



DBA Estates

Pen Y Bont, Chirk

Flood Consequence Assessment

881358 R1 (02)-FCA



**INVESTORS
IN PEOPLE**



MAY 2018

RSK GENERAL NOTES

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Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK LDE Ltd.

CONTENTS

1	INTRODUCTION	1
2	CONTEXT AND SCOPE OF WORK.....	4
3	SITE DESCRIPTION	5
3.1	Location	5
3.2	Land use and topography.....	6
3.3	Hydrology	7
3.4	Geology	7
3.5	Climate Change	7
4	DEVELOPMENT PROPOSALS.....	8
5	LEGISLATION AND POLICY CONTEXT	9
5.1	National policy	9
5.2	Local policy	10
6	TECHNICAL ADVICE NOTE 15	12
6.1	Assessing Flood Consequences	12
7	SOURCES OF INFORMATION	13
7.1	Natural Resources Wales consultation	13
7.2	Relevant studies	14
7.3	Drainage	15
8	SOURCES OF FLOOD RISK.....	16
8.1	Criteria	16
8.2	Flooding from rivers (fluvial flood risk).....	16
8.3	Flooding from the sea (tidal flood risk)	16
8.4	Flooding from the land (overland pluvial flood risk).....	17
8.5	Flooding from groundwater	18
8.6	Flooding from sewers	18
8.7	Reservoirs	19
8.8	Canals	20
8.9	Flood risk resulting from the development	21
9	DRAINAGE STRATEGY	22
9.1	Surface Water.....	22
10	PLANNING CONSIDERATIONS AND MITIGATION OPTIONS.....	26
10.1	Site layout and design	26
10.2	Safe access and egress	26
10.3	Watercourse easements	27
11	CONCLUSIONS	28
12	REFERENCES	29

APPENDICES

APPENDIX A SERVICE CONSTRAINTS

APPENDIX B TOPOGRAPHIC SURVEY

APPENDIX C DEVELOPMENT PROPOSALS

APPENDIX D NRW CORRESPONDENCE

APPENDIX E GREENFIELD RUNOFF CALCULATIONS

APPENDIX F WINDES 4 STAGE DESIGN OF DRAINAGE FEATURES

1 INTRODUCTION

RSK Land and Development Engineering Ltd (RSK) was commissioned to carry out a Flood Consequence Assessment (FCA) by DBA Estates. The assessment is in support of the development of the masterplan for the proposed development of land at the former Pen Y Bont landfill, Chirk.

The assessment has been prepared in accordance with the Planning Policy Wales (PPW) ^(Ref. 1) and its accompanying Technical Advice Note (TAN) 15 ^(Ref. 2), the Interim Code of Practice for Sustainable Drainage ^(Ref. 3), BS 8533-2011 Assessing and Managing Flood Risk in Development Code of Practice ^(Ref. 4) and the Recommended non-statutory standards for sustainable drainage (SuDS) in Wales ^(Ref. 5), with site-specific advice from Natural Resources Wales (NRW), the Lead Local Flood Authority (LLFA), the Local Planning Authority (LPA), where available, as well as the architect and the client.

The PPW / TAN 15 sets out the criteria for development and flood risk by stating that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. The key definitions are:

- “areas at risk of flooding” means land within Flood Zones B and C; or land within Flood Zone A which has critical drainage problems and which has been notified to the local planning authority by the Natural Resources Wales; and
- “flood risk” means risk from all sources of flooding - including from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems, and from reservoirs, canals and lakes and other artificial sources.

For this site, the key aspects that require the assessment are:

- the total site area is approximately 49.3Ha in size consisting of the former brickworks site, landfill restoration area and agricultural fields;
- the Welsh Assembly Government’s Development Advice Map (WAG DAM) (**Figure 1.1**) shows that the developable area is located within Zone A and some areas fronting the watercourse within the wider site located in B and C; and
- the Natural Resources Wales Flood Map (**Figure 1.2**) shows the proposed development to lie wholly within Flood Zone 1 with some areas on the wider site along the watercourse in Flood Zone 2 and 3.

Due to the size and potential flood risk to the site, a Flood Consequence Assessment is required in accordance with the requirements of TAN 15.

The comments given in this report and opinions expressed are subject to RSK Group Service Constraints provided in **Appendix A**.

The outlines shown within the figures of this assessment are as follows:

- Blue outline refers to the wider ‘site’ boundary
- Red outline refers to the area proposed for residential dwellings; and

- Green outline refers to the area proposed to be developed for eco-lodges.

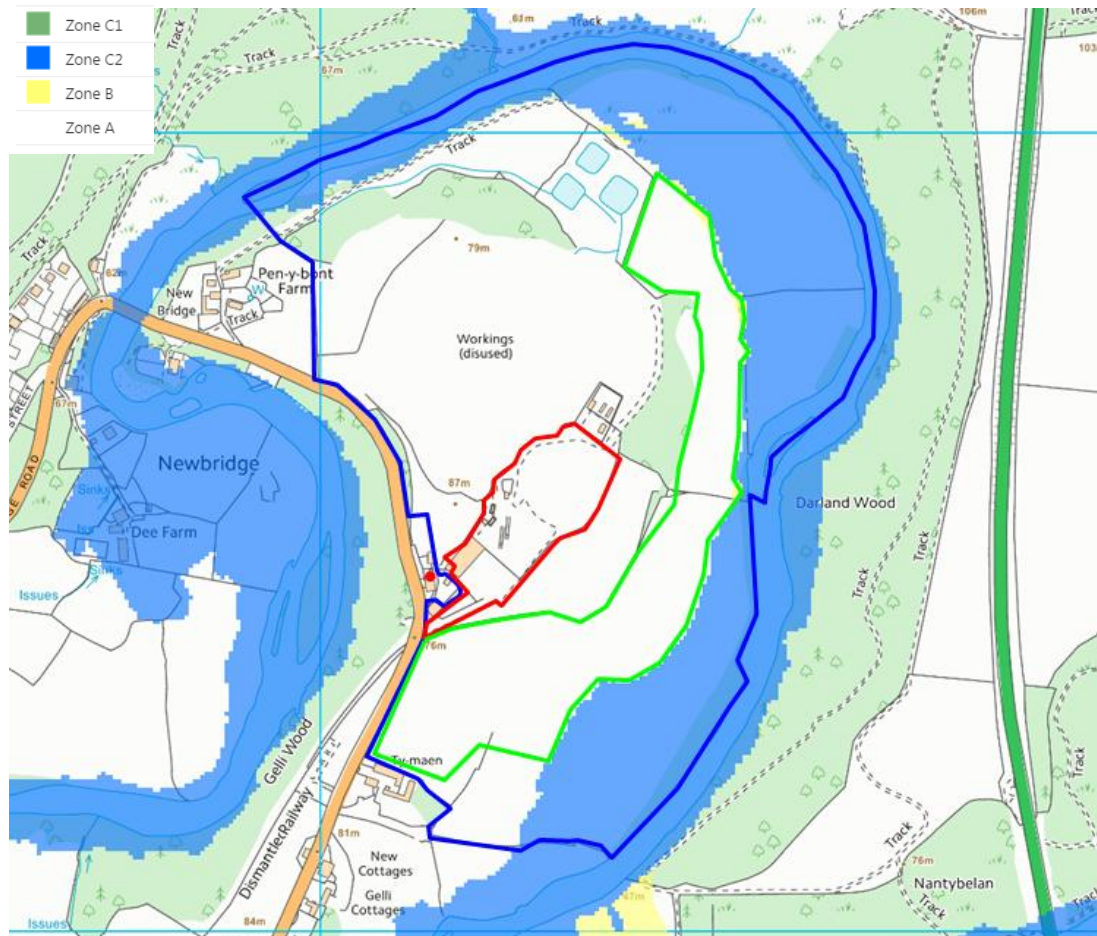


Figure 1.1: WAG Development Advice Maps (accessed May 2018)

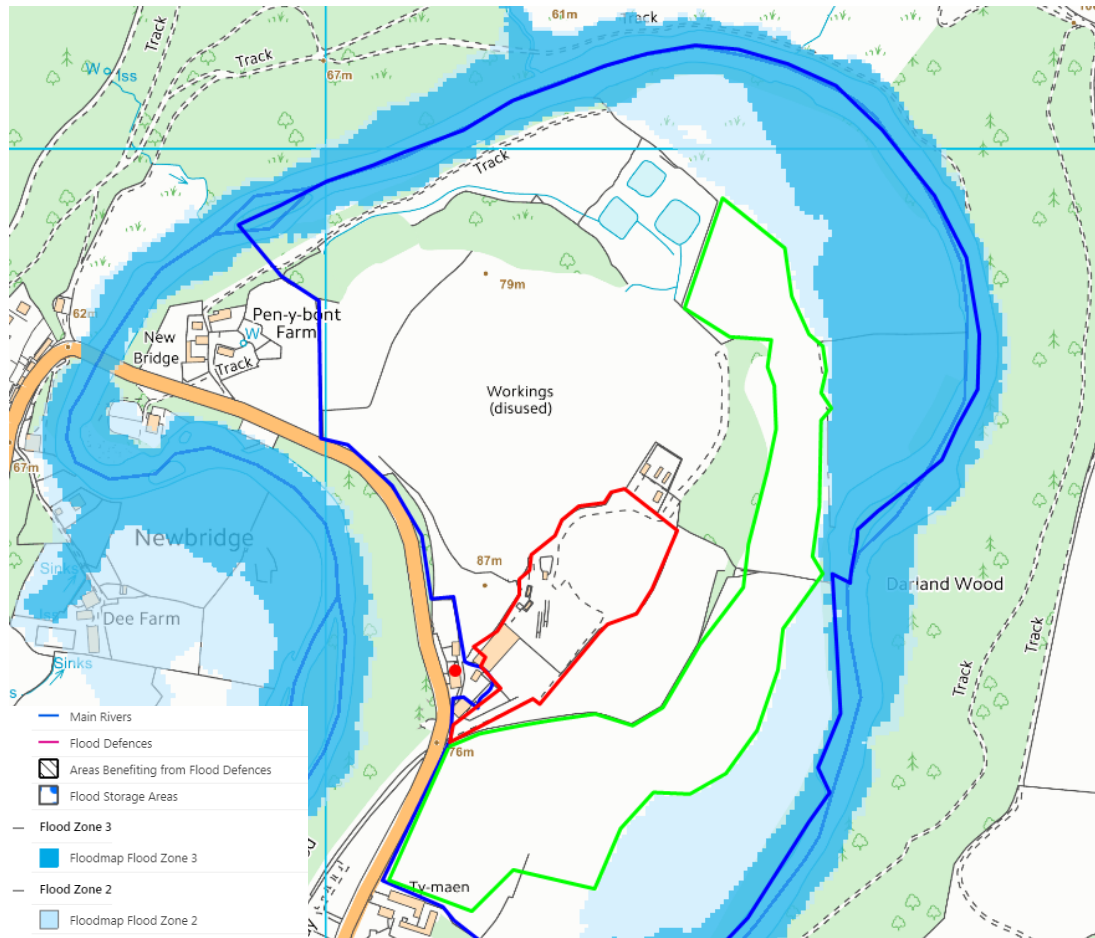


Figure 1.2: NRW Flood Zone Map (accessed May 2018)

2 CONTEXT AND SCOPE OF WORK

A key element of project development is to prepare a FCA to establish the flood risk associated with the proposed development and to propose suitable mitigation, if required, to reduce the risk to a more acceptable level.

The scope of work relating to a FCA is based on the guidance provided in PPW and its accompanying Technical Advice Notice 15.

A site-specific FCA must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall. The scope of this assessment therefore comprises the following elements:

- To review architect plans, planning information and other studies to determine existing site conditions;
- To obtain information on the hydrology and hydrological regime in and around the site;
- To obtain the views of the NRW / LLFA including scope, location and impacts;
- To determine the extent of new flooding provision and the influence on the site based on updated hydraulic modelling of the watercourse and associated floodplain;
- To assess the impact on the site from climate change effects and anticipated increases in rainfall over a 100 year period for the proposed residential/camping development;
- To review site surface water drainage based on the proposed layout and, if necessary, to determine the extent of infrastructure required; and
- To prepare a report including calculations and summaries of the source information and elements reviewed.

3 SITE DESCRIPTION

3.1 Location

Site Name: Pen Y Bont

Site Address: Pen y Bont Landfill, Pen y Bont House, Pentre, Wrexham LL14 5AR

Site National Grid Reference: Easting: 329290; Northing: 341704

The site is situated approximately 750m due east of Newbridge to the south of Wrexham. The site is a former brickworks and landfill surrounded by agricultural land on the banks of the River Dee, **Figure 3.1**.

Table 3.1: Site setting

Direction	Characteristic
North	The site is directly bounded by the River Dee with woodland beyond.
South	Bounded by agricultural land and a small hamlet of residential dwellings.
East	The site is directly bounded by the River Dee with woodland beyond.
West	The site is directly bounded by the B5605 and the River Dee with woodland and the residential area of Newbridge beyond.

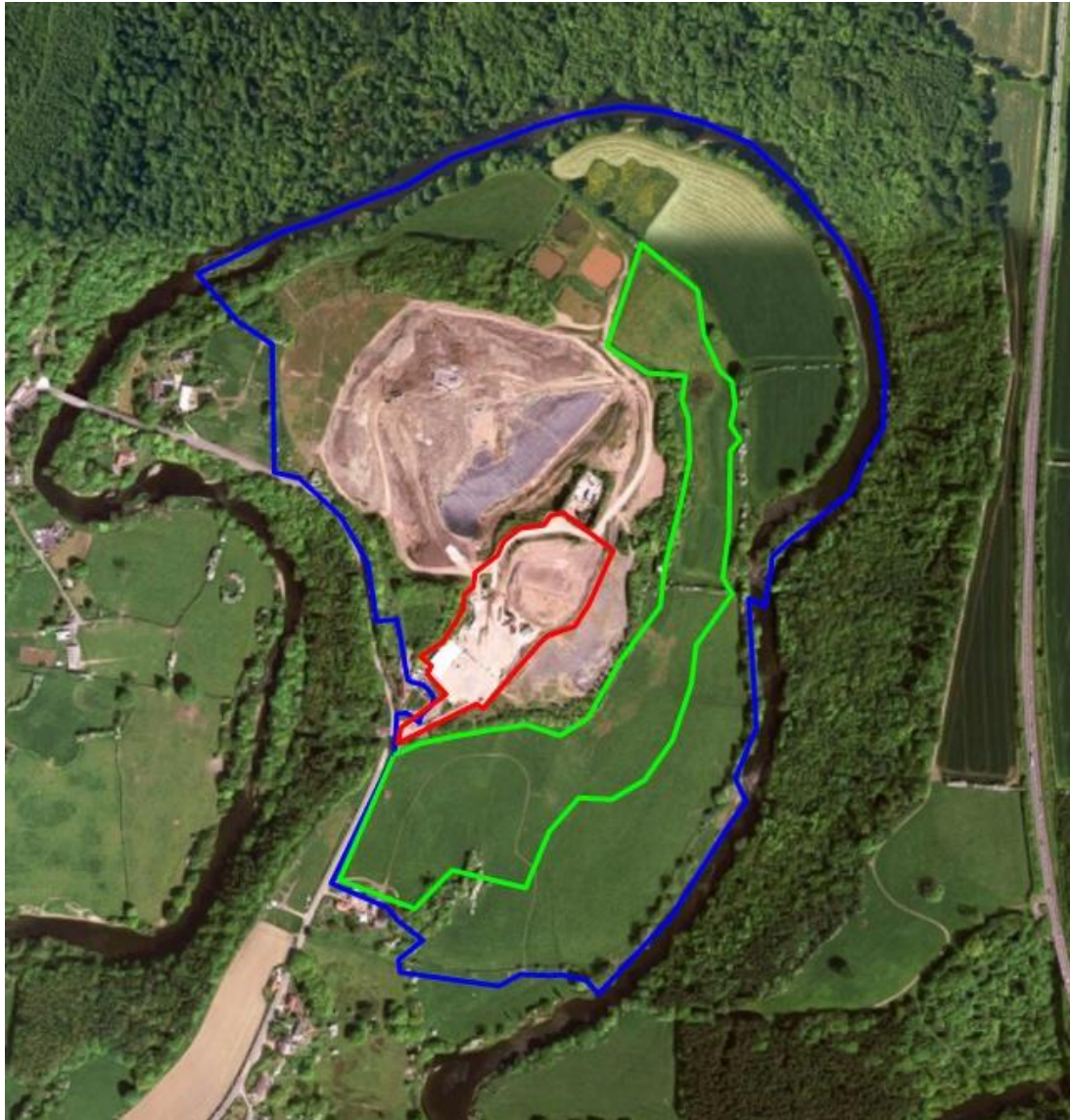


Figure 3.1: Site location plan

3.2 Land use and topography

The site currently has a mixed land use. There is an area for landfill in the centre of the site, with agricultural land uses on the east and north. There are a small number of access tracks and buildings which form the compound for the landfill works.

A site specific topographical survey has been carried out on the site. The land undulates and has falls in multiple directions from a high point away from the centre of the site where levels are in the region of 91m AOD. There is a plateau towards the periphery of the site adjacent to the watercourse with levels in the region of 53m AOD.

The topographic survey and existing site layout is included in **Appendix B**.

3.3 Hydrology

The closest Main River to the site is the River Dee which meanders around the site to the north, east and west flowing in clockwise direction. In this location the River Dee is not tidally influenced.

A number of surface water settlement ponds are located in the northern area of the site, these ponds take run off from the working area and ultimately flow into the River Dee.

3.4 Geology

Based on published geological records for the area (British Geological Survey online mapping), the site exhibits the following geology:

- Split Superficial Geology:
 - River Terrace Deposits (undifferentiated) - Sand and Gravel. Superficial Deposits formed up to 3 million years ago in the Quaternary Period. Local environment previously dominated by rivers.
 - Till, Devensian - Diamicton. Superficial Deposits formed up to 2 million years ago in the Quaternary Period. Local environment previously dominated by ice age conditions
- Base rock Geology: Etruria Formation - Mudstone. Sedimentary Bedrock formed approximately 308 to 319 million years ago in the Carboniferous Period. Local environment previously dominated by rivers.

3.5 Climate Change

Within the context of the existing flood risk at the site, and the requirements of the PPW and TAN15, climate change impacts from different flood sources have been considered alongside the present day scenario as described in Section 7.

As an overview; climate change can affect local flood risk in several ways. Impacts will depend on local conditions and vulnerability.

In the Dee River Basin District, wetter winters and more rain falling in wet spells may increase river flooding for rivers and tributaries. In turn, this may increase pressure on drains, sewers and water quality. Storm intensity in summer could increase even in drier summers. Rising sea or river levels may increase local flood risk inland or away from major rivers because of interactions with drains, sewers and smaller watercourses.

In accordance with the requirements of the PPW the latest climate change predictions will be considered within this assessment. Wrexham County Borough Council has stated that the climate change factor which they would expect to see in terms of rainfall for the lifetime of the development would be 30%.

4 DEVELOPMENT PROPOSALS

The proposed development is for a mixed used residential and recreational development.

The concept framework shows that the proposed site will contain multiple parcels of residential development as well as play areas, public open spaces, highways and drainage features, as shown within **Appendix C**.

Table 4.1: proposed land uses

Land use	Area (m ²)
Housing	25,778
Eco Lodges and Recreational Area	87,871
Remainder of site/restoration area	379,096

5 LEGISLATION AND POLICY CONTEXT

5.1 National policy

Table 5.1: National legislation and policy context

Legislation	Key provisions
Planning Policy Wales Edition 9 (Nov 2016)	The aims of planning policy on development and flood risk are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk. Development proposals should seek to reduce, and certainly not increase, flood risk arising either from river and/or coastal flooding or from additional run-off from development in any location. <u>13.4.2</u> ...Surface water run-off is to be controlled as near to the source as possible by the use of sustainable urban drainage systems...should also ensure that development does not: • increase the risk of flooding elsewhere by loss of flood storage or flood flow route; or • increase the problem of surface water run-off.
Technical Advice Note 15 (2004)	PPW is supported by the Technical Advice Note 15, which provide additional guidance on flood risk.
Flood and Water Management Act 2010 ^(Ref. 6)	This legislation was formally ratified in April 2010 with the aim is to implementing the findings of the 2007 Pitt Review and co-ordinating control of drainage and flood issues. There are a number of increased responsibilities within the act that affect adoption of Sustainable Drainage Systems (SuDS) features and the role of the NRW to expand on the mapping data they provide. The implementation of SuDS features has many beneficial impacts on the treatment of surface water during remediation works.
Water Resources Act 1991 ^(Ref. 7)	Section 24 –NRW is empowered under this Act to maintain and improve the quality of 'controlled' waters Section 85 – It is an offence to cause or knowingly permit pollution of controlled waters Section 88 – Discharge consents are required for discharges to controlled waters
Water Framework Directive (2000) ^(Ref. 8)	The Water Framework Directive (WFD) requires all inland and coastal waters to reach 'good' chemical and biological status by 2015. Flood risk management is unlikely to have a significant impact on chemical water quality except where maintenance works disturb sediment (such as de-silting) or where pollutants are mobilised from contaminated land by floodwaters. The main impact of the WFD on flood risk management, both now and in the future, relates to the ecological quality of water bodies. Channel works, such as straightening and deepening, or flood risk

Legislation	Key provisions
	management schemes that modify geomorphological processes can change river morphology. The WFD aims to protect conservation sites identified by the EC Habitats Directive and Birds Directive that have water-related features, by designating them as 'protected sites'.

5.2 Local policy

Local policies ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding and making development safe without increasing flood risk elsewhere and where possible, reducing flood risk. The current adopted Development Plan for the Wrexham Local Planning Authority Area is the Wrexham's Unitary Development Plan (UDP).

Wrexham County Borough Council formally adopted the UDP in February 2005. The main objective of the UDP is to ensure sustainable development. It seeks to integrate economic, social and environmental goals and accords with the Council's Local Agenda. Future land development land needs are satisfied in a controlled and incremental manner and new development is balanced against the interests of conservation and rehabilitation.

Relevant policies to flood risk, drainage and hydrology are outlined in **Table 5.2** below.

Table 5.2: Local policy context

UDP document	Key provisions and policies
Policy GDP1	i) Ensure that development does not result in, or is subject to, flooding, soil erosion, landslides or contamination, either on or off the site.
Policy EC12 – Development and Flood Risk	Development (including the raising of land) within defined flood plains will only be permitted if it:- a) would not be subject to an unacceptable risk of flooding on-site; and/or b) does not result in an unacceptable risk of flooding on or off-site; and/or c) does not adversely affect flood management or maintenance schemes
Policy EC13 – Surface Water Run-off	Development which would result in an unacceptable adverse impact on the water environment due to additional surface water run-off will not be permitted. 5.18 Development on green field sites usually results in an increase in the amount of impermeable land. This can alter the natural water cycle as rates and volumes of surface water reaching a surface watercourse generally increase. 5.19 Wherever practicable surface water should be disposed of as

UDP document	Key provisions and policies
	close to the source as possible. Where potential risks are identified appropriate flow attenuation facilities or mitigation measures may be a pre-requisite for development. Consideration should be given to the use of softer engineering structures referred to as Sustainable Urban Drainage Systems (SUDS). SUDS is a concept that focuses decisions about drainage design, construction and maintenance on the quality of the receiving environment and people. SUDS are physical structures built to receive surface water runoff. They typically include swales, ponds, infiltration basins and porous surfaces and should be considered as alternatives to conventional drainage where appropriate. The Council will require the developer to demonstrate, both financially and practically, how the long term maintenance of any attenuation facilities or mitigation measures will be achieved.

6 TECHNICAL ADVICE NOTE 15

TAN15 provides technical guidance on flood risk and development which supplements the policy set out in Planning Policy Wales.

In line with Figure 2 of TAN15, the development category for the works is Highly Vulnerable Development, which includes all residential premises. In line with Figure 1 of TAN15, Highly Vulnerable Development is acceptable in Flood Zone A.

6.1 Assessing Flood Consequences

To satisfy the criteria of the assessment of flood consequences, the following conditions should be satisfied;

1. Flood defences must be shown by the developer to be structurally adequate;
2. The cost of future maintenance for all new / approved flood mitigation measures, including defences must be accepted by the developer and agreed with NRW;
3. The developer must ensure that future occupiers of the development area are aware of the flooding risk and consequences;
4. Effective flood warnings are provided at the site;
5. Escape / evacuation routes are shown by the developer to be operational under all conditions;
6. Flood emergency plans and procedures produced by the developer must be in place;
7. The development is designed by the developer to allow the occupier the facility for rapid movement of goods to areas away from the floodwaters;
8. Development is designed to minimise structural damage during a flooding event and is flood proofed to enable it to be returned to its prime use quickly in the aftermath of the flood;
9. No flooding elsewhere.

7 SOURCES OF INFORMATION

7.1 Natural Resources Wales consultation

7.1.1 Flood zone maps

The NRW Flood Zone mapping study for Wales is available on their website at <https://naturalresources.wales/our-evidence-and-reports/maps/flood-risk-map/?lang=en>

The current displayed map is reproduced as **Figure 1.1** and shows the site to lie mainly within Flood Zone 1, at very low risk of flooding from fluvial or tidal sources, with some areas along the watercourse in Flood Zone 2 and 3.

The Welsh Assembly Development Advice Map has also been reproduced as **Figure 1.2** and shows the Welsh Assembly's TAN15 data.

In addition to the above mapping a number of other maps have been suggested by the NRW response. This confirms that the site is not known to have suffered from historic flooding.

7.1.2 Site specific consultation

Natural Resources Wales was formally consulted as part of this assessment, with request for flood related information. Their full response to the flood data request can be found in **Appendix D**.

7.2 Relevant studies

Table 7.1: Relevant studies

Study	Comments
Wrexham County Borough Council Local Flood Risk Management Strategy April 2013 (Ref. 9)	The Local Strategy must specify: - the risk management authorities in the authority's area; - the flood and coastal erosion risk management functions that may be exercised by those authorities in relation to the area; - the objectives for managing local flood risk (including any objectives included in the authority's flood risk management plan prepared in accordance with the Flood Risk Regulations 2009); - the measures proposed to achieve those objectives; - how and when the measures are expected to be implemented; - the costs and benefits of those measures, and how they are to be paid for; - the assessment of local flood risk for the purpose of the strategy; - how and when the strategy is to be reviewed; and - how the strategy contributes to the achievement of wider environmental objectives. The Local Strategy must be consistent with the National Strategy for Flood and Coastal Erosion Risk Management in Wales.
Local Planning Guidance: Management of Surface Water Generated from New Development (Ref. 10)	Early consultation with all relevant authorities is recommended. The key authorities are as follows: - The Council's Flood and Water management - Dŵr Cymru / Welsh Water - Cyfoeth Naturiol Cymru / Natural Resources Wales (NRW) - The Council's Highways Development Control Team. Wrexham County Borough Council advocates that surface water run-off should be controlled as near to its source as possible. Preferably sustainable drainage systems (SuDS) should be utilised. The variety of SuDS techniques available means that virtually any development should be able to include a scheme based around these principles. Surface water should be disposed of to the receptors listed in order of priority below: - Infiltrated to ground; - To a watercourse - To a surface water sewer - Other For undeveloped Greenfield sites discharge rates and volumes are normally required to be limited to the equivalent Greenfield runoff rate (with on-site attenuation for all events up to the 1% (1 in 100 year) rainfall event with an appropriate allowance for climate change). Storage of Water on Site: The drainage system should be designed so that flooding does not occur on any part of the development for

Study	Comments
	the 3.33% (1 in 30 year) rainfall event other than in those areas/systems designated to store or convey water. It may be acceptable to allow some on-site flooding of roads etc. for rainfall events beyond this. However flooding within the development site should not occur in any part of a building or utility plant susceptible to water during a 1% (1 in 100 year) + climate change rainfall event. A practicable minimum limit on the discharge rate from a flow attenuation device is often a compromise between attenuating to a satisfactorily low flow rate while keeping the risk of blockage to an acceptable level. It is suggested that this is 5 litres per second, using an appropriate vortex flow control device or other technically acceptable flow control device. The minimum size of pipe discharging from a flow attenuation device should be 150mm laid at a gradient not flatter than 1 in 150, which meets the requirements of Sewers for Adoption 7th Edition.
River Dee Catchment Flood Management Plan, January 2010 (CFMP) ^(Ref. 11)	The CFMP considers all types of inland flooding, from rivers, groundwater, surface water and tidal flooding, but not flooding directly from the sea (coastal flooding), which is covered by Shoreline Management Plans (SMPs). Coverage of surface and groundwater is however limited due to a lack of available information. The role of CFMPs is to establish flood risk management policies which will deliver sustainable flood risk management for the long term. CFMPs helps to understand the scale and extent of flooding now and in the future, and should be used to inform spatial planning and decision making by local authorities. CFMPs assess how flood risk is likely to change in the next 100 years. They do this at a strategic level and not at a detailed, local level. It is estimated that a 1% AEP (Annual Exceedance Probability) river flood event, could place approximately 290 properties at flood risk if the event occurred across the whole CFMP area in the future. The CFMP has identified a number of key locations currently at risk in a 1% AEP flood. The site falls within the 'Wrexham' sub-catchment and the policy applicable to this site is Policy Option 4 - Areas of low, moderate or high flood risk where NRW are already managing the flood risk effectively but where we may need to take further actions to keep pace with climate change.

7.3 Drainage

7.3.1 Private drainage

No details of the existing site drainage network have been provided; however, it is reasonable to assume that there are private surface water and foul networks within the area which are not recorded.

8 SOURCES OF FLOOD RISK

8.1 Criteria

In accordance with the PPW and advice from NRW, a prediction of the flood sources and levels is required along with the effects of climate change from the present throughout the design life of the development (in this case assumed to be 100 years). The aim of this is to consider the effects of climate change over the lifetime of the development.

The flood risk elements that need to be considered for any site are defined in BS 8533 as the “Forms of Flooding” and are listed as:

- Flooding from Rivers (fluvial flood risk);
- Flooding from the Sea (tidal flood risk);
- Flooding from the Land;
- Flooding from Groundwater;
- Flooding from Sewers (sewer and drain exceedance, pumping station failure etc); and
- Flooding from Reservoirs, Canals and other Artificial Structures.

The following section reviews each of these in respect of the subject site.

8.2 Flooding from rivers (fluvial flood risk)

8.2.1 Main River

The latest Welsh Government Development Advice Maps (**Figure 1.1**) shows that the site (houses and eco lodges) lies largely within Flood Zone A, representing a site that is considered to be at little or no risk of fluvial or coastal/tidal flooding with some areas located adjacent to the River Dee to be within Flood Zone C2.

NRW have not provided flood level data which has informed the Flood Zone map or the WAG DAM, as such the mapped outlines will be use to develop the flood consequence assessment on this basis.

8.2.2 Climate change

Fluvial flooding is likely to increase as a result of climate change. A greater intensity and frequency of precipitation is likely to raise river levels and increase the likelihood of a river overtopping its banks. Due to the topography on the site a small increase in water levels is unlikely to have an impact on the flood extents.

8.3 Flooding from the sea (tidal flood risk)

The site is not considered to be at risk from tidal flooding due to its inland location.

8.4 Flooding from the land (overland pluvial flood risk)

If intense rain is unable to soak into the ground or be carried through manmade drainage systems, for a variety of reasons, it can run off over the surface causing localised floods before reaching a river or other watercourse.

Generally, where there is impermeable surfacing or where the ground infiltration capacity is exceeded, surface water runoff will occur. Excess surface water flows from the site are believed to drain naturally to the local water features, either by overland flow or through infiltration.

Natural Resources Wales's surface water flood map (**Figure 8.1**) shows that there are sections of the site which are at medium to high risk of flooding from pluvial sources. However, these occupy localised topographic lows as shown within the topographic survey in **Appendix B**, or confined to the water's edge along the River Dee.

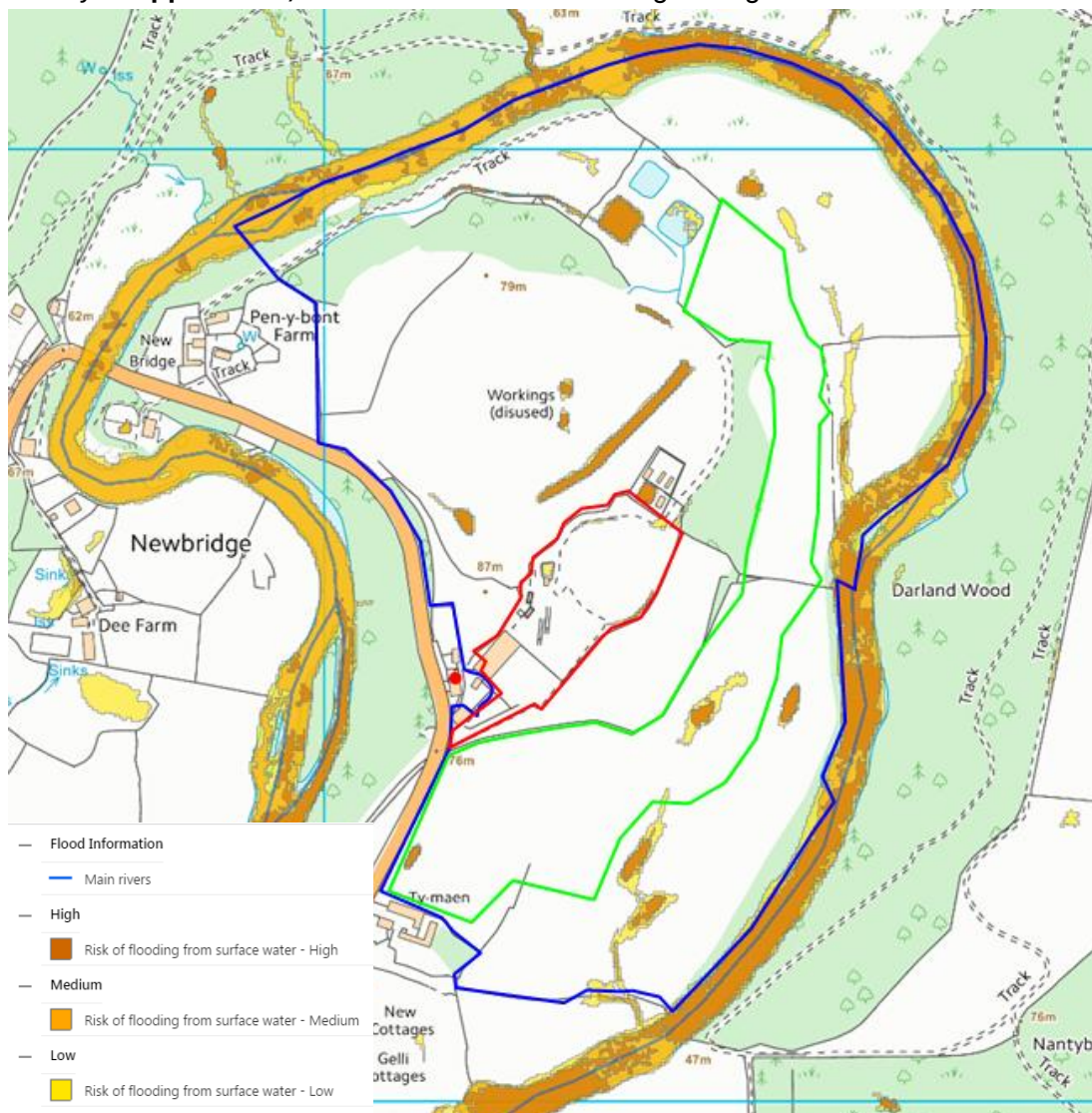


Figure 8.1: Natural Resources Wales surface water flood risk map (accessed May 2018)

In line with the Natural Resources Wales data, the risk of pluvial flooding to the site can be considered as mostly **very low** with localised areas of medium to high risk which will be taken into account within the design and layout of the site.

Areas of steep ground have the potential to generate runoff, which can present a flood source to immediately lower areas. This source of flooding is often exacerbated when steep ground is combined with impermeable soils and geology and / or significant areas of development with associated hard standing areas. Where roads are laid perpendicular to the contours of the land, preferential surface water flow pathways may be created. As there are no existing major flow paths, only areas of ponding, the creation of new pathways will be considered.

8.4.1 Climate change

Surface water flooding is likely to increase as a result of climate change in a similar ratio to fluvial flooding. Increased intensity and frequency of precipitation is likely to lead to reduced infiltration and increased overland flow.

8.5 Flooding from groundwater

Groundwater flooding tends to occur after much longer periods of sustained high rainfall. Higher rainfall means more water will infiltrate into the ground and cause the water table to rise above normal levels. Groundwater tends to flow from areas where the ground level is high, to areas where the ground level is low. In low-lying areas the water table is usually at shallower depths anyway, but during very wet periods, with all the additional groundwater flowing towards these areas, the water table can rise up to the surface causing groundwater flooding.

According to the Wrexham County Borough Council's Preliminary Flood Risk Assessment:

"There were no records of past groundwater flooding within WCBC; this is due to the topography and geology of the area."

As a result, the flood risk from this source can be considered to be **low**.

8.5.1 Climate change

Climate change could increase the risk of Groundwater flooding as a result of increased precipitation filtering into the Groundwater body. If winter rainfall becomes more frequent and heavier, Groundwater levels may increase. Higher winter recharge may however be balanced by lower recharge during the predicted hotter and drier summers. This is less likely to cause a significant change to flood risk than from other sources, since Groundwater flow is not as confined. It is probable that any locally perched aquifers may be more affected, but these are likely to be isolated. The change in flood risk is likely to be low.

8.6 Flooding from sewers

Flooding from artificial drainage systems occurs when flow entering a system, such as an urban storm water drainage system, exceeds its conveyance capacity, the system

becomes blocked or it cannot discharge due to a high water level in the receiving watercourse. A sewer flood is often caused by surface water drains discharging into the combined sewer systems; sewer capacity is exceeded in large rainfall events causing the backing up of floodwaters within properties or discharging through manholes.

Most adopted surface water drainage networks are designed to the criteria set out in Sewers for Adoption ^(Ref. 13). One of the design parameters is that sewer systems be designed such that no flooding of any part of the site occurs in a 1 in 30 year rainfall event. By definition a 1 in 100 year event would exceed the capacity of the surrounding sewer network as well as any proposed drainage.

However, due to the lack of sewers within the vicinity of the site, the flood risk from this source can be considered to be **very low**.

8.6.1 Climate change

The impact of climate change is likely to be negative regarding flooding from sewers. Increased rainfall and more frequent flooding put existing sewer and drainage systems under additional pressure resulting in the potential for more frequent surcharging and potential flooding. This would increase the frequency of local sewer flooding but would not be significant in terms of the proposed development.

8.7 Reservoirs

Flood events can occur from a sudden release of large volumes of water from reservoirs, canals and artificial structures.

The Natural Resources Wales reservoir flood map shows that the site is at potential risk of flooding from this source (**Figure 8.2**). It is not known where the source of this flood risk originates as there are no major reservoirs immediately upstream of the site and it is likely that the flood extent would not exceed that as shown by the Flood Zone 2 outline which represents a 1000 year fluvial flood event.

Reservoir flooding is also extremely unlikely. There has been no loss of life in the UK from reservoir flooding since 1925. Since then reservoir safety legislation has been introduced to ensure reservoirs are maintained.

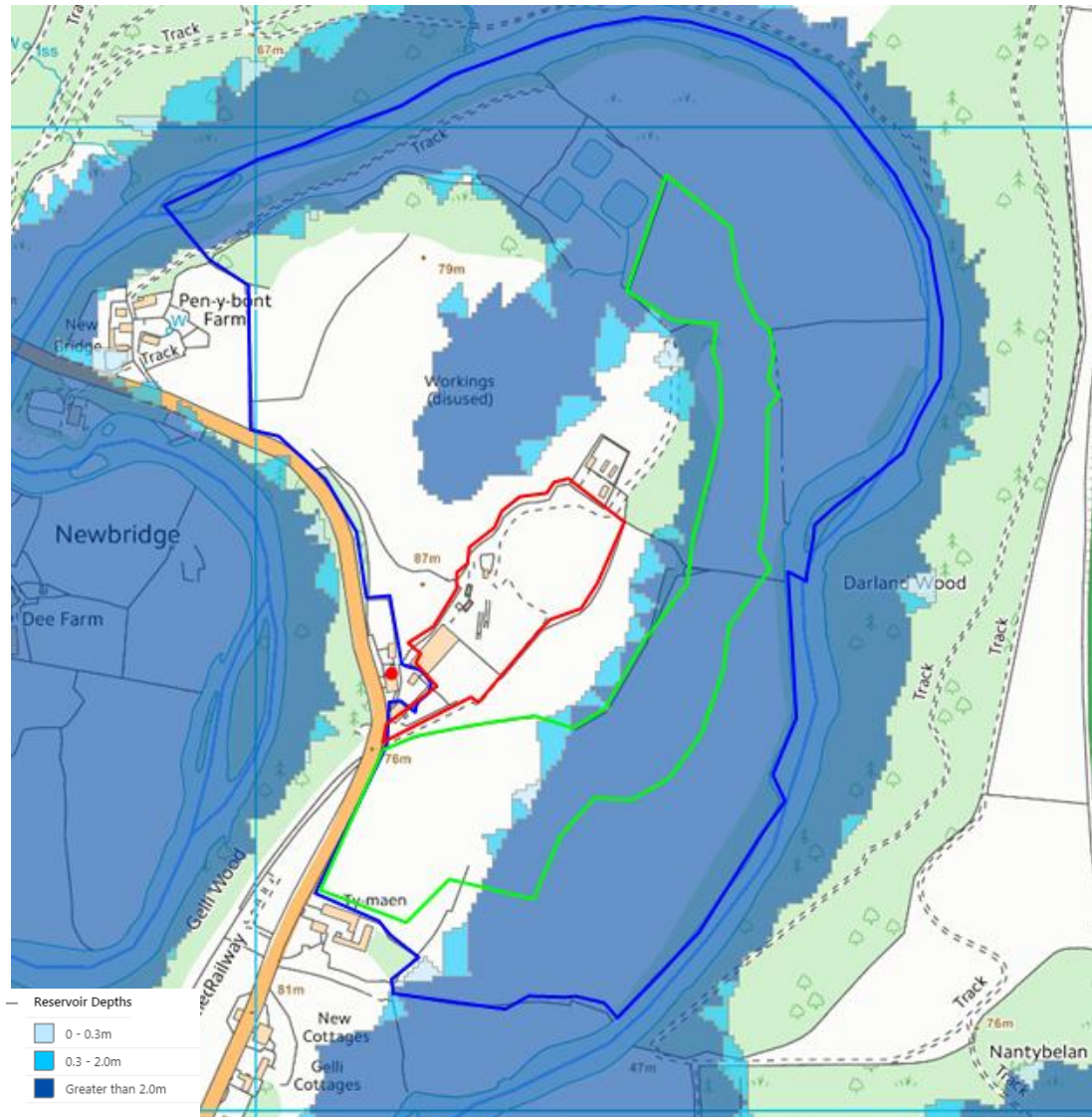


Figure 8.2: Natural Resources Wales reservoir flood risk map (accessed May 2018)

8.7.1 Climate change

Reservoirs can be managed over time, controlling inflow/outflow of water and therefore there is the capacity to control the effects of climate change. Increased rainfall has the potential to increase base flow, but this should be minimal. It is unlikely that there will be a substantial change to the risk of flooding for this site.

8.8 Canals

There are no Canal & River Trust owned canals within the vicinity of the site, therefore no risk is attributed to this source.

8.9 Flood risk resulting from the development

The proposed development will use the latest best practice guidance to ensure that flood risk is not increased as a result of the development. This will require the provision of a suitable surface water management plan to ensure that the surface water generated from the development is managed on-site.

9 DRAINAGE STRATEGY

9.1 Surface Water

9.1.1 Overview

The PPW and TAN 15 states that SuDS should be considered wherever practical. The use of SuDS is also encouraged by local policy (see Section 5).

In addition, Building Regulations Part H ^(Ref 14) requires that the first choice of surface water disposal should be to discharge to an adequate soakaway or infiltration system, where practicable. If this is not reasonably practicable then discharge should be to a watercourse, the least favourable option being to a sewer (surface water before combined). Infiltration techniques should therefore be applied wherever they are appropriate.

The Recommended non-statutory standards for sustainable drainage (SuDS) in Wales states; *“This Standard addresses the use of surface water by the development and where it should be discharged. The aim is to ensure that runoff is treated as a resource and managed in a way that minimises the impact of the development on flood risk, the morphology and pollution of receiving waters and the associated ecology. This will ensure that early consideration is given to the use of rainwater harvesting systems to both manage runoff and deliver a source of non-potable water for the site where practical. Where it is not, prioritisation should be given to infiltration. Discharges to sewerage systems should be limited where possible.”*

This section discusses the potential quantitative effects of the development on both the risk of surface water flooding on-site and elsewhere within the catchment, as well as the type of potential SuDS features that could be incorporated as part of the masterplan.

9.1.2 Pre-development situation

The total site area is approximately 49.3Ha; however, approximately 37.93Ha is to remain undeveloped from a hydraulic prospective; the latest development areas are as follows:

Land use	Area (m ²)
Housing	25,778
Eco Lodges and Recreation	87,871
Remainder of site/restoration area	492,745

It is assumed that only the housing and eco lodges will benefit from a formal drainage system with the remaining areas discharging any runoff to ground due to the minimal areas of impermeable surfaces.

The pro-rata IOH 124 method ^(Ref. 15) has been used to estimate the Greenfield surface water runoff for the site. Calculations are contained in **Appendix E**.

Table 9.1: IOH 124 surface water runoff (Greenfield)

Return period	Peak flow (l/s)	
	Total Site (49.3Ha)	Pro-rata (per Ha)
QBar	129.2	2.62
1 in 30 year	227.8	4.62
1 in 100 year	281.7	5.71

As a developed site, it is important to first consider infiltration based SuDS as a surface water disposal method.

Table 9.2: IOH 124 surface water runoff for each development parcel

Land use	Developable Area (m ²)	Impermeable Area (m ²)	Proposed discharge rate l/s
Housing	25,778	14,178	6.73
Eco Lodges and Recreation	87,871	21,968	23.00
Remainder of site/restoration area	492,745	N/A	No formal drainage proposed

As discussed within **Section 3.4** the superficial geology within the area is split between Glacial Till and Sand and Gravel with the underlying bedrock consisting of mudstone. It would be reasonable to assume that much of the superficial has been removed during the quarrying process. Mudstone is generally not conducive to permit the use of infiltration based SuDs.

9.1.2.1 Off site discharge options

Infiltration

Infiltration should be considered as the primary option to discharge surface water from the developed study area. The effectiveness of infiltration is completely dependent on the physical conditions at the study area. Potential obstacles include:

- Local variations in permeability preventing infiltration – It is understood from the BGS geological mapping that discharge to infiltration in the study area maybe a feasible

option based on the underlying superficial geology. However, as much of the superficial soil will have been removed as a result of quarrying and the Mudstone Bedrock will not likely yield good infiltration rates;

- Shallow groundwater table - For infiltration drainage devices, Building Regulation approved document H2 states that these “*should not be built in ground where the water table reaches the bottom of the device at any time of the year*”.
- Groundwater levels are unknown and would require confirmation though on site testing.

Due to the removal of the superficial soils it is likely that infiltration will not be a feasible drainage solution for the developable areas. As a result an alternative solution has been sought.

Discharge to watercourse

The site is surrounded by the River Dee on three flanks and therefore would offer a suitable option to discharge surface water from the site. Overland flow from the current site drains naturally towards the river channel through overland or subsurface flow paths.

Discharge to public sewer

Due to the rural nature of the site it is not thought that the site benefits from a formal drainage system, therefore this option is not being considered as an option for surface water disposal from the wider site.

9.1.3 Post-development situation

The proposed developable area will be for residential properties and eco-lodges, as explained within **Section 4**. It is assumed that approximately 55% of the residential development and 25% of the area designated for eco-lodges and recreation will be impermeable. This will result in an increase in surface water across the site and therefore it will be necessary to manage surface water on-site limited to the predevelopment greenfield rates, as per **Table 9.2**.

It will be considered necessary to provide improvements to water quality through appropriate source treatment as the site is discharging into the local watercourse. It is anticipated that sufficient levels of treatment could be achieved through trapped gullies within the highways, conveyance swales, a catch pit to remove suspended solids, a petrol interceptor and an infiltration basin.

9.1.4 Storage estimates

To determine the approximate volume of attenuation storage that would be required on the site, the WinDes 'Quick Storage' calculation has been used. WinDes 'Quick Storage' calculations provide a range of volumes as an approximation of the storage requirement (**Appendix F**). These volumes can be later revised at detail design.

Table 9.3: Surface water attenuation volumes

Land use	Proposed discharge rate l/s	1 in 100 year + 40% climate change Attenuation Volume (m ³)
Housing	6.73	1,117
Eco Lodges	23.00	1,323

These volumes are provided to demonstrate that the proposed drainage strategy for the development can be achieved. The applicant will work with the Lead Local Authority to agree the final attenuation volumes at the detailed design stage.

9.1.5 Proposed drainage strategy

The proposed SuDS strategy for the site includes on-site conveyance of surface water towards attenuation features serving the housing and eco lodges areas of the site. The design is that surface water is conveyed through piped networks from the majority of the proposed development, on a downwards gradient towards the attenuation features which provides sufficient volume to attenuate flow for the 1 in 100 year event inclusive of 40% climate change prior to discharge to the River Dee at a controlled rate.

Permeable paving could be incorporated within private roads, shared surfaces and drive ways that are part of the development. These areas of paving can be used to collect and store runoff from the houses and surrounding hardstanding areas before joining the on-site surface water network that flows into and basin. Permeable paving reduces the volume of suspended sediment and hydrocarbon pollution associated with residential developments. Adopted roads will not be constructed using permeable paving due to ownership and future maintenance issues, where responsibility will most likely lie with the highway authority. As the surface area available for permeable paving is currently unknown then the storage volume of permeable paving has not been included in the calculations.

The dimensions, volumes and location of the SuDS features will need to be provided as the development framework plan develops and during the detailed planning stage. Indicative volumes are provided as part of this report to provide an indication of the volume that would be required for attenuation. Detailed design of individual features is not part of the scope of this report. Preliminary design criteria have been based upon guidance given in the CIRIA publication The SuDS Manual and the information received to date.

10 PLANNING CONSIDERATIONS AND MITIGATION OPTIONS

10.1 Site layout and design

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development, hence the reason for completing this Flood Consequences Assessment.

TAN 15 uses a sequential, risk-based approach should be applied to try to locate more vulnerable land use to higher ground, while more flood-compatible development (e.g. vehicular parking, recreational space) can be located in higher risk areas.

Waterside areas, or areas along known flow routes, can be used for recreation, amenity and environmental purposes, allowing the preservation of flow routes and flood storage, and at the same time providing valuable social and environmental benefits contributing to other sustainability objectives. Landscaping should ensure safe access to higher ground from these areas, and avoid the creation of isolated islands as water levels rise.

Although the site is located outside the area mapped to be at flood risk it is recommended that the erection of suitable warning notices to inform people entering the recreational area shown to be at risk of flooding should be provided and there should be effective warning and evacuation plans where necessary. The operators of the site should liaise with the local planning authority and NRW about any flooding constraints which might apply and the arrangements for notifying users of the warning systems and evacuation procedures.

In addition, as the proposed eco-lodges are located adjacent to an area mapped to be at risk of fluvial flooding it is recommended that the site should sign up to receive flood warnings. Flood warnings and alerts have no effect on flood levels or flows, but provides communities with an opportunity to respond in advance of an extreme flood outside the scope of this assessment. They also provide the opportunity for devising an appropriate 'incident' management strategy. Management procedures are to be developed to assess the risk of flooding following advice either from the NRW or the Emergency planners. Should a flood warning be issued, showing a potential risk to the site due to an extreme event the area should be evacuated until the warnings and flood levels have receded.

10.2 Safe access and egress

As the NRW flood map and indicates that the site access (B5605) is located in Flood Zone 1 and therefore dry access and egress can be achieved at all times by pedestrians and vehicles.

10.3 Watercourse easements

There are currently no developable areas located within the 8-metre easement of the River Dee which is necessary for maintenance or repair. However, there are features such as a footpath located within this easement which will require a permit from NRW.

11 CONCLUSIONS

This FCA seeks to comply with the TAN 15 and PPW and demonstrates that flood risk from all sources has been considered in the proposed development. It is also consistent with the Local Planning Authority requirements with regard to flood risk.

The Natural Resources Wales Flood Map (**Figure 1.2**) shows the site to lie mainly within Flood Zone 1 with some areas along the watercourse in Flood Zone 2 and 3.

TAN 15 sets out a Justification Test, which states that preference should be given to development located within Flood Zone 1 (DAM Zone A). All of the development is located in Flood Zone 1 and therefore is at low risk..

The proposed development will alter the impermeable area on site and as a result a surface water drainage strategy will be required as the outline masterplan progresses.

This flood consequence assessment has concluded that:

- the Welsh Assembly Government's Development Advice Map (**Figure 1.1**) shows that the site is located largely within Zone A and some areas fronting the watercourse in B and C;
- The Natural Resources Wales Flood Map (**Figure 1.2**) shows the site to lie mainly within Flood Zone 1 with some areas along the watercourse in Flood Zone 2 and 3;
- The site is far enough inland not to be at risk of any tidal flooding event;
- Flood risk from surface water across the site is predominantly considered to be very low with isolated areas of low to medium flood risk which are present on site and these will be considered in the layout of the site;
- Flood risk from groundwater is considered low;
- Flood risk from other sources including sewers, reservoirs and artificial sources – is demonstrated to be low;
- The development will have no impact on other forms of flooding;
- There will be an increase in surface water runoff from the site. Runoff from the site will be limited to the greenfield QBAR rate and appropriate attenuation provided for rainfall events upto and including the 100 year plus 40% allowance for climate change; and
- The area within the flood zone will be subject to additional mitigation including the development of a suitable evacuation plan and subscription to the latest flood warning service.

Overall, taking into account the above points, the development of the site should not be precluded on flood risk grounds, as all on-site flood risk and potential off site flooding risk can be safely and properly mitigated in line with current guidance and regulations.

12 REFERENCES

1. Welsh Assembly Government, *Planning Policy Wales Edition 9*, Jan 2016.
2. Welsh Assembly Government, *Planning Policy Wales, Technical Advice Note 15: Development and Flood Risk*, July 2004
3. DEFRA (2004), 'Interim Code of Practice for Sustainable Drainage Systems' National SUDS Working Group, July 2004.
4. BSI (2011), 'BS 8533-2011 Assessing and managing flood risk in development Code of practice'.
5. Welsh Assembly Government (2016) 'Recommended non-statutory standards for sustainable drainage (SuDS) in Wales – designing, constructing, operating and maintaining surface water drainage systems.
6. Flood and Water Management Act, 2010.
7. Water Resources Act, 1991.
8. European Commission (2000) , 'Directive 2000/60/EC - Water Framework Directive
9. Wrexham County Borough Council: Local Flood Risk Management Strategy April 2013
10. Wrexham County Borough Council: Local Planning Guidance: Management of Surface Water Generated from New Development
11. River Dee Catchment Flood Management Plan, January 2010 (CFMP)
12. Communities and Local Government, 'Improving the flood performance of new buildings – flood resilient construction', 2007.
13. WRC, 'Sewers for Adoption' 7th Edition, 2012.
14. Building Regulations Part H
15. Institute of Hydrology (IoH), 'Flood Estimation for small catchments - Report 124', 1994.

APPENDIX A

SERVICE CONSTRAINTS

RSK Group service constraints

1. This report and the Drainage design carried out in connection with the report (together the "Services") were compiled and carried out by RSK LDE Ltd (RSK) for DBA Estates (the "client") in accordance with the terms of a contract between RSK and the "client". The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable Civil Engineer at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.
2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date hereof, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services, which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the



Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.

7. The Services are based upon RSK's observations of existing physical conditions at the site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

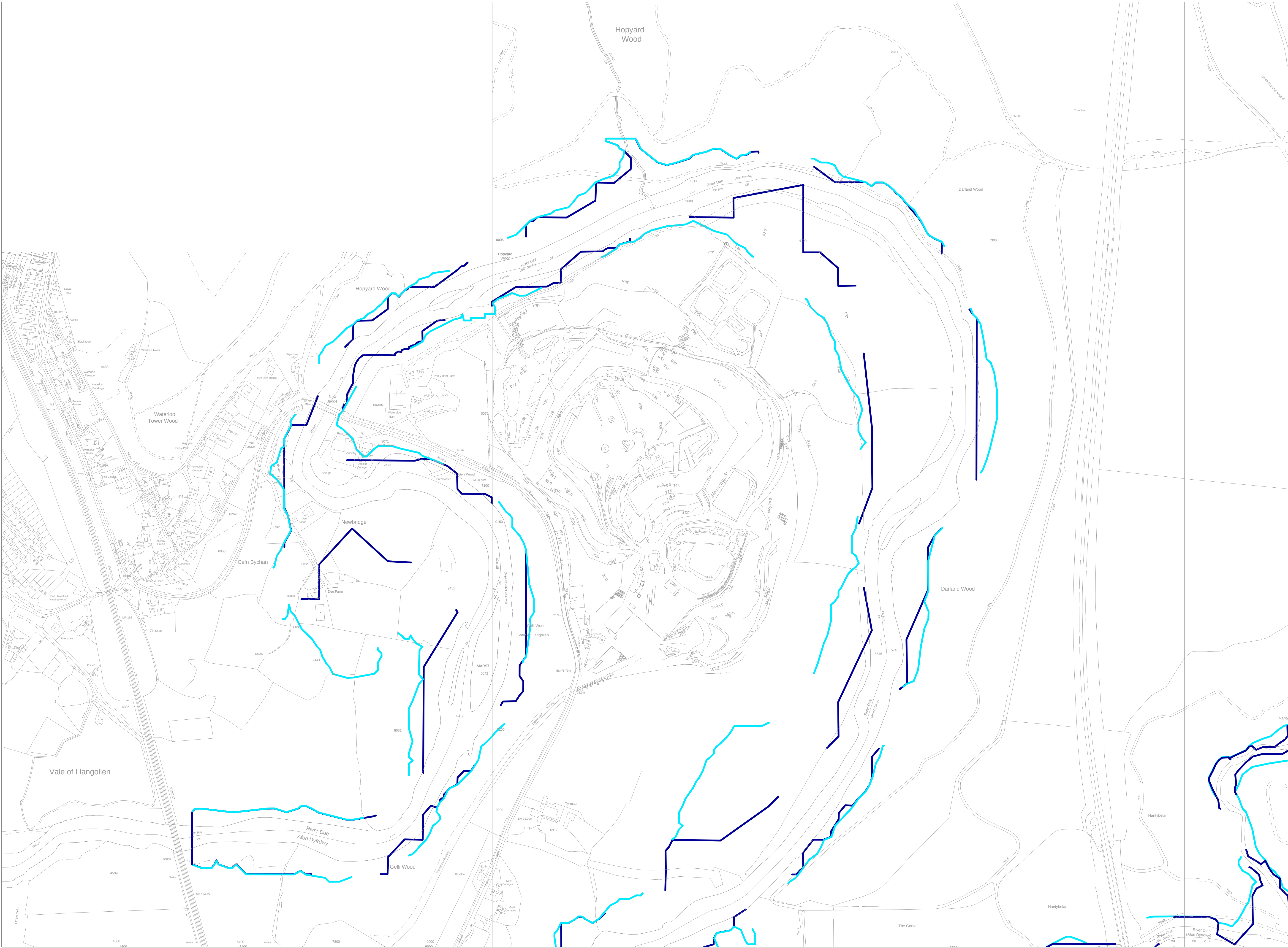
8. The phase II or intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site.



APPENDIX B

TOPOGRAPHIC SURVEY



1. SCALE FROM 1:1000
DRAWING ALL DIMENSIONS
TO BE TAKEN FROM
DIMENSION STRINGS.

3. WHERE ANY DISCREPANCIES
ARE FOUND BETWEEN
DIMENSIONS THESE MUST
BE BROUGHT TO THE
ATTENTION OF THE
ARCHITECTS FOR
RESOLUTION.

4. WHERE DISCREPANCIES EXIST
BETWEEN REFERENCE OR
ASSEMBLY DRAWINGS &
DETAIL DRAWINGS, THE
LATTER TAKE PREFERENCE.

LEGEND

FOR INFORMATION

FCC Env brand (horiz #3BA27.jpg)

GSDA
GARRY STEWART DESIGN ASSOCIATES
Highlands House, Office 300A, 165 The
Broadway, Wimbledon, London, SW19 1NE
T. 020 8544 6065

PEN-Y-BONT

PROJECT

DRAWING

SCALE DATE

DWG. NO. REVISION CHECKED

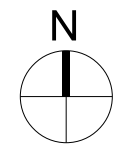


APPENDIX C

DEVELOPMENT PROPOSALS



- NOTE
1. THIS DRAWING IS COPYRIGHT GSDA LTD
 2. THE CONTRACTOR MUST NOT SCALE FROM THE DRAWING ALL DIMENSIONS TO BE TAKEN FROM DIMENSION STRINGS.
 3. WHERE ANY DISCREPANCIES ARE FOUND BETWEEN DIMENSIONS THESE MUST BE BROUGHT TO THE ATTENTION OF THE ARCHITECTS FOR RESOLUTION.
 4. WHERE DISCREPANCIES EXIST BETWEEN REFERENCE OR ASSEMBLY DRAWINGS & DETAIL DRAWINGS, THE LATTER TAKE PRECEDENCE.



LEGEND

- Red Line Boundary
- Ownership Boundary (Drawing 466M252 Environmental Monitoring Plan)
- Proposed Recreational Path
- River Dee
- Existing Woodland
- Proposed Woodland
- Access Routes

18.05.03 Issued for information

FOR INFORMATION

FCC Environment

GSDA
GARRY STEWART DESIGN ASSOCIATES

Highlands House, Office 300A, 165 The Broadway, Wimbledon, London, SW19 1NE
T: 020 8544 6085

PEN-Y-BONT		
PROJECT		
Red Line Overlay on Simplified Site Zoning Option 2		
DRAWING		
1:2000@A1 180503		
SCALE	DATE	
1354 SK009	-	GS
DWG. NO.	REVISION	CHECKED



APPENDIX D

NRW CORRESPONDENCE

Colin Whittingham

From: Data Distribution [datadistribution@cyfoethnaturiolcymru.gov.uk]
Sent: 17 November 2017 14:42
To: Kathryn Olive
Subject: ATI14074A Pen y Bont, Chirk, Wrexham, LL14 5AR 131117

Dear Ms Olive,

Thank you for your email requesting information for the above property.

Did you know that you can find some information for your queries online. Please follow the relevant links posted below by your queries:

1. Confirmation of the site's Flood Zone designation, alternatively could you provide the flood flows and levels for a range of return periods including the 1 in 2, 10, 30, 100, 100+CC, 200, 1000,

Flood Zone 2 - <http://lle.gov.wales/catalogue/item/FloodZ2/?lang=en>

Flood Zone 3 - <http://lle.gov.wales/catalogue/item/Flood3/?lang=en>

Please find a link to our Open Government Licence (OGL) here -
<http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>

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2. Information on the recently published climate change guidance for this area and how this may impact on the data available for the area,

On **23rd August 2016** the Welsh Government published a Policy Clarification Letter regarding climate change allowances for planning purposes, supplemented by a guidance note and map. The letter and supporting documents supplement the policy advice provided in Technical Advice Note (TAN) 15: Development and Flood Risk. Local planning authorities, applicants and their consultants are expected to use these climate projections from **1st December 2016**.

The documents are available via the following link:
<http://gov.wales/topics/planning/policy/policyclarificationletters/2016/cl-03-16-climate-change-allowances-for-planning-purposes/?lang=en>

3. Information on surface water flood risk including flow pathways and depths,

You will be informed on what data we have in this area in due course.

4. Information on historic flooding,

Historic Flood Outlines - <http://lle.gov.wales/catalogue/item/HistoricFI/?lang=en>

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<http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>

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5. Information on flood defences in the area, if any,

Areas Benefiting from Flood Defences -

<http://lle.gov.wales/catalogue/item/FloodMapAreasBenefitingFromFloodDefences/?lang=en>

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6. Any data on existing surface water discharges to the surrounding watercourses,

Risk of Flooding from Surface Water -

<http://lle.gov.wales/catalogue/item/RiskOfFloodingFromSurfaceWater/?lang=en>

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7. Any data on groundwater flooding,

You will be informed on what data we have in this area in due course.

8. Any information on reservoir flooding; and,

Flood Storage Areas - <http://lle.gov.wales/catalogue/item/FIstor/?lang=en>

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<http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>

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9. Any information on culverted watercourses or private sewers which you know of which do not show up on the public sewer records.

Please contact the relevant utility company for information on private sewers. Here is a link to NRW discharge consents –

<http://lle.gov.wales/catalogue/item/ConsentedDischargesToControlledWatersWithConditions/?lang=en>

Please find a link to our Open Government Licence (OGL) here -

<http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>

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With regards to culverted watercourses, you will be informed on what data we have in this area in due course.

10. Finally, please could you provide any recommendation on how the surface water is to be managed; for example, restrictions in discharge rates the requirements for SuDS, possible discharge locations and attenuation requirements?

As this is more a planning query, please see the following links to consult with our Planning Department for further advice - <https://naturalresources.wales/guidance-and-advice/business-sectors/planning-and-development/contact-details-for-planning-enquiry/?lang=en>

<https://naturalresources.wales/guidance-and-advice/business-sectors/planning-and-development/advice-for-developers/our-service-to-developers/?lang=en>

With regards the location of the site, I have been unable to establish this. Therefore, in order for me to process the remainder of your request and any additional queries on the links I've provided above, please could you send a map/plan identifying the exact location by way of a cross/mark.

I look forward to hearing from you.

Yours sincerely,

Michelle

Eich Enw/Your name: Michelle Lewis

Teitl Swydd/Job Title: Swyddog Cysylltiadau Allanol/ External Relations Officer

Teitl eich tim/Title of your team: Cysylltiadau Allanol/External Relations

Cyfoeth Naturiol Cymru/Natural Resources Wales

Ffon/Tel: **VOIP: 03000653577** or Ganolfan Gwasanaethau Cwsmeriad/Customer Services Centre - 03000 65 3000

E-bost/E-mail: datadistribution@naturalresourceswales.gov.uk

Ewch i / Browse our [Data Services webpage](#)

Gwefan/Website: www.cyfoethnaturiolcymru.gov.uk/www.naturalresourceswales.gov.uk

Os hoffech i'n hymateb fod yn Gymraeg neu'n ddwyieithog, rhwch wybod i mi drwy roi clych o amgylch yr opsiwn priodol isod: If you would like our response to be in the Welsh language or bilingual, please let me know by circling the appropriate option below: [Cymraeg/Welsh](#) - [Dwyieithog/Bilingual](#)

Ein diben yw sicrhau bod adnoddau naturiol Cymru yn cael eu cynnal, eu gwella a'u defnyddio yn gynaliadwy, yn awr ac yn y dyfodol. Our purpose is to ensure that the natural resources of Wales are sustainably maintained, enhanced and used, now and in the future.

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

From: KOlive@rsk.co.uk

Received: Mon Nov 13 2017 10:45:53 GMT+0000 (GMT Standard Time)

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

Subject: Flood Information Request - Pen y Bont, Chirk 881358

Dear Sir/Madam,

Please could I order information on flooding and drainage for the following site in order to inform a Flood Risk Assessment:

Pen y Bont
Chirk,
Wrexham
LL14 5AR

Grid reference – 329256 E, 341626 N

I would like all the flooding information you have including the following, if available:

- Confirmation of the site's Flood Zone designation, alternatively could you provide the flood flows and levels for a range of return periods including the 1 in 2, 10, 30, 100, 100+CC, 200, 1000,
- Information on the recently published climate change guidance for this area and how this may impact on the data available for the area,
- Information on surface water flood risk including flow pathways and depths,
- Information on historic flooding,
- Information on flood defences in the area, if any,
- Any data on existing surface water discharges to the surrounding watercourses,
- Any data on groundwater flooding,
- Any information on reservoir flooding; and,
- Any information on culverted watercourses or private sewers which you know of which do not show up on the public sewer records.

Finally, please could you provide any recommendation on how the surface water is to be managed; for example, restrictions in discharge rates the requirements for SuDS, possible discharge locations and attenuation requirements?

We have a relatively quick turn around on this project and would therefore appreciate a quick response.

If you have any queries please don't hesitate to contact me.

Kind regards,

Kathryn

Kathryn Olive

Administrator

Land & Development Engineering

RSK

14 Beecham Court, Pemberton Business Park, Wigan, WN3 6PR, UK

Switchboard: +44 (0) 1942 493255

<http://www.rsk.co.uk>

RSK Land & Development Engineering Ltd is registered in England at Spring Lodge, 172 Chester Road, Helsby, Cheshire, WA6 0AR, UK

Registered number: 4723837

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APPENDIX E

GREENFIELD RUNOFF CALCULATIONS

RSK LDE Ltd		Page 1																								
18 Frogmore Road Hemel Hempstead Herts, HP3 9RT																										
Date 15/05/2018 14:40 File	Designed By RBrenton Checked By																									
Elstree Computing Ltd	Source Control W.12.5																									
<u>ICP SUDS Mean Annual Flood</u> Input <table> <tr> <td>Return Period (years)</td> <td>100</td> <td>Soil</td> <td>0.300</td> </tr> <tr> <td>Area (ha)</td> <td>49.300</td> <td>Urban</td> <td>0.000</td> </tr> <tr> <td>SAAR (mm)</td> <td>955</td> <td>Region Number</td> <td>Region 9</td> </tr> </table> Results l/s <table> <tr> <td>QBAR Rural</td> <td>129.2</td> </tr> <tr> <td>QBAR Urban</td> <td>129.2</td> </tr> <tr> <td>Q100 years</td> <td>281.7</td> </tr> <tr> <td>Q1 year</td> <td>113.7</td> </tr> <tr> <td>Q30 years</td> <td>227.8</td> </tr> <tr> <td>Q100 years</td> <td>281.7</td> </tr> </table>			Return Period (years)	100	Soil	0.300	Area (ha)	49.300	Urban	0.000	SAAR (mm)	955	Region Number	Region 9	QBAR Rural	129.2	QBAR Urban	129.2	Q100 years	281.7	Q1 year	113.7	Q30 years	227.8	Q100 years	281.7
Return Period (years)	100	Soil	0.300																							
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APPENDIX F

WINDES 4 STAGE DESIGN OF DRAINAGE FEATURES

RSK LDE Ltd			Page 1		
18 Frogmore Road Hemel Hempstead Herts, HP3 9RT		Pen Y Bont Eco Lodges Q100 +40%			
Date Jan 18 File eco lodges 18.05....		Designed By CW Checked By			
Elstree Computing Ltd		Source Control W.12.5			
<u>Summary of Results for 100 year Return Period (+40%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	49.259	0.459	19.0	440.2	O K
30 min Summer	49.407	0.607	19.0	603.6	O K
60 min Summer	49.560	0.760	19.4	783.0	O K
120 min Summer	49.703	0.903	20.5	961.5	O K
180 min Summer	49.772	0.972	21.1	1050.1	O K
240 min Summer	49.807	1.007	21.4	1096.5	O K
360 min Summer	49.837	1.037	21.7	1136.6	O K
480 min Summer	49.846	1.046	21.7	1148.4	O K
600 min Summer	49.848	1.048	21.8	1151.9	O K
720 min Summer	49.846	1.046	21.7	1149.5	O K
960 min Summer	49.835	1.035	21.6	1134.3	O K
1440 min Summer	49.796	0.996	21.3	1082.1	O K
2160 min Summer	49.724	0.924	20.7	988.6	O K
2880 min Summer	49.650	0.850	20.1	894.2	O K
4320 min Summer	49.506	0.706	19.1	718.1	O K
5760 min Summer	49.372	0.572	19.0	563.5	O K
7200 min Summer	49.256	0.456	19.0	436.6	O K
8640 min Summer	49.168	0.368	18.9	345.3	O K
10080 min Summer	49.110	0.310	18.4	286.4	O K
Storm Event	Rain (mm/hr)	Time-Peak (mins)			
15 min Summer	111.276	26			
30 min Summer	76.836	40			
60 min Summer	50.812	68			
120 min Summer	32.465	126			
180 min Summer	24.581	186			
240 min Summer	20.008	244			
360 min Summer	14.913	360			
480 min Summer	12.100	420			
600 min Summer	10.277	482			
720 min Summer	8.989	546			
960 min Summer	7.267	680			
1440 min Summer	5.372	958			
2160 min Summer	3.960	1368			
2880 min Summer	3.185	1768			
4320 min Summer	2.337	2556			
5760 min Summer	1.876	3288			
7200 min Summer	1.584	3968			
8640 min Summer	1.379	4664			
10080 min Summer	1.227	5336			
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18 Frogmore Road Hemel Hempstead Herts, HP3 9RT	Pen Y Bont Eco Lodges Q100 +40%				
Date Jan 18 File eco lodges 18.05....	Designed By CW Checked By				
Elstree Computing Ltd	Source Control W.12.5				
<u>Summary of Results for 100 year Return Period (+40%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Winter	49.310	0.510	19.0	494.8	O K
30 min Winter	49.472	0.672	19.0	679.0	O K
60 min Winter	49.640	0.840	20.0	882.1	O K
120 min Winter	49.799	0.999	21.3	1086.7	O K
180 min Winter	49.877	1.077	22.0	1191.4	O K
240 min Winter	49.919	1.119	22.4	1248.4	O K
360 min Winter	49.959	1.159	22.8	1304.4	Flood Risk
480 min Winter	49.972	1.172	22.9	1322.5	Flood Risk
600 min Winter	49.970	1.170	22.9	1319.7	Flood Risk
720 min Winter	49.967	1.167	22.8	1314.8	Flood Risk
960 min Winter	49.950	1.150	22.7	1292.0	Flood Risk
1440 min Winter	49.892	1.092	22.2	1211.8	O K
2160 min Winter	49.785	0.985	21.2	1067.4	O K
2880 min Winter	49.673	0.873	20.2	923.6	O K
4320 min Winter	49.452	0.652	19.0	655.7	O K
5760 min Winter	49.246	0.446	19.0	426.5	O K
7200 min Winter	49.117	0.317	18.5	293.1	O K
8640 min Winter	49.052	0.252	17.0	228.8	O K
10080 min Winter	49.015	0.215	15.5	194.0	O K
Storm Event	Rain (mm/hr)	Time-Peak (mins)			
15 min Winter	111.276	26			
30 min Winter	76.836	40			
60 min Winter	50.812	68			
120 min Winter	32.465	124			
180 min Winter	24.581	182			
240 min Winter	20.008	240			
360 min Winter	14.913	352			
480 min Winter	12.100	458			
600 min Winter	10.277	552			
720 min Winter	8.989	576			
960 min Winter	7.267	730			
1440 min Winter	5.372	1038			
2160 min Winter	3.960	1480			
2880 min Winter	3.185	1908			
4320 min Winter	2.337	2720			
5760 min Winter	1.876	3400			
7200 min Winter	1.584	3968			
8640 min Winter	1.379	4592			
10080 min Winter	1.227	5248			
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18 Frogmore Road Hemel Hempstead Herts, HP3 9RT	Pen Y Bont Eco Lodges Q100 +40%	
Date Jan 18 File eco lodges 18.05....	Designed By CW Checked By	
Elstree Computing Ltd	Source Control W.12.5	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.300	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time / Area Diagram

Total Area (ha) 2.197

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.732	4-8	0.732	8-12	0.732

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18 Frogmore Road Hemel Hempstead Herts, HP3 9RT	Pen Y Bont Eco Lodges Q100 +40%	
Date Jan 18 File eco lodges 18.05....	Designed By CW Checked By	
Elstree Computing Ltd	Source Control W.12.5	

Model Details

Storage is Online Cover Level (m) 50.000

Tank or Pond Structure

Invert Level (m) 48.800

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	850.0	1.200	1420.0

Hydro-Brake® Outflow Control

Design Head (m) 1.200 Diameter (mm) 187
Design Flow (l/s) 23.0 Invert Level (m) 48.800
Hydro-Brake® Type Md5 SW Only

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.6	1.200	23.1	3.000	36.5	7.000	55.7
0.200	14.6	1.400	24.9	3.500	39.4	7.500	57.6
0.300	18.2	1.600	26.6	4.000	42.1	8.000	59.5
0.400	19.0	1.800	28.2	4.500	44.6	8.500	61.4
0.500	18.8	2.000	29.8	5.000	47.1	9.000	63.1
0.600	18.7	2.200	31.2	5.500	49.4	9.500	64.9
0.800	19.7	2.400	32.6	6.000	51.6		
1.000	21.3	2.600	33.9	6.500	53.7		

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18 Frogmore Road Hemel Hempstead Herts, HP3 9RT		Pen Y Bont Eco Lodges Q100 +40%			
Date Jan 18 File housing 18.05.201...		Designed By CW Checked By			
Elstree Computing Ltd		Source Control W.12.5			
<u>Summary of Results for 100 year Return Period (+40%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	49.172	0.372	5.3	290.5	O K
30 min Summer	49.295	0.495	5.3	400.3	O K
60 min Summer	49.427	0.627	5.3	525.1	O K
120 min Summer	49.561	0.761	5.5	659.7	O K
180 min Summer	49.635	0.835	5.7	737.0	O K
240 min Summer	49.682	0.882	5.8	787.1	O K
360 min Summer	49.742	0.942	6.0	853.2	O K
480 min Summer	49.780	0.980	6.1	896.1	O K
600 min Summer	49.805	1.005	6.2	924.3	O K
720 min Summer	49.821	1.021	6.2	943.0	O K
960 min Summer	49.837	1.037	6.3	961.5	O K
1440 min Summer	49.839	1.039	6.3	963.8	O K
2160 min Summer	49.826	1.026	6.3	949.0	O K
2880 min Summer	49.806	1.006	6.2	925.3	O K
4320 min Summer	49.756	0.956	6.0	869.0	O K
5760 min Summer	49.706	0.906	5.9	813.4	O K
7200 min Summer	49.657	0.857	5.7	760.2	O K
8640 min Summer	49.609	0.809	5.6	709.3	O K
10080 min Summer	49.562	0.762	5.5	660.8	O K
Storm Event	Rain (mm/hr)	Time-Peak (mins)			
15 min Summer	111.276	26			
30 min Summer	76.836	41			
60 min Summer	50.812	70			
120 min Summer	32.465	130			
180 min Summer	24.581	190			
240 min Summer	20.008	248			
360 min Summer	14.913	366			
480 min Summer	12.100	486			
600 min Summer	10.277	604			
720 min Summer	8.989	724			
960 min Summer	7.267	962			
1440 min Summer	5.372	1242			
2160 min Summer	3.960	1624			
2880 min Summer	3.185	2024			
4320 min Summer	2.337	2856			
5760 min Summer	1.876	3688			
7200 min Summer	1.584	4536			
8640 min Summer	1.379	5288			
10080 min Summer	1.227	6144			
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18 Frogmore Road Hemel Hempstead Herts, HP3 9RT	Pen Y Bont Eco Lodges Q100 +40%				
Date Jan 18 File housing 18.05.201...	Designed By CW Checked By				
Elstree Computing Ltd Source Control W.12.5					
<u>Summary of Results for 100 year Return Period (+40%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Winter	49.213	0.413	5.3	326.0	O K
30 min Winter	49.348	0.548	5.3	449.2	O K
60 min Winter	49.492	0.692	5.3	589.5	O K
120 min Winter	49.639	0.839	5.7	741.8	O K
180 min Winter	49.721	0.921	5.9	830.1	O K
240 min Winter	49.773	0.973	6.1	887.9	O K
360 min Winter	49.841	1.041	6.3	965.5	O K
480 min Winter	49.885	1.085	6.4	1017.1	O K
600 min Winter	49.915	1.115	6.5	1052.4	O K
720 min Winter	49.936	1.136	6.6	1077.0	O K
960 min Winter	49.959	1.159	6.6	1105.5	Flood Risk
1440 min Winter	49.968	1.168	6.7	1116.5	Flood Risk
2160 min Winter	49.950	1.150	6.6	1093.8	O K
2880 min Winter	49.923	1.123	6.5	1062.3	O K
4320 min Winter	49.853	1.053	6.3	979.4	O K
5760 min Winter	49.778	0.978	6.1	894.4	O K
7200 min Winter	49.705	0.905	5.9	813.1	O K
8640 min Winter	49.634	0.834	5.7	736.2	O K
10080 min Winter	49.565	0.765	5.5	663.4	O K
Storm Event		Rain (mm/hr)	Time-Peak (mins)		
15 min Winter		111.276	26		
30 min Winter		76.836	41		
60 min Winter		50.812	70		
120 min Winter		32.465	128		
180 min Winter		24.581	186		
240 min Winter		20.008	244		
360 min Winter		14.913	360		
480 min Winter		12.100	476		
600 min Winter		10.277	592		
720 min Winter		8.989	706		
960 min Winter		7.267	932		
1440 min Winter		5.372	1360		
2160 min Winter		3.960	1708		
2880 min Winter		3.185	2168		
4320 min Winter		2.337	3080		
5760 min Winter		1.876	3984		
7200 min Winter		1.584	4840		
8640 min Winter		1.379	5712		
10080 min Winter		1.227	6560		
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RSK LDE Ltd		Page 3
18 Frogmore Road Hemel Hempstead Herts, HP3 9RT	Pen Y Bont Eco Lodges Q100 +40%	
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Elstree Computing Ltd	Source Control W.12.5	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Shortest Storm (mins)	15
Ratio R	0.300	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time / Area Diagram

Total Area (ha) 1.418

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.473	4-8	0.473	8-12	0.473

RSK LDE Ltd		Page 4
18 Frogmore Road Hemel Hempstead Herts, HP3 9RT	Pen Y Bont Eco Lodges Q100 +40%	
Date Jan 18 File housing 18.05.201...	Designed By CW Checked By	
Elstree Computing Ltd	Source Control W.12.5	

Model Details

Storage is Online Cover Level (m) 50.000

Tank or Pond Structure

Invert Level (m) 48.800

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	700.0	1.200	1225.0

Hydro-Brake® Outflow Control

Design Head (m) 1.200 Diameter (mm) 104
Design Flow (l/s) 6.7 Invert Level (m) 48.800
Hydro-Brake® Type Md6 SW Only

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.2	1.200	6.8	3.000	10.7	7.000	16.3
0.200	5.2	1.400	7.3	3.500	11.5	7.500	16.9
0.300	5.1	1.600	7.8	4.000	12.3	8.000	17.5
0.400	4.9	1.800	8.3	4.500	13.1	8.500	18.0
0.500	4.9	2.000	8.7	5.000	13.8	9.000	18.5
0.600	5.0	2.200	9.2	5.500	14.5	9.500	19.0
0.800	5.6	2.400	9.6	6.000	15.1		
1.000	6.2	2.600	10.0	6.500	15.7		