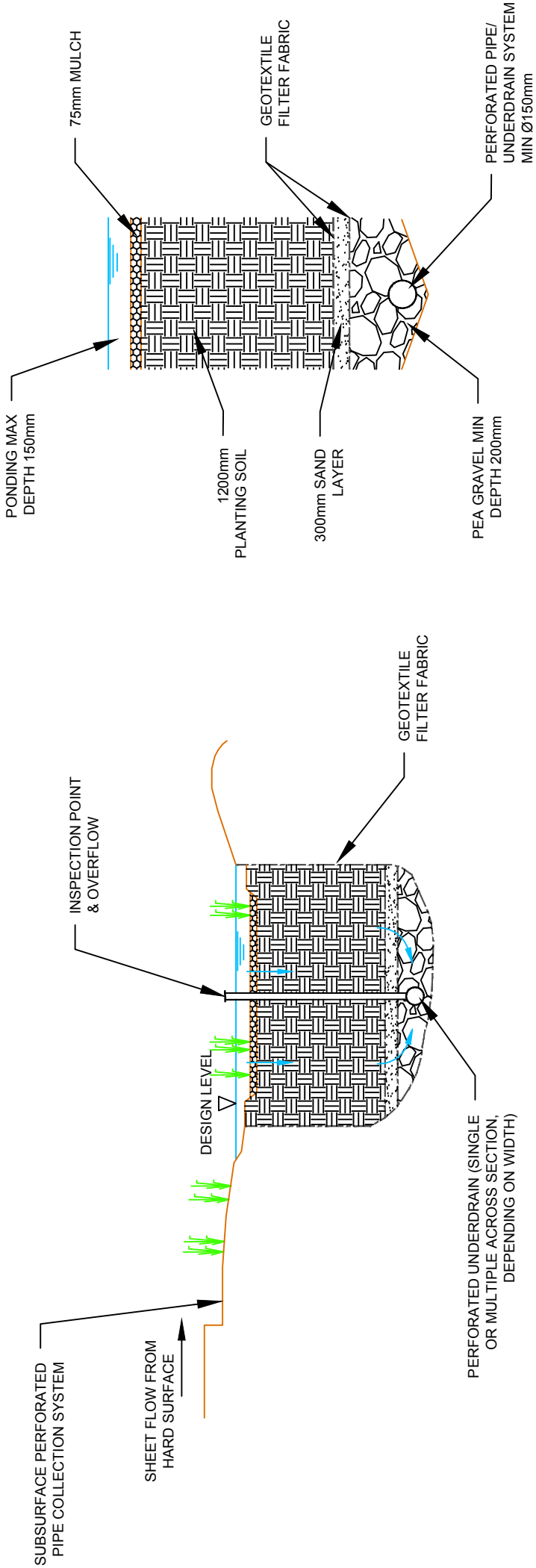
BETTS ASSOCIATES
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Unit 6, Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire CH5 2LY
Tel: 01244 288178 Fax: 01244 288516 enquiries@betts-associates.co.uk

PROJECT:	TYPICAL SUDS DETAIL			
TITLE:	DETENTION BASINS			
DATE: SEP 2014	SCALE @ A3	SIZE: CP	DRAWN: RDN	CHECKED: RDN
PROJECT No: BETTS	DRAWING No: 110	REV: A		

DO NOT SCALE



PLAN VIEW



PROFILE

TYPICAL SECTION

PROJECT:

TYPICAL SUDS DETAIL

TITLE:

BIORETENTION APPLICATIONS

DATE: SEP 2014	SCALE @ SIZE: @ A3	DRAWN: CP	CHECKED: RDN
PROJECT No: BETTS	DRAWING No: 112	REV: A	

REV	DATE	BY	DESCRIPTION	CHK
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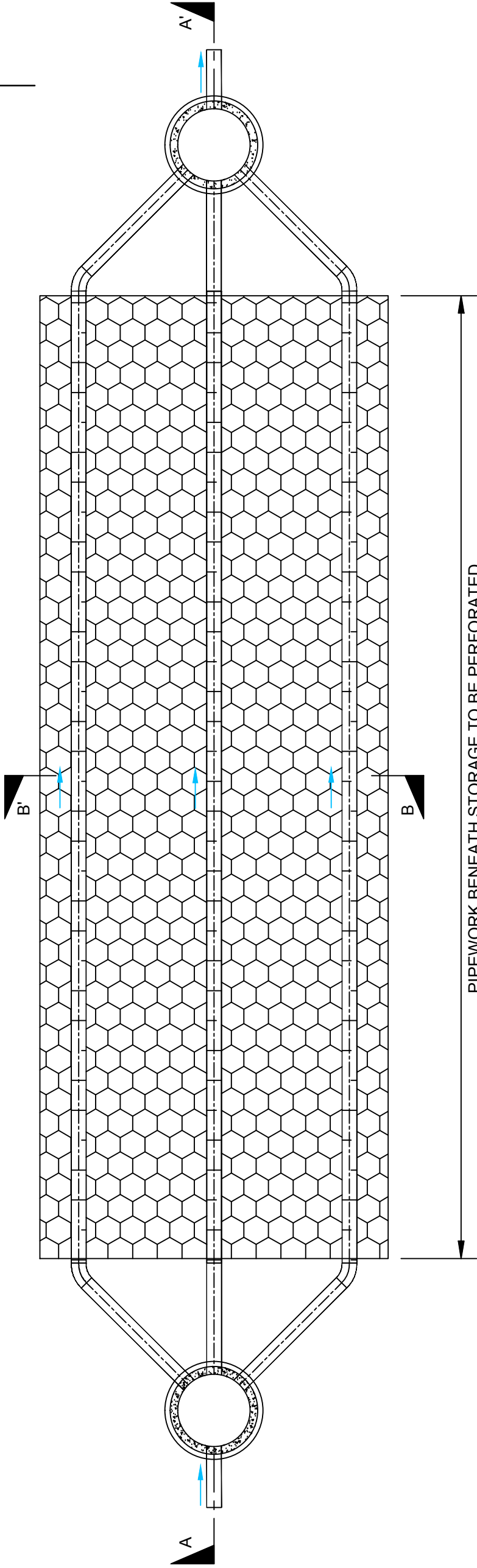
DRAWING STATUS: PRELIMINARY



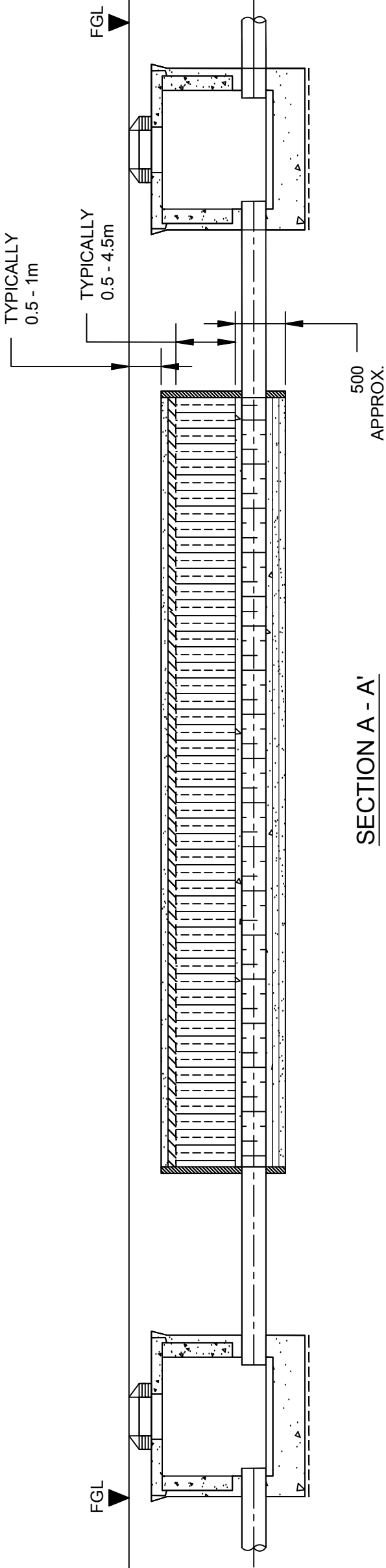
BETTS ASSOCIATES
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Tel: 01244 288178 Fax: 01244 288516
enquiries@betts-associates.co.uk

PROJECT:	
TYPICAL SUDS DETAIL	
TITLE:	
BIORETENTION APPLICATIONS	

DO NOT SCALE

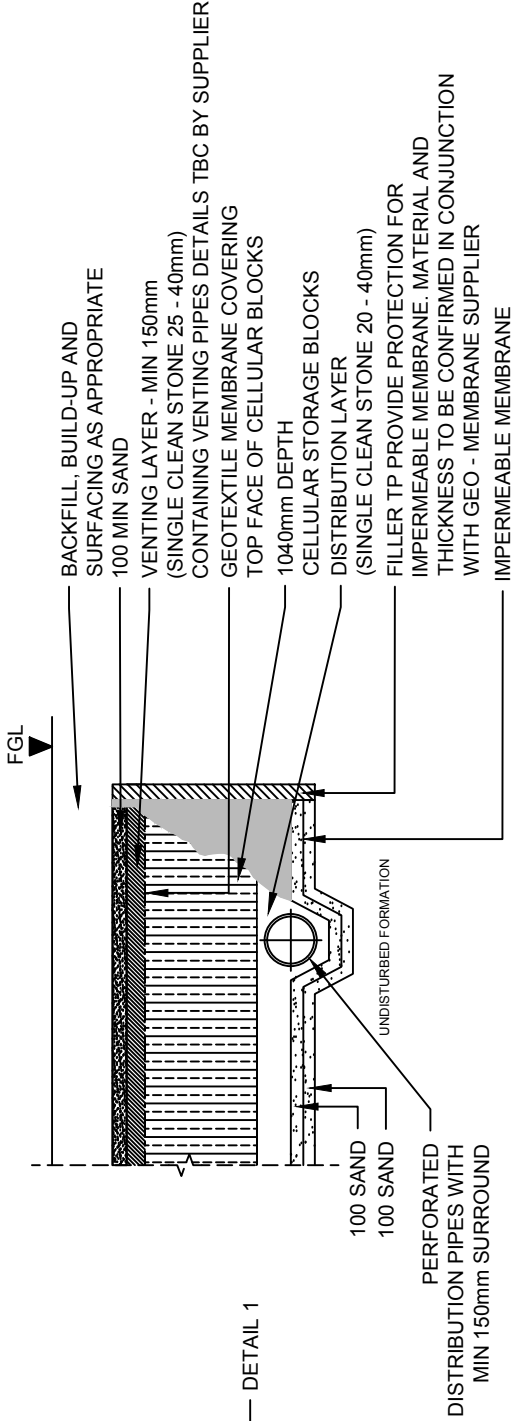
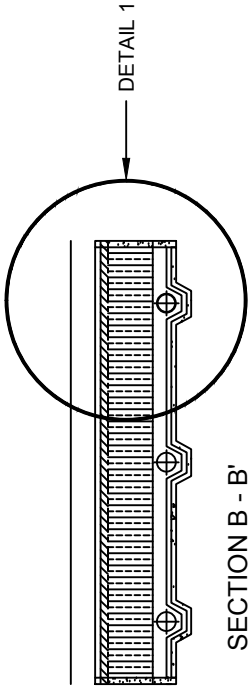


PLAN



SECTION A - A'

ALL DIMENSIONS AND DEPTHS DEPENDENT ON REQUIRED VOLUME AND LOCAL GROUND CONDITIONS



DETAIL 1

REV	DATE	BY	DESCRIPTION	CHK
DRAWING STATUS: PRELIMINARY				



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Tel: 01244 288178 Fax: 01244 288516 enquiries@betts-associates.co.uk

PROJECT: TYPICAL SUDS DETAIL				
TITLE: CELLULAR STORAGE				
DATE: SEP 2014	SCALE @ SIZE: @ A3	DRAWN: CP	CHECKED: RDN	REV: A
PROJECT No: BETTS		DRAWING No: 113		REV: A

APPENDIX O: PROPOSED DRAINAGE STRATEGY PLANS

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LEGEND



Land in Control of Developer



Site Extents

EXISTING DRAINAGE INFRASTRUCTURE



Combined Sewer



Foul Water Sewer



Surface Water Sewer

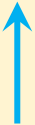


Ordinary Watercourse



Pond

PROPOSED DRAINAGE FEATURES



Surface Water Connection(s)



Foul Water Connection(s)



SuDS/Attenuation Area



Indicative 8m Easement Extent

Notes:

THIS DRAWING IS NOT A DRAINAGE 'DESIGN' IT IS A PRELIMINARY DRAINAGE STRATEGY SHOWING INDICATIVE SEWER LOCATIONS. NO HYDRAULIC SIMULATION OR ASSESSMENT OF THESE PROPOSALS HAS BEEN UNDERTAKEN.

PROPOSED POINTS OF CONNECTION TO THE EXISTING CULVERTS REQUIRE INVERT LEVELS TO BE ACCURATELY ESTABLISHED. SURCHARGING OF THE PROPOSED OUTFALL WILL REQUIRE MODELLING TO SATISFY THE REQUIREMENTS OF UNITED UTILITIES ALONG WITH FULL HYDRAULIC ANALYSIS.



BETTS HYDRO
CONSULTING ENGINEERS

APPENDIX P: STORMWATER STORAGE ESTIMATES

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STORMWATER STORAGE ESTIMATES

Micro Drainage		Variables				
Variables Results Design Overview 2D Overview 3D Vt	FEH Rainfall		Cv (Summer)	0.750		
	Return Period (years)		1	Cv (Winter)	0.840	
	Version		1999	Impemeable Area (ha)	0.123	
	Site		GB 337500 347350 SJ 37500 47350	Maximum Allowable Discharge (l/s)	5.0	
	C (1km)	-0.025	D3 (1km)	0.307	Infiltration Coefficient (m/hr)	0.00000
	D1 (1km)	0.309	E (1km)	0.285	Safety Factor	2.0
	D2 (1km)	0.419	F (1km)	2.391	Climate Change (%)	0

Micro Drainage		Results
		Global Variables require approximate storage of between 2.3 m³ and 6.3 m³. These values are estimates only and should not be used for design purposes.
Variables		
Results		

Micro Drainage		Variables				
Variables Results Design Overview 2D Overview 3D Vt	FEH Rainfall		Cv (Summer)	0.750		
	Return Period (years)		30	Cv (Winter)	0.840	
	Version		1999	Impemeable Area (ha)	0.123	
	Site		GB 337500 347350 SJ 37500 47350	Maximum Allowable Discharge (l/s)	5.0	
	C (1km)	-0.025	D3 (1km)	0.307	Infiltration Coefficient (m/hr)	0.00000
	D1 (1km)	0.309	E (1km)	0.285	Safety Factor	2.0
	D2 (1km)	0.419	F (1km)	2.391	Climate Change (%)	0

Micro Drainage		Results
		Global Variables require approximate storage of between 16 m³ and 24 m³. These values are estimates only and should not be used for design purposes.
Variables		
Results		

 Variables Results Design Overview 2D Overview 3D Vt	Variables			
	FEH Rainfall		Cv (Summer)	0.750
	Return Period (years) 100		Cv (Winter)	0.840
	Version 1999		Impervious Area (ha)	0.123
	Site GB 337500 347350 SJ 37500 47350		Maximum Allowable Discharge (l/s)	5.0
	C (1km) -0.025	D3 (1km) 0.307	Infiltration Coefficient (m/hr)	0.00000
	D1 (1km) 0.309	E (1km) 0.285	Safety Factor	2.0
	D2 (1km) 0.419	F (1km) 2.391	Climate Change (%)	20

 Variables Results	Results
	Global Variables require approximate storage of between 34 m³ and 47 m³. These values are estimates only and should not be used for design purposes.

 Variables Results Design Overview 2D Overview 3D Vt	Variables			
	FEH Rainfall		Cv (Summer)	0.750
	Return Period (years) 100		Cv (Winter)	0.840
	Version 1999		Impervious Area (ha)	0.123
	Site GB 337500 347350 SJ 37500 47350		Maximum Allowable Discharge (l/s)	5.0
	C (1km) -0.025	D3 (1km) 0.307	Infiltration Coefficient (m/hr)	0.00000
	D1 (1km) 0.309	E (1km) 0.285	Safety Factor	2.0
	D2 (1km) 0.419	F (1km) 2.391	Climate Change (%)	40

 Variables Results	Results
	Global Variables require approximate storage of between 41 m³ and 57 m³. These values are estimates only and should not be used for design purposes.

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APPENDIX Q: OVERLAND FLOOD FLOW ROUTES

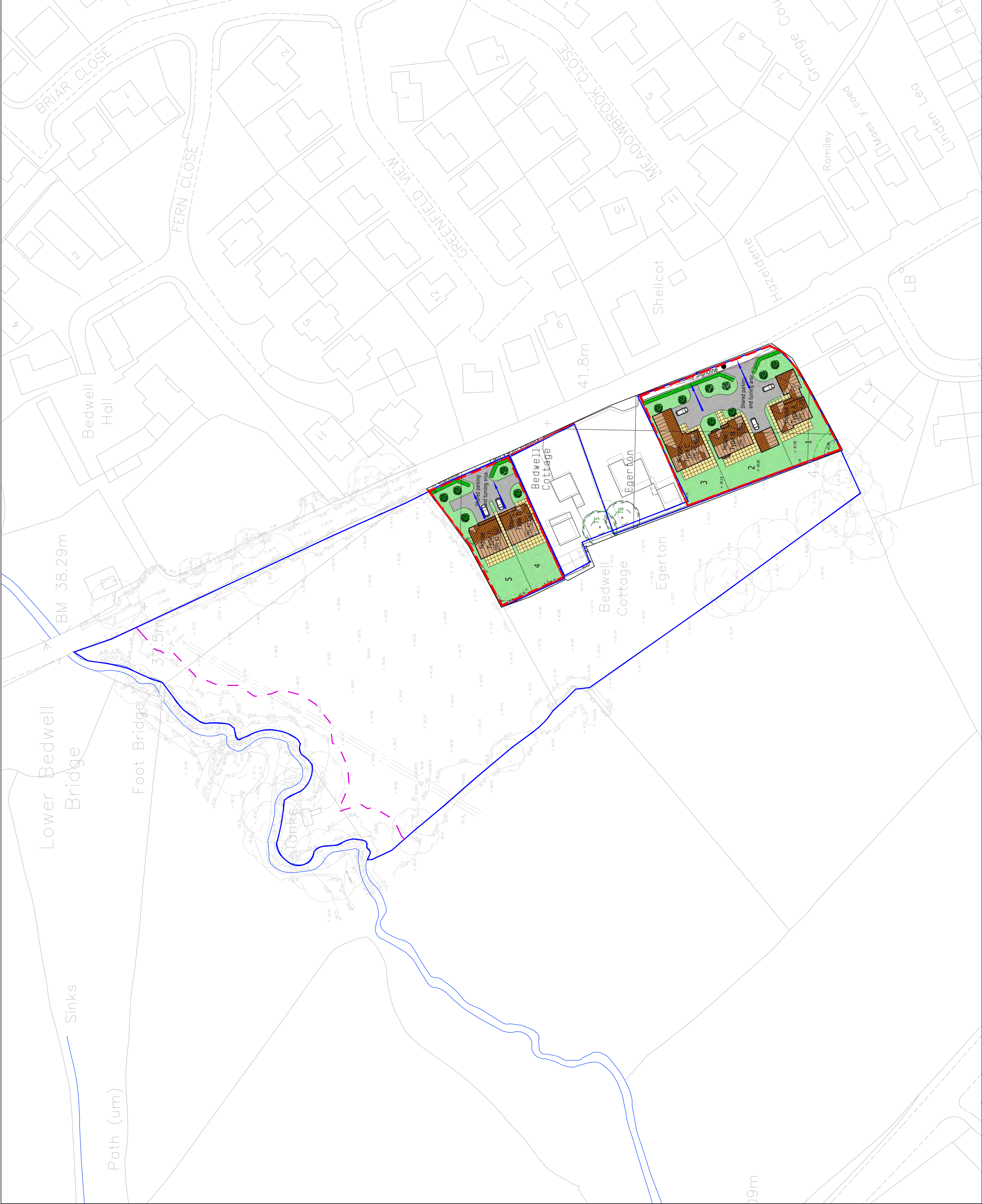
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DO NOT SCALE

LEGEND

- LAND IN CONTROL OF THE DEVELOPER - 1.269ha
- DEVELOPMENT AREA - 0.242ha
- OVERLAND FLOOD FLOWS



REV	DATE	BY	DESCRIPTION	CHK
B	22/06/18	KW	UPDATED TO REFLECT COMMENTS	DK
A	05/06/18	MB	PRELIMINARY ISSUE FOR REVIEW	KW
				CHK

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D.S. Jones & Co.

BEDWELL ROAD
CROSS LANES

POST-DEVELOPMENT
OVERLAND FLOOD FLOW PLAN

DATE: JUNE 2018	SCALE @ SITE: 1:750 @ A1	DRAWN: KW	CHECKED: DK
PROJECT No: HYD331	DRAWING No: 202	REV: B	

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APPENDIX R: NOTES OF LIMITATIONS

The data essentially comprised a study of available documented information from various sources together with discussions with relevant authorities and other interested parties. There may also be circumstances at the site that are not documented. The information reviewed is not exhaustive and has been accepted in good faith as providing representative and true data pertaining to site conditions. If additional information becomes available which might impact our conclusions, we request the opportunity to review the information, reassess the potential concerns and modify our opinion if warranted.

It should be noted that any risks identified in this report are perceived risks based on the available information.

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This document has been prepared for the titled project only and should any third party wish to use or rely upon the contents of the report, written approval from Betts Hydro Ltd must be sought.

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