Bridgend College

DEVELOPMENT AT PENCOED CAMPUS, BRIDGEND

Drainage Strategy & Flood Advice

4970-WSP-XX-XX-C-RP-001

DECEMBER 2020

PUBLIC

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PROJECT NO. 70074970

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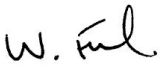
Signature				
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CONTENTS

1. INTRODUCTION

1.1.1. WSP have been commissioned by Bridgend College to provide a drainage strategy and flood advice, in support of the Stage 2 Candidate Site Assessment relating to the emerging Bridgend Local Development Plan, for a proposed residential development at the land adjacent to Pencoed Campus, Bridgend.

1.1.2. It is our understanding that additional information has been requested by Bridgend Council, in relation to flooding and drainage to support its assessment of the site and proposed allocation in the Deposit LDP.

1.1.3. The objectives of the report are to:

- Assess the risk of flooding from other sources (sea, surface water, groundwater, sewers and artificial sources).
- Consider whether safe access and egress can be achieved.
- Consider the effect of predicted climate change on future flood risk to the site.
- Describe existing flood measures which may reduce the risk of flooding and provide general advice on additional measures for consideration.
- Review the existing drainage arrangements on site for both surface and foul water;
- Assess the feasibility of Sustainable Drainage Systems (SuDS) features within the development to control and discharge surface water runoff to comply with the requirements of the statutory National Standards for Sustainable Drainage System;
- Provide a preliminary design for surface water (SuDS) systems including indicative sizing of storage/attenuation features and major conveyance through the development.
- Assess the options for the disposal of foul water from the development; and

1.1.4. The following tasks have been undertaken to complete this report:-

- Undertake a desktop investigation of the site's surface water drainage arrangements;
- Outline anticipated solutions for foul and surface water management. This includes preliminary calculations, in order that the conceptual designs may be agreed with the relevant authorities. In preparing the surface water drainage strategy, we will assess flood and ground water levels in the location of attenuation features;
- Determine the approximate area of impermeable surfaces that will be added by the proposed development and estimate the equivalent greenfield run-off rates of these areas;
- Assess the feasibility of using infiltration as a disposal method, based on available ground conditions information and investigations undertaken that the site;
- Estimate the volume of storm water attenuation storage needed to manage run-off from the site post-development

1.1.5. A number of sources have been used to compile this drainage strategy. Whilst WSP believe them to be trustworthy, WSP is unable to guarantee the accuracy of the information that has been provided by others.

1.1.6. This report is based on information available at the time of preparation. Consequently, there is potential for further information to become available. These changes may lead to future alteration to the conclusions drawn in this report for which WSP cannot be held responsible.

1.1.7. A series of recommendations are made in this Report to ensure that flood risk and drainage considerations can adequately be addressed as part of the current masterplanning process, and to demonstrate that there is no in-principle constraint to the development of the site in these respects. It also considers whether there would be a need for any additional mitigation measures. Many of these considerations have been incorporated into the masterplan already or would be expected to be provided as part of a planning application. To that end, the conclusion can be reached that there is no requirement for additional information to justify the development and allocation of the site within the LDP.

2. EXISTING & PROPOSED SITE

2.1. SITE LOCATION

2.1.1. Figure 2-1 indicates the site location, which is located just east of the A473.

2.2. SITE DESCRIPTION

2.2.1. The 43ha site comprises predominantly of greenfield land made up of multiple fields with existing trees and hedgerows along the main boundaries. The existing Bridgend College, Pencoed Campus is located in the north west of the site, which comprises of numerous building and carparking areas. The topography sloping generally from east to west across the site with the low point of the site being the north-western corner.

2.2.2. The site has direct vehicle access off the public highway on the western or southern boundary, from the A473 or Felindre road or through the existing college campus.

Figure 2-1 - Site Location Plan

©OpenStreetMap contributors

2.3. EXISTING WATERCOURSES AND DRAINAGE

2.3.1. From available mapping information it has been established that there are a number of existing watercourses located in the vicinity of the site. The Ewenny River, which is classified as a Main River, is to the west of the site and flows south along the A473. There is also a smaller watercourse, the

Ewenni Fach, along the eastern boundary of the site which flows to the south. There are several existing drainage ditches alongside the public highways, which are likely to received runoff from the site.

2.3.2. Review of Welsh Water records show there are no public foul or surface water sewers on or directly adjacent to the site. However, an existing Welsh Water 375mm concrete combined sewer crosses the site approximately half way down, flowing to the westerly direction. The combined sewer then crosses the A473 before flowing south alongside the Ewenny River. Figure 2-2 below contains an extract of Welsh Water asset plan for the area.

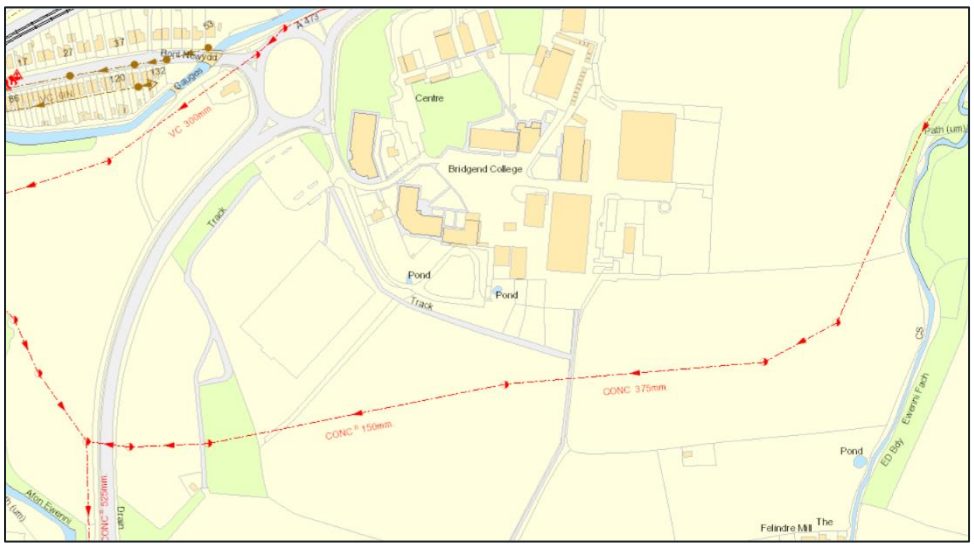


Figure 2-2 - Extract of Welsh Water Asset Plan

2.4. DEVELOPMENT PROPOSALS

2.4.1. The current masterplan proposal consists of up to 770 residential dwellings with associated infrastructure and access roads, 1FE primary school with sport pitches and playing fields. It is assumed that no changes to the existing college campus as proposed as part of this development.

3. FLOOD ADVICE NOTE

This section of this report contains a review of data from relevant sources relating to flood risk and provides the context of Technical Advice Note 15 and associated guidance.

3.1. EXISTING REPORTS / INFORMATION REFERRED TO

- Natural Resources Wales Flood Mapping
- Shoreline Management Plan – Lavernock Point to St Ann's Head
- Environment Agency Extreme Sea Levels Data
- Bridgend County Borough Council Strategic Flood Consequence Assessments (2010 & 2020 versions)

3.2. HYDROGRAPHIC ENVIRONMENT

The Bridgend College development site, shown in Figure 3-1, is located to the south and east of the A473 and to the north of the M4's junction 35, with a small parcel also located to the west of the A473.

The site is bounded by two main rivers, the Ewenni Fach to the east, and the Ewenni to the west, which converge approximately 2.5km to the south east of the site. The western and southern boundary of the main site include drainage features, understood to be land drainage ditches serving the site, and possibly also the adjacent highways. A number of large ponds outside of the site boundary have been identified, as shown in Figure 2-1, two constructed ponds adjacent to the Ewenni Fach, along with a further pond within the proposed Llanilid development site to the east. The Bristol Channel lies approximately 10km to the south.

The site is largely composed of greenfield plots, adjacent to the Bridgend College site.

Ground levels appear to generally fall from approximately 47mAOD at the north-eastern boundary to a minimum of 30mAOD at the south-western boundary.

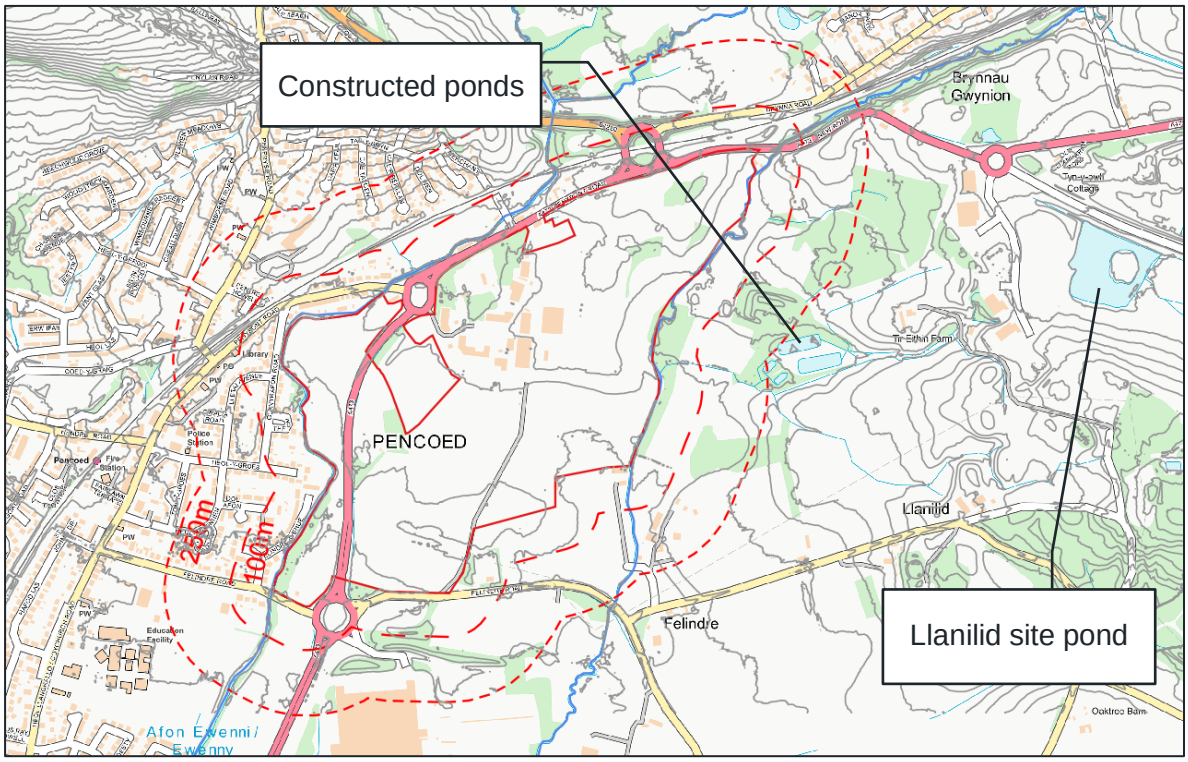


Figure 3-1 - 2.5m Interval Contour Plan of Site and Surrounds Derived from LiDAR Data

3.3. SOURCES OF FLOOD RISK

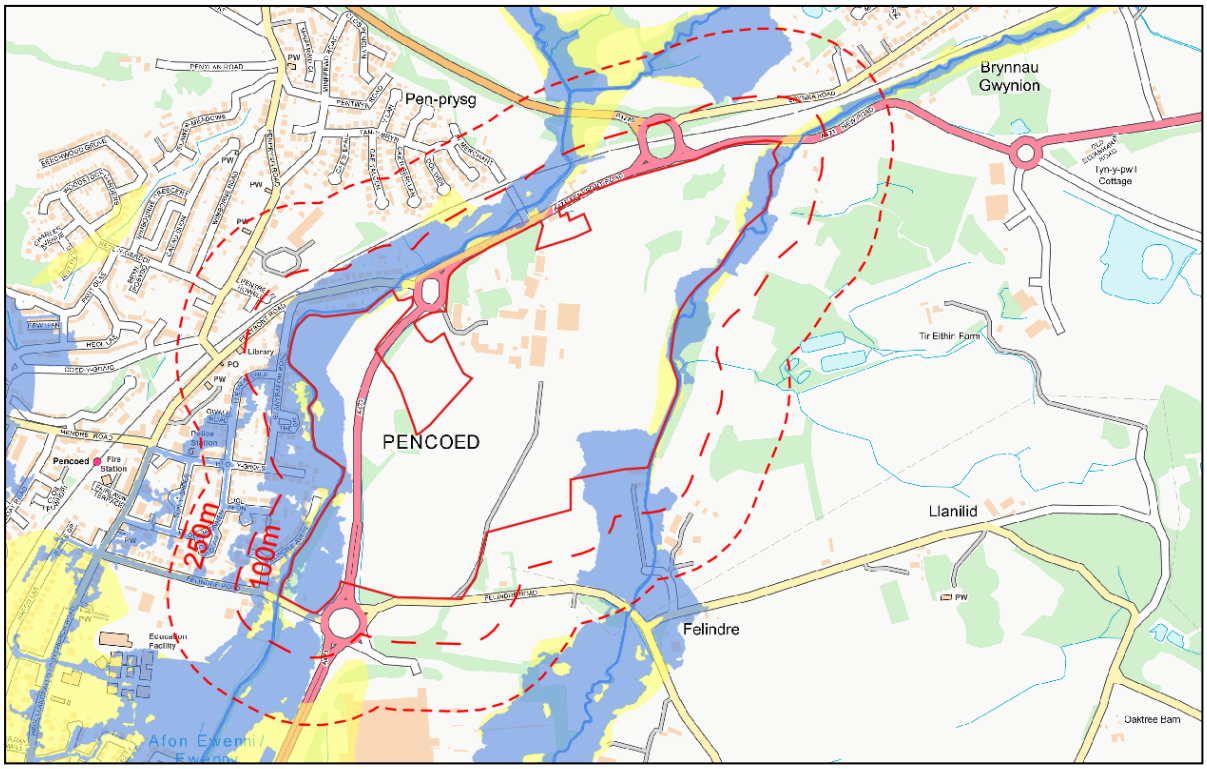
This section reviews the current understanding of flood risk from key sources. Inserts are used throughout the section, however a set of flood maps is available in Appendix A.

3.3.1. DEVELOPMENT ADVICE MAP

The Flood Map for Planning reproduced in Figure 3-2 below shows that the site lies largely within Development Advice Map (DAM) Zone A, this means that this portion of the site is considered to be at little or no risk of flooding from fluvial or tidal sources. However, eastern portions of the site adjacent to Ewenni Fach are seen to lie in DAM Zones B and C2. Furthermore, the majority of the development area lying to the west of the A473 is located in DAM Zone C2. The masterplan and housing layout shows all new homes to be outside of the zone C2 extent.

NRW defines DAM Zone C2 as an area not served by significant flood defences, whilst Zone B is defined as the area known to have flooded in the past, noting that this history is evidenced by sedimentary geology, rather than a specific recorded incident.

These definitions are used in relation to classifications of development. Refer to Section 3.4 for more details of development and flood zone compatibility.



Zone C1: Served by significant infrastructure, including flood defences (Not Shown)
Zone C2: Without significant flood defence infrastructure
Zone B: Areas known to have been flooded in the past
Zone A: Considered to be at little or no risk of fluvial or coastal/tidal flooding

Figure 3-2 - Development Advice Map

3.3.2. RISK OF FLOODING FROM RIVERS AND THE SEA

3.3.2.1. Combined Mapping

NRW produce a number of flood maps relating to flood risk from fluvial sources and the sea.

A review of this mapping, reproduced in Figure 3-3, shows that eastern and western portions of the site lie in what is defined as Flood Zones 2 and 3.

Flood Zone 2 is the area NRW defines as being at a risk greater than 0.1% from rivers or the sea or are known to have flooded in the past. Flood zone 3 is the area NRW defines as being at a risk greater than 1.0% from rivers, or a risk greater than 0.5% from the sea.

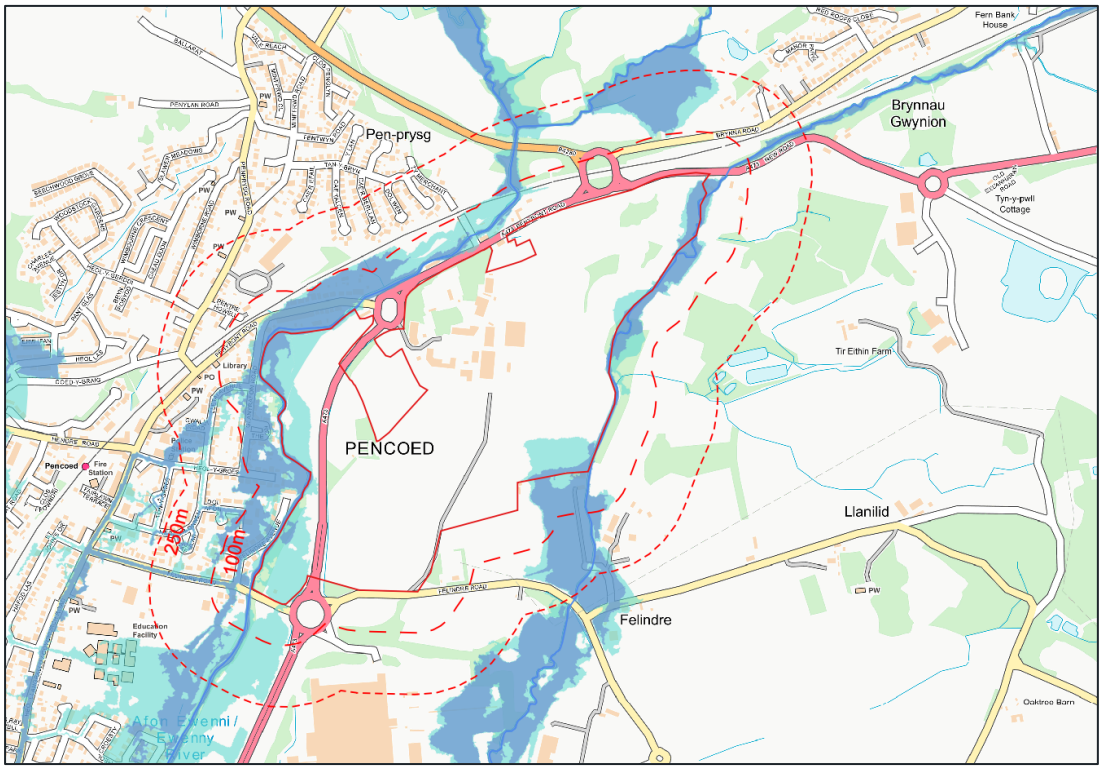


Figure 3-3 - NRW Flood Zones

The majority of the site, however, does not lie in an area considered to be at risk of flooding within the Flood Zone maps.

Review of the NRW mapping for flood risk from rivers and the sea, reproduced in Figure 3-4, shows that eastern portions of the site area considered at medium and low risk of flooding from these sources, with risk areas in the site mostly located at the north eastern and south eastern extents of the site. The parcel to the west of the A473 also is observed to be at risk, with a large area of high risk in the centre of the parcel, along with areas of low and medium risk at the north and south of the parcel.

However, the majority of the site is not within an area considered at risk of flooding from rivers and the sea.

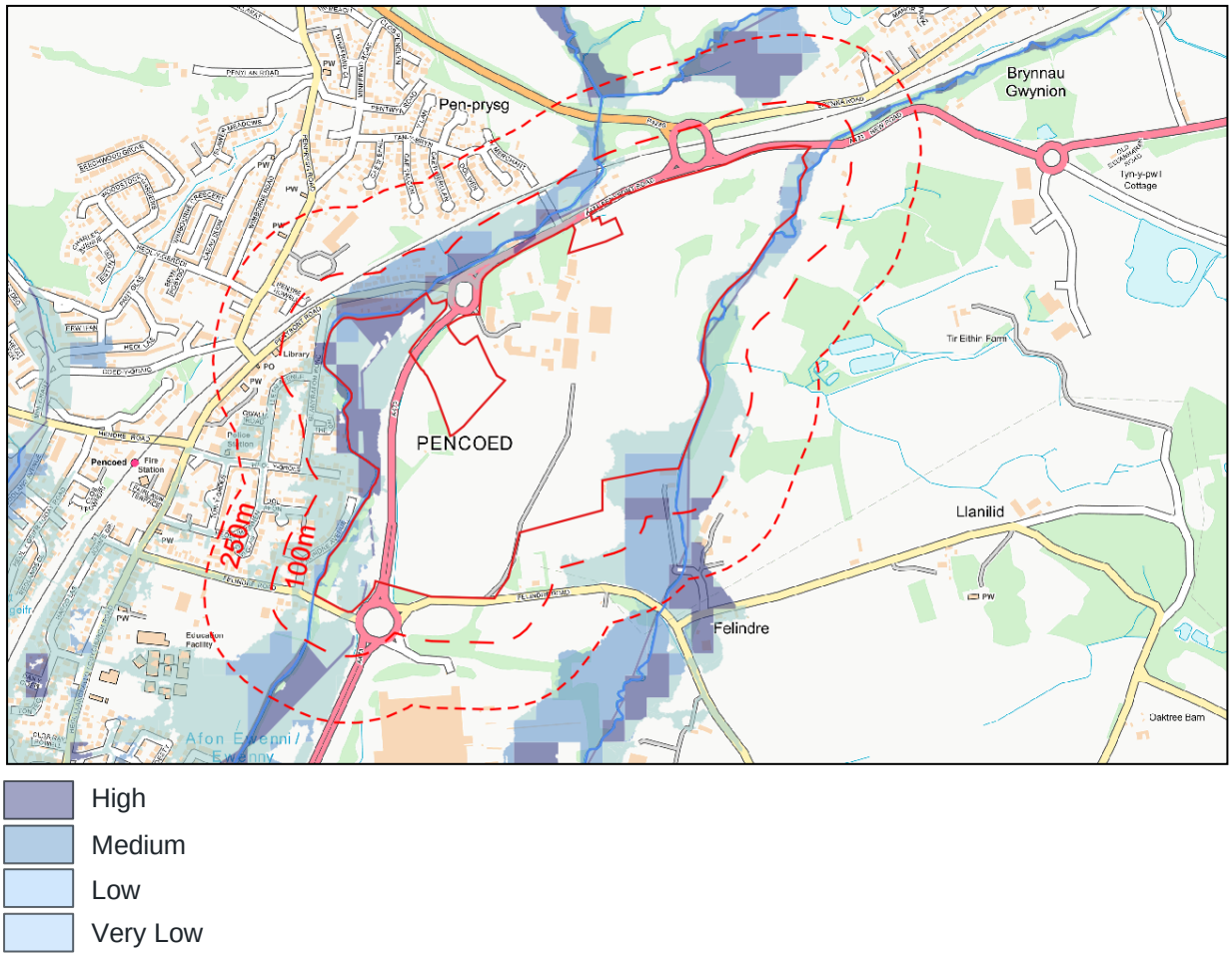


Figure 3-4 - Flood Risk from Rivers and the Sea

3.3.2.2. Tidal Flood Risk and Flood Risk from the Sea

As discussed in section 3.3.2.1, portions of the site are described as at high risk of flooding from rivers or the sea, however, as site levels are between 30 and 47mAOD and maximum extreme tidal levels in the vicinity are less 10mAOD this should be attributed to fluvial sources, and largely towards the boundaries of the site. In this case, the risk of flooding associated with tidal sources can be discounted.

3.3.2.3. Fluvial Flood Risk

Review of NRW's flood mapping shows areas of risk along the eastern site boundary, with an area of Zone 2 spanning the site boundary with Felindre Mill at the SE corner of the site. Areas of risk within the western parcel also follow the extent of the Ewenni, with areas of high risk in direct proximity to it, and a large extent of high risk lying between the Ewenni and the roundabout of Felindre Road and the A473. An extent of low risk is also present spanning across the site in a south westerly direction from the junction of Penybont Road and Ty Merchant at the northern site boundary, over to the A473.

Flooding issues associated with the A473 from the Ewenni and Ewenni Fach along Penybont Road and New Road, should be given consideration in relation to access to the north western portion of the

site, as flooding appears to be predicted both to the east and west of the proposed access along the A473, although it is not predicted to flood the roundabout linking the B4280 and the A473.

The 2020 SFCA confirms the TAN 15 DAM Zone C2 extents but goes on to state that detailed modelling presents a reduced risk to the site where only the western boundary is affected by flooding during the 1% AEP event plus climate change.

3.3.3. SURFACE WATER FLOOD RISK

NRW's Flood Risk from Surface Water map classes the site as generally not being at risk from surface water. However, there are small pockets of risk areas across the whole site. There are two major areas of high risk within the Bridgend College site, around existing buildings, and also an area of high risk adjacent to the Ewenni Fach, which appears to be associated to a golf bunker.

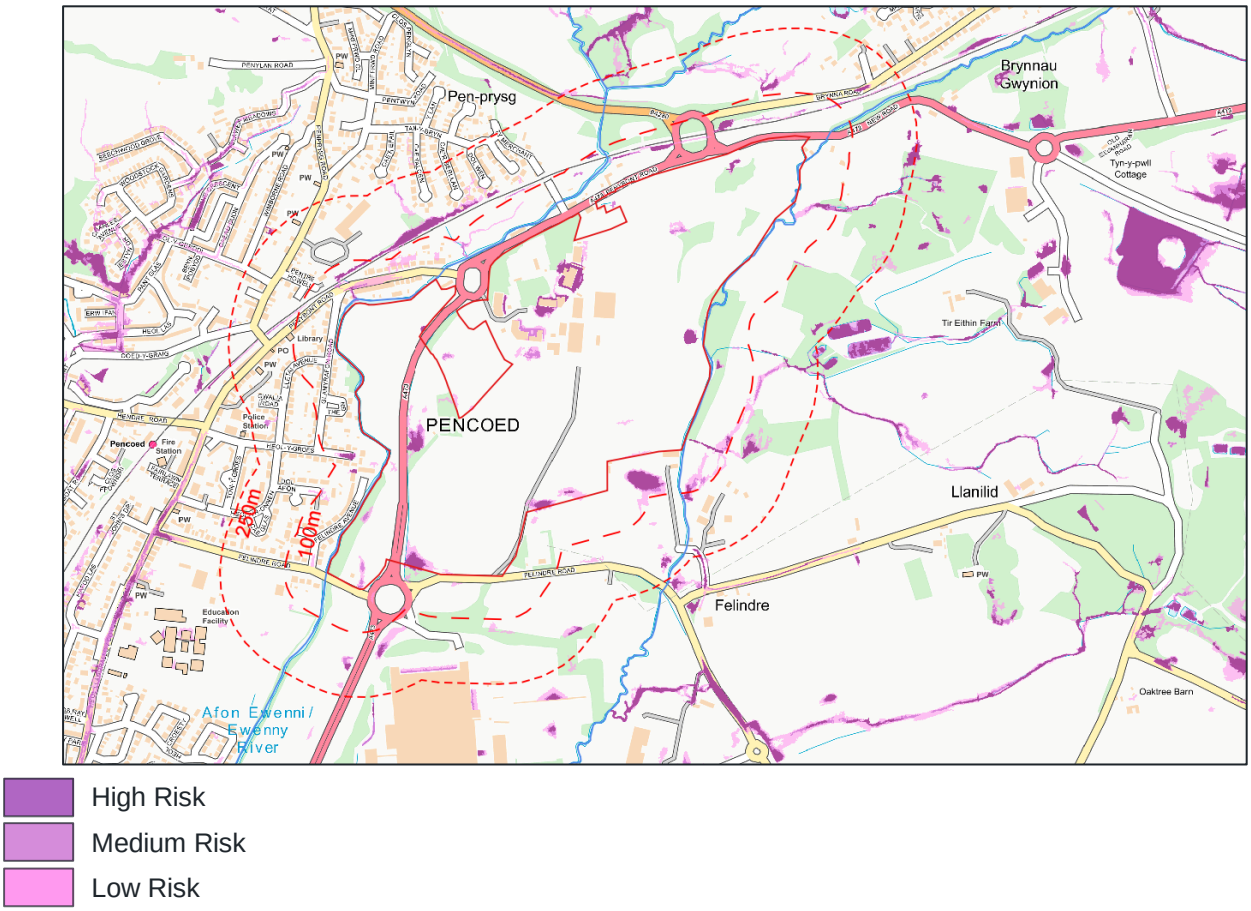


Figure 3-5 - Flood Risk from Surface Water

Existing ground levels generally fall from north east to south west, and as such surface water flows are likely to route in this direction, towards the A473 and the Ewenni, and appears to collect in a land drain that is follows the paths of the A473 and Felindre Road, before discharging in an unknown location.

Surface water flooding within the site would likely be accommodated by any future drainage systems.

The 2020 SFCA concurs this this conclusion, where it states that 'limited areas of the site are at high risk of surface water flooding and there are no significant surface water flow paths. It is expected that this risk of surface water flooding can be managed through the use of SuDS techniques and good design.'

3.3.4. GROUNDWATER FLOOD RISK

Review of the aquifer designations at the site show the aquifers around the site are dominated by flow via fractures and is considered "moderately productive".

The south western corner of the site contains a source protection zone, noted as of "special interest", which is typically defined as a surface water catchment which drains into an aquifer feeding groundwater supply[1]. There are likely to be considerations that should be made in relation to this, such as limitations to surface water drainage and treatment in proximity to the zone, and restrictions on storage or processing of materials on site that could act as a pollutant to the aquifer.

The 2010 SFCA displays an area considered at relatively high risk from groundwater flooding within the western parcel[2]. Subject to contrary findings of site ground investigations, it is considered that groundwater is unlikely to pose a significant risk as it tends to emerge slowly, and any groundwater release would route towards rivers and proposed surface water drainage systems. Groundwater risk was estimated within the 2010 SFCA using correlations between geology and aquifer classification datasets, which are developed for use at a broad scale, and as such may overestimate the risk as groundwater levels at the site are likely to be dominated by the adjacent Afon Ewenni.

The 2020 SFCA notes that 'the majority of the site has shallow groundwater depths (at or near, within 0.025m of the surface) with the area to the north east not at risk of groundwater flooding. The risk of groundwater flooding should be considered further in any development proposals and may dictate the depth of SuDS assets across the proposed development site'.

Further consideration of this risk is recommended at the planning application stage, along with consideration of most appropriate development classes in the western parcel given this potential risk.

[1] Environment Agency, 2018. *Groundwater source protection zones*. Available at: http://apps.environment-agency.gov.uk/wiyby/37833.aspx [Accessed 4th August 2020]

[2] Capita Symonds, 2010. *Strategic Flood Consequence Assessment of Bridgend County Borough Council: Maps. Available at:* https://www.bridgend.gov.uk/media/1808/maps_a.pdf. [Accessed 4th August 2020]

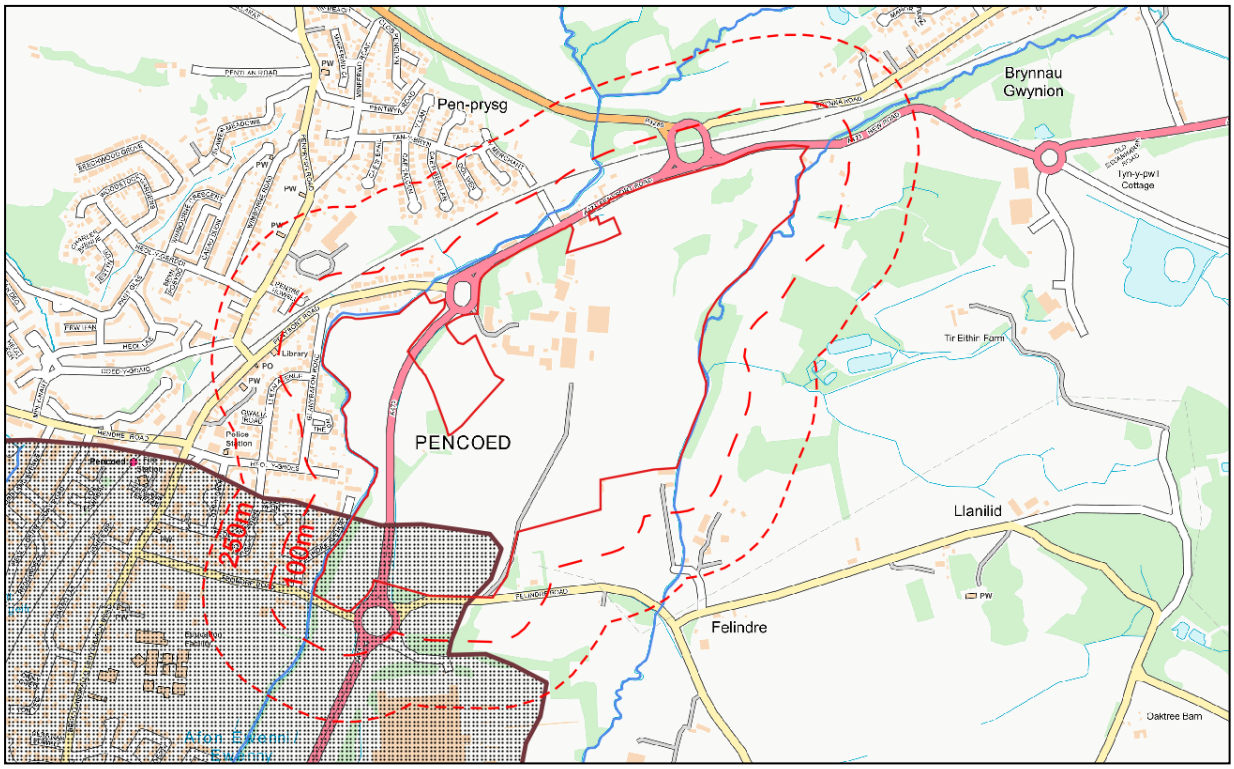


Figure 3-6 - Source Protection Zones showing SPZ of Special Interest

3.3.5. RESERVOIR AND INFRASTRUCTURE FLOOD RISK

Review of NRW's flood mapping shows no flood risk from reservoirs to be present at the site. Furthermore, considering the inspection and maintenance regime of reservoirs in the UK, any risk from reservoirs is usually considered residual and often acceptable, unless there are known concerns with the specific structure.

There are a number of water bodies in proximity to the site, including some lying above the site. Two large ponds are sited to the east of the site, adjacent to Tir Eithin Farm. The drainage routing of these appears to such that they discharge into a stream contributing to the Ewenni Fach, converging near Felindre Mill. A review of the 2010 SFCA suggests that these ponds may have been commissioned in order to reduce flooding in the area immediately local to Felindre Road[3], with a view to improving the viability of development in the area.

There is also a large pond located on the site of the Rhondda Cynon Taf, LDP-designated, Parc Llanilid development, the drainage routes of which are not entirely clear from the data reviewed for this report. The 2010 SFCA maps also notes a potential source of flooding from artificial sources in this area, assumed to be the pond on the Llanilid site.

Breaches or overtopping in any of the above ponds could pose flood risk to the site given the ground levels, which would route flows towards the eastern site boundary where they would likely be

[3] Capita Symonds, 2010. *Strategic Flood Consequence Assessment of Bridgend County Borough Council: Volume I.* Available at: https://www.bridgend.gov.uk/media/1143/strategic-flood-consequences-assessment-of-bridgend-county-borough-volume-one-user-guide.pdf. [Accessed 4th August 2020]

intercepted by the Ewenni Fach. Therefore, it is recommended that, whilst the Ewenni Fach should mitigate flows in the event of a catastrophic breach, a suitable freeboard should be employed to future development levels.

The 2020 SFCA confirms that no artificial sources of flood risk have been identified for this strategic site.

Having considered the flood risk from lakes, reservoirs and canals, two principal infrastructure sources remain: a burst water main and the foul (or combined) drainage network. A burst water main would likely have a similar effect as a sizable rainfall event, in which flows would route towards the Ewenni Fach, and the land drains at the south and west of the site, and towards the Ewenni within the western parcel.

Damaged water or drainage infrastructure would likely create flow paths towards the south and west of the site, where it may gather against the site boundaries in the land drains.

Review of Welsh Water utilities plans shows a number of features, including a combined concrete sewer passing from east to west through the site (375 and 150mm), before converging with another combined sewer in the western parcel, with a maximum diameter of 525mm, which routes south through the western parcel.

There is a 200mm distribution main following the route of the A473 and Felindre Road, appearing to supply the Bridgend College Campus.

There is also a private foul pumping station associated with Felindre Mill, directly adjacent to the site, the discharge routing of which is not known.

Examination of flooding records associated with sewers in the 2010 SFCA does not show any flood events in proximity to the site.

The 2020 SFCA confirms that no significant reports of sewer flooding have been recorded around this strategic site, but notes that DCWW should be consulted on a site specific basis.

Once any additional loading on the foul system has been agreed as acceptable with the sewerage undertaker, the risk of flooding from this source may be considered as residual and should not forestall development.The majority of the site appears to lie within areas for which NRW provide flood alerts and warnings associated with the Ewenni and Ewenni Fach.

Blockage of structures on either watercourse may need consideration as part of the design as these would increase the extents of a flood event, it may be advisable that proposed development in the vicinity of such structures have additional flood mitigation considered such as flood resistance and resilience. It is appropriate for this to be considered further during the planning application stage.

3.3.6. HISTORY OF FLOODING

The SFCA and NRW's historic flood mapping (refer to Appendix A) shows that the north-west portion of the western parcel has been flooded in the past, however, no additional data is noted regarding dates or other information for this specific event. The hatched areas are those which have been recorded to have flooded in the past. The records come from a number of evidence sources including Natural Resources Wales, its predecessors or other Risk Management Authorities. They may show flooding from rivers, the sea or surface water. Where they show flooding from rivers or the sea, and deemed of an appropriate quality, they form part of Flood Zone 2.

Searches of the Chronology of British Hydrological Events for “Pencoed”, “Ewenni” and “Ewenny” did not yield any results.

Review of news sources did not yield any accounts of flooding at the site itself.

3.4. PLANNING DOCUMENTS AND POLICY

The site is not specifically allocated for development within the current Local Development Plan (LDP) for years 2006-2021, but has been put forward as a candidate site in the 2018-2033 replacement plan (ref: 219.C1). The Strategic Flood Consequences Assessment (v2 Oct 2020) was written since the first issue of this report and explicitly considers this candidate site. The findings of the 2020 SFCA assessment are in agreement with those set out within this report. Whilst the 2020 SFCA does not appear to include any significant departures from TAN15 or previous policy documents, noting that TAN15 is under review, Policy OBJ 4e may be of specific interest. This LDP objective states ‘To manage development in order to avoid or minimise the risk and fear of flooding and enable and improve the functionality of floodplains’, this suggests that the LLFA may consider favourably enhancements to the existing floodplain.

It is understood that the proposed development includes residential properties; under Technical Advice Note 15 Section 9[4], the development classification of this use is “highly vulnerable”. Recreational areas such as MUGAs and 3G sports pitches are generally acceptable in any area in relation to flood risk, although buildings associated with them may not be.

Table 3-1 lists the requirements of developments as classified by TAN15, dependent on the flood zone in which they lie. Portions of the site lie within NRW’s Development Advice Map Zone C2. However, TAN15 states that highly vulnerable development should not be permitted within Zone C2, and as such, the master planning process should ensure that development classifications are compatible with any flood zone in which they may lie.

Table 3-1: TAN 15 Flood Zone Compatibility and Requirements

	Highly Vulnerable	**Public Open Space, Recreation & Agriculture**
Flood Zone A	• Justification Test not applicable • Refer to surface water requirements of TAN 15 • No increase in flooding elsewhere	• These are likely to be acceptable in all areas where there is a risk of flooding, however, any ancillary buildings or structures, which are subject to prior approval,

[4] Welsh Government, 2004. *Technical Advice Note 15: Development and Flood Risk*. Available at: https://gov.wales/sites/default/files/publications/2018-09/tan15-development-flood-risk.pdf. [Accessed 4th August 2020]

Flood Zone B	• 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 of TAN 15 • 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	may need to be assessed to determine their consequences and acceptability.
Flood Zone C2	• Plan allocations should not be made for such development and planning applications not proposed	

3.5. SITE ISSUES AND DELIVERY

From a review of the available information, there is a moderate risk of flooding within certain portions of the proposed development, notably the western parcel between the river and the road, and the south eastern corner of the site. A Flood Consequence Assessment (FCA) is recommended, to support a future planning application, in order to assess future risk and mitigation measures (including finished levels). Available evidence suggests that with appropriate flood mitigation, consideration of the compatibility of flood zones and development vulnerability classes of proposals and associated master-planning, the sites are likely to be appropriate for development.

In accordance with TAN15, an FCA and Drainage Strategy is recommended for any future development on these sites.

- The FCA will assess the risk from all sources over the lifetime of the development
- As noted in the 2020 SFCA: 'It is the responsibility of developers to consider flood risk issues at a site as early as possible and to consult with NRW and the LLFA prior to undertaking any FCA.' 'The scope of any FCA should be agreed with the Local Planning Authority and NRW. It may also be appropriate to consulting with others, including Sewerage Undertakers, Highways Authorities and Reservoir Undertakers.'
- The 2020 SFCA also states that:

  The majority of the site is unaffected by fluvial flood risk and suitable for all development types. Development within the limited flood risk areas should proceed with caution and built development should not take place within the floodplain unless essential and of a low vulnerability.

- The Drainage Strategy will need to be developed in consultation with the SuDS Approval Body, Lead Local Flood Authority and Dwr Cymru Welsh Water to agree discharge rates and points of connection for foul and surface water. It will also need to consider the anticipated shallow groundwater table and the localised risk of surface water flooding highlighted on the NRW mapping.

Whilst more detailed assessment of flood risk and design work will be required to inform a formal planning application, the risks identified in this document only affect small areas of the site are not considered to present a significant constraint the site's development. The current masterplan has considered these constraints and appropriately positioned development around them.

3.6. POTENTIAL FLOOD MITIGATION

- Localised land raising may be required to provide flood mitigation; however, this will depend on the location of development within the site, and its impact on third party flooding. Increased flood risk to third parties is considered unacceptable, and hydraulic modelling of any proposals may be required to prove no increase in risk.
- Avoidance of development in areas of unacceptable flood risk
- Raised building thresholds may be required
- In terms of resilient construction, consideration of the suggestions of the EA's documents *Prepare your property for flooding*[5] is recommended, although no significant abnormal costs associated with additional mitigation measures are considered to be required.

3.7. RECOMMENDED FUTURE WORK

Whilst this document should provide sufficient justification for allocation of the site, the following measures should either be incorporated into the scheme or follow at planning application stage.

- Completion of a Flood Consequence Assessment (including the design of future development levels and flood mitigation measures) and Levels / Drainage Strategy.
- Early consultation with Welsh Water, the LLFA and NRW with respect to the FCA and Drainage Strategy
- Additional buffer areas and easements are likely to be required to watercourses, in addition to allowances for ecological corridors and to meet maintenance obligations
- The identified drainage ditches at the south and west of the main site may also require buffer zones, subject to the requirements of the LLFA and/or LHA
- Consultation with NRW in relation to the source protection zone at the south west of the site, and any potential restrictions on works and drainage arrangements in proximity to it
- Access to the site should be located outside the floodplain.

[5] Environment Agency, 2009. *Prepare your property for flooding*. Available at: https://www.gov.uk/government/publications/prepare-your-property-for-flooding [Accessed 4th August 2020]

- Ideally, accesses would be flood free in all events, however, criteria within TAN15 identify levels of flood risk which may be acceptable in extreme event, and these should be assessed in detail as part of further investigations conducted as part of a full FCA

- Proposed development
  - Development classifications are generally commensurate with the DAM Zones in which they are located
  - Consideration of access arrangements for the north-western parcel of the site in relation to flood risk associated to the A473 along Penybont Road and New Road
  - Consideration of compatibility of any future proposed buildings associated with MUGAs and sports pitches on the western parcel, as the majority of the parcel lies within areas of higher flood risk

3.8. SUMMARY

Flood risk from fluvial sources at the site is considered moderate, however, subject to completion of further work as recommended in Section 3.7, the majority of the site is likely to be suitable for development.

Whilst further work is required to support a planning application, the areas currently identified as being at risk of flooding, as shown on the masterplan, are not proposed for any inappropriate forms of development.

4. SURFACE WATER DRAINAGE

4.1.1. The aim of the surface water drainage strategy is to mimic the natural catchment processes as closely as possible and adopt the principles of water management scheme as stated in section 2 of the statutory "Sustainable Drainage Systems Standards for Wales" (SDSSW) document 2018.

4.1.2. From the 7th January 2019 Schedule 3 of the Flood and Water Management Act has been implement by the Welsh Government which requires any development of more than 1 unit or where the construction area is greater than 100m² to comply with the SuDS Approving Bodies (SAB's) design guidance and ministers standards which will require all sites to adopt SuDs in their design. The standards are listed below;

- S1 – Surface Water Runoff Destination
- S2 – Surface Water Runoff Hydraulic Control
- S3 – Water Quality
- S4 – Amenity
- S5 – Biodiversity
- S6 – Design of Drainage for Construction, Operation and Maintenance

4.1.3. The Standards listed will need to be met by the design in order to comply with the SDSSW. S1 is a hierarchy standard with standards S2-S6 being fixed.

4.2. S1 – SURFACE WATER RUNOFF DESTINATION

4.2.1. In determining a suitable method for disposal of surface water flows from this development, it is necessary to explore the technical options outlined under Standard S1 of the SDSSW 2018 document published by Welsh Government. This states that disposal should be made through the hierarchical approach which are, in order of preference; surface water runoff collected for use, infiltration methods, discharge to surface water body, discharge to a surface water sewer, highway sewer or another drainage system and finally discharge to a combine sewer. Each of these options are considered below.

4.2.2. Collected for Use

The suitability of this option will depend on the proposed water usage of the development, if the development has low grey water demand, as is typical of residential developments the collection of water for reuse would be not be economical or feasible, however if the demand for grey water is deemed to be high then rainwater harvesting would be an appropriate solution for parts of the development. The use of rainwater harvesting would need to be used in conjunction with one of the below methods of discharge in order to cater for exceedance flows in extreme rainfall events where the rainfall volume exceeds the volume of surface water storage provided by the rainwater harvesting tanks.

4.2.3. Infiltration Methods

Based on the Cranfield University Soilscapes mapping the subsoils in the area of the site are noted as freely draining Loamy soils. At the time of writing, no infiltration testing had been carried out at the site, however, it should be noted, testing will be required to be undertaken as part of the ground

investigation to confirm the viability of this option of surface water disposal. A conservative strategy based on discharge to watercourses will be put forward within this strategy, however, once infiltration testing has been carried out at the site, the strategy should be fully reviewed in order to inform design supporting a formal planning application and to ascertain whether it remains appropriate. With the benefit of infiltration, attenuation volumes may be reduced in the future and therefore the strategy below is considered a worst-case scenario.

4.2.4. Discharge to Surface Water Body

Sequentially, the next consideration in the hierarchical approach is discharge to a surface water body. There are existing watercourses along the western and eastern boundary of the application site as well as drainage ditch adjacent to the A48. The existing catchment plan in Appendix B shows which areas of the site are assumed to drain into each of the watercourses. This drainage strategy will aim to mimic the site existing drainage regime and continue to discharge surface water to each of the watercourse. Further investigation would need to be carried out on site to establish the exact location, condition and level of the receiving watercourses to establish its suitability for receiving surface water runoff from the development site.

4.2.5. Discharge to Surface Water Sewer

There are no surface water sewers directly adjacent to the development site, however based on the sites ability to discharge to a watercourse there is no requirement to consider this option further.

4.2.6. Discharge to Combined Sewer

Based on the above there would be no requirement for the site to discharge to the public combined sewer network.

4.3. S2 – SURFACE WATER RUNOFF HYDRAULIC CONTROL

4.3.1. This standard requires surface water to be managed to prevent as far as possible any discharge from the development for rainfall events of less than 5mm and that the surface water runoff rate and volume for up to a 1 in 100-year return period should be managed to protect people, properties and the receiving water body. Consideration is also required to the risk associated with runoff from events greater than 1 in 100-year return period with mitigating proposals developed for the scheme.

4.3.2. Interception of Runoff

4.3.3. Interception will need to be considered under the statutory standards. Interception aims to mimic greenfield runoff conditions by preventing runoff from the majority of all small rainfall events. This can contribute to reducing pollution load to receiving surface water bodies. Meeting the Interception criterion is not expected during particularly wet periods, when permeable surfaces and subsoils are saturated, so a suggested target is that 80% compliance should be achieved during the summer and 50% in winter. Refer to table G2.1 in the Statutory Standards for Sustainable Drainage Systems 2018 document published by Welsh Government for details of interception mechanisms and their assumed compliance with the standards. This site will meet interception demands through the use of above ground SuDS features such as raingarden, swales, rills and basins. The location and details of these features are to be defined at a later stage.

4.3.4. Hydraulic Control and Attenuation Storage

4.3.5. For the purposes of this report it is assumed that infiltration will not be the primary method of disposing surface water runoff generated from the development, however this will need to be investigated further and may offer a more suitable alternative at a later stage. In order to meet the standards, this strategy has adopted the simple approach outlined in the statutory standards of restricting all runoff from the development site for all return periods up to and including the 1 in 100-year event plus 40% climate change to Qbar, as outlined in table 4-2 below.

4.3.6. The total site area is circa 43ha, which is currently entirely greenfield. The greenfield run-off rates have been calculated using FEH rainfall data within Microdrainage hydraulic software.

4.3.7. The FEH methodology requires that, for catchments of less than 50ha, the assessment is completed for a 50ha area with the results linearly interpolated to determine the flow rate per hectare.

4.3.8. Table 4-1 below summarises the greenfield runoff off rates for each return period (Qbar, 30-year & 100-year).

Table 4-1 - Greenfield Run-off Rates

Return Period	50ha (l/s)	1ha (l/s/ha)
Qbar	321.3	6.4
30-year	571.2	11.4
100-year	699.1	14.0

4.3.9. In accordance with statutory guidelines, the development of this site should not increase flood risk elsewhere and as such, all runoff from areas on site should be contained within the site boundary for up to and including a 1 in 100 year design period storm, plus 40% climate change. These allowances will have to be agreed with the SAB prior to detailed design.

4.3.10. It is proposed to discharge surface water runoff from the development at runoff rates equivalent to the current greenfield runoff, subject to approval from the SAB. Surface water flows from the proposed development will therefore be restricted via a flow control, and on-site storage provided for surface water runoff for all rainfall events up to and including a 1 in 100 year event with 40% allowance for climate change.

4.3.11. The proposed development has been split in four hydraulic drainage catchments, all of which will have an independent drainage network, outfall and allowance discharge rate. These catchments have been derived using the proposed masterplan in conjunction with existing topography, with the aim to closely mimic the natural drainage regime. The proposed catchment boundaries and outfall locations are shown on the surface water drainage strategy drawing in Appendix B.

4.3.12. To determine the allowable discharge rates, the total impermeable area of each catchment was calculated with the following percentage impermeable (PIMP) values:

- Residential – 60% impermeable plus additional 10% for urban creep.
- Primary School – 80% impermeable.

Large areas of green space or playing fields were not included in the runoff assessment.

4.3.13. Since catchment 3, on the west side of the A473 consists of sport pitches and playing fields, which are assumed to be entirely permeable with no drainage implications, no drainage strategy has been developed for this area. It is therefore assumed to continue to drainage as it does in its current state. If future proposals are likely to have drainage implications or increase impermeable area of the catchment, the drainage strategy will need to be reconsidered.

4.3.14. A Qbar rate of 6.43 l/s/ha has been applied to all impermeable areas to conservatively calculate the overall discharge rate allowable from each area. Discussions with the LLFA and SAB should be held in order to confirm the allowable discharge rates in advance of the submission of a planning application.

4.3.15. The drainage strategy promotes the use of surface source control and conveyance features, such as raingardens and swales, leading to open attenuation basins. A single attenuation basin has been provided at the low point of each catchment, providing the required storage volumes for the 1 in 100-year rainfall event plus 40% climate change.

4.3.16. Table 4-2 below provides the estimated storage volumes and allowable discharge rate for each catchment. Calculations deriving these figures are found in Appendix C. It should be noted that the estimated attenuation storage volumes set out below are still subject to agreement of a site masterplan and detailed analysis/design, as well as the assumption that infiltration is not viable. There is potential to split the below volumes across a number of storage/SuDS features within each catchment, however, the most appropriate strategy for delivery will determined at a later stage as the masterplan is developed.

Table 4-2 – Proposed Attenuation *Storage Requirements*

Catchment	Total Contributing Impermeable Area (ha)	Allowable Discharge Rate Qbar (l/s)	Storage Volume Required (m^3)	Attenuation Feature
1	5.643	54.9	3720	Swales, Permeable Paving, Basins
2	10.628	101.6	7130	Basin
3	Greenfield	na	na	na
4	1.921	18.7	1250	Basin

**The size and depth of the storage will be dependent on the form of storage used and the depth of the proposed outfall location which will need to be establish following further on-site investigation works.*

4.3.17. The attenuation volumes given in table 4-2 can be stored in attenuation facilities within the corresponding catchment. The basins shown on the strategy plan have a maximum water depth of 2.0m during the 100-year rainfall event, which will subside as the water is slowly released into the watercourses.

4.3.18. A 300mm additional freeboard should be provided between the maximum water level and the top of bank.

4.3.19. Exceedance Flows and Flood Pathways

4.3.20. "*It is inevitable that as a result of extreme rainfall the capacities of sewers, covered watercourses and other drainage systems will be exceeded on occasion. Periods of exceedance occur when the rate of surface runoff exceeds the drainage system inlet capacity, when the pipe system becomes overloaded, or when the outfall becomes restricted due to flood levels in the receiving water. Underground conveyance cannot economically or sustainably be built large enough for the most extreme events and, as a result, there will be occasions when surface water runoff will exceed the design capacity of drains. When drainage exceedance capacity is exceeded the excess water (exceedance flow) is conveyed above ground, and will travel along streets and paths, between and through buildings and across open space. Indiscriminate flooding of property can occur when this flow of water is not controlled."* (CIRIA C753).

4.3.21. Flood-flow pathways should be designed to convey the overland flows from rainfall events above a 1in100 year return period to suitable areas of open space, such as landscaped areas, car parking areas and other hard surfaced areas in order to protect properties against flooding. Consideration should also be given to exceedance pathways from storage areas in the event of extreme rainfall or failure with allowance made to convey flows away from properties both on and off the site. These should be considered as part of the detailed drainage and levels design of the development. The overarching site strategy of providing swales adjacent to roads would allow the road areas to become conveyance routes in exceedance events.

4.3.22. Flood Risks to People

4.3.23. "People are at risk of suffering death or serious injury when flooding occurs. People are unable to stand in deep or fast flowing floodwater. Once they are unable to stand, there is a high risk of death or serious injury. Adults are unable to stand in still floodwater with a depth of about 1.5m or greater, although this is obviously affected by the height of a person. The depth of flowing floodwater where people are unable to stand is much less. For example, some people will be at risk when the water depth is only 0.5m, if the velocity is 1m/s (about 2 mph). If the velocity increases to 2m/s (about 4 mph) some people will be unable to stand in a depth of water of only 0.3m. Most people will be unable to stand when the velocity is 2m/s and the depth is 0.6m." (Defra/ Environment Agency, FD2321/TR2)

4.3.24. During the detailed design, a hydraulic model should be built to assist the design of the proposed surface water drainage networks. When an extreme storm event is simulated within the model, potential flooding locations will become evident and the flood flow pathways can be designed/defined based on the proposed layout and levels of the hard areas and landscaping. The depth and velocity of the overland flood water can be determined and then compared with Figure 2.1 (Combinations of flood depth and velocity that cause danger to people) in the Defra / EA Flood Risks to People publication. The velocity and depth as described above would then give a category of flood hazard and the corresponding risk to people. If the risk is deemed to be too high, then the design would require reassessment.

4.4. S3 – WATER QUALITY

4.4.1. This standard requires treatment of surface water runoff to prevent negative impacts on the receiving water quality and/or protect downstream drainage systems including sewers.

4.4.2. The aim of the surface water management strategy with regards to water quality is to follow the guiding principles of the SDSSW and use simple, natural processes that promote biodiversity and long-term

sustainability. As such, it employs a SuDS management train approach, providing drainage components in series. Figure 3-2 below provides a typical example of a management train.

Figure 3-2 - SuDS Management Train Example

4.4.3. The management trains to be used on the project would have been assessed using the Simple Index Assessment (SIA) tool available publicly (http://www.ukSuDS.com/drainage-calculation-tools/water-quality-assessment-for-SuDS-developments) which is built around the principles for simple assessment outlined in CIRIA C753 to assess the levels of treatment provided by the proposals.

4.4.4. Sediment will need to be trapped and retained on site and consideration for maintenance access to be provided for the purpose of intermittent sediment removal.

4.4.5. The possible impact of accidental spills will need to be addressed with the most vulnerable areas to a spill or other pollution incident being the car park areas and access roads. The carpark areas and some access roads could be constructed in preamble paving which will provide a level of treatment for pollution. These areas will also have to pass through swales and an attenuation basin before leaving the site boundary. As such, by having a cut-off point upstream of the discharge location, this allows the isolation of any spills within the site boundary, which can then be addressed before the surface water system is then allowed to discharge freely again.

4.4.6. Planting within the SuDS features should form part the water quality strategy. SuDS components like swales providing water quality improvements by reducing sediment and contaminants from runoff either through settlement or biological breakdown of pollutants are most likely to be exposed to contaminants as part of their interceptor function, so only robust and tolerant species of planting should be specified. Once these species establish this will decrease the flow rate of water travelling through and filter pollutants and contaminants before entering any downstream waterbodies, i.e attenuation basin & pond.

4.4.7. Overall the combination of the planting will create a new eco-system and once colonised will be able to decrease the flow rate of the water within the swale, filter contaminants & pollutants and create an overall attractive biological community.

4.5. S4 – AMENITY

4.5.1. This standard requires that the design of the surface water management system should maximise amenity benefits.

4.5.2. The primary amenity focus of the SuDS scheme should be to improve the health and well-being of the residents. The scheme will need to be based on natural forms that mimic natural landscapes found within the region and the vegetated swales and detention pond areas are designed with natural slope forms, safe and accessible paths and locally contextual species that will encourage natural colonisation. Other key amenity benefits should include improving air quality around the development,

increasing carbon sequestration and improving water quality through removal of pollutants via vegetated swales & attenuation pond.

4.6. S5 – BIODIVERSITY

4.6.1. This standard requires that the surface water management system should maximise biodiversity benefits.

4.6.2. The SuDS scheme biodiversity strategy should revolve around the creation of significant and varied habitat to increase the overall biodiversity of the site and ecological value. The inclusion of plant species that will enhance the general eco system and simultaneously act as a water filtration system to clean pollutants and contaminants should be used and where possible provide meandering swales and a large attenuation basin to maximise the variety of habitats available.

4.6.3. The plant species selected should be both locally contextual and appropriate for the varied habitat zones including primary characteristics that shall ensure:

- Good soil binding and filtration species
- Minimised erosion
- Improved filtration via dense root and stem species
- Tolerance to seasonal variations including droughts and inundations
- Good suspended solids retention
- Pollutant tolerant
- Emergent and pioneering species for natural ecological colonisation
- The creation of diverse, self-sustaining and resilient ecosystems for high species biodiversity
- Support for local and regional habitat strategies

4.6.4. In general, the proposed detention basins will be the focal habitat for the development and consists of a large basin that is resilient to inundation and a smaller permanent aquatic habitat with a variety of water depths. The pond should not be over planted to allow for natural colonisation and to ensure high visibility of people particularly children in and around the pond. Sight lines should be left open to attract certain species and shaded areas under adjacent tree canopies further enhance the varied ecosystem potential.

4.6.5. The attenuation basin should be constructed in a manner that avoids compacted sub bases and healthy organic matter will be backfilled to ensure ideal growing conditions. The pools varying depths will provide refuge for overwintering species and structural diversity and the pond will be resilient to seasonal changes, drought periods and inundation.

4.7. S6 – DESIGN OF DRAINAGE FOR CONSTRUCTION AND MAINTENANCE AND STRUCTURAL INTEGRITY

4.7.1. The surface water drainage system should be designed with the overriding ethos of simplicity in construction, use and maintenance. This then allows a very simple translation from the principles described within standard S6, namely that all elements of the surface water drainage system should be designed so that they can be constructed, as well as maintained and operated "…easily, safely,

cost-effectively, in a timely manner, and with the aim of minimising the use of scarce resources and embedded carbon (energy).” (SDSSW).

4.7.2. The proposed system will be offered for adoption as it will serve more than one property, therefore the SAB will be responsible for the maintenance of the system to ensure it continues to comply with SuDS standards. In order for the drainage system to be adopted it must be designed and constructed in accordance with the SDSSW document and any conditions of approval stipulated by the SAB.

4.7.3. Information with regards to the construction methodology and requirements of the proposed system will be developed as part of the detailed design stage of the project, likewise the maintenance requirements and regime of the proposed system will be developed into the full maintenance strategy for the site during the next phase of design development. This will be developed in conjunction with the client’s maintenance team and the SAB, as it is not considered appropriate for these details to be developed by the design team in isolation from the end users. This will then need to be confirmed and submitted for approval to the SAB prior to construction commencing on site.

5. FOUL DRAINAGE

5.1. FOUL DRAINAGE

5.1.1. The most sustainable method for the disposal of foul water discharge from the proposed development site is via the public gravity sewerage network. Two existing public Dwr Cymru Welsh Water (DCWW) combined gravity sewers pass through the development areas, along with a connection from a private combined rising main.

5.1.2. The first of these sewers, with a maximum diameter of 375mm, passes from the north eastern corner of the site in a generally south westerly direction; the private rising main connects to this combined sewer adjacent to the Ewenni, near the eastern boundary of the site.

5.1.3. The second sewer, with a maximum diameter of 525mm, passes through the western parcel of the site in a generally southerly direction, following the route of the Afon Ewenni, and converges with the first sewer on the western side of the A473, before continuing along the Ewenni.

5.1.4. The combined sewers drain to the Merthyr Mawr WwTW, serving Pencoed and Bridgend, which is located approximately 10km to the south east of the development site.

5.1.5. It is recommended that the 375mm sewer which passes through the main site is realigned, subject to DCWW approval, to suit the proposed masterplan layout. The proposed route will typically follow the main development spine roads and will serve as the main carrier sewer through the site.

5.1.6. It is proposed that all new building connect and discharge into the diverted combined sewer, through a series of new foul drainage runs. All drainage serving more than one properties will be subject to DCWW adoption, where they will take ownership and future maintenance responsibilities of the network.

5.1.7. Since the site falls from north to south to an ultimate low point in the south west corner, adjacent to the roundabout, the southern half of the site cannot currently achieve a gravity connection to existing 375mm combined sewer located within the site boundary. It is therefore recommended that the existing sewer is diverted south through the site, with new on-site connections made to the diverted DCWW sewer network.

5.1.8. A suggested alignment is shown on foul drainage plan 70074970-WSP-ZZ-XX-DR-CE-503. The final route is subject to detailed design and in consultation with DCWW.

5.1.9. The new suggested connection point to the DCWW sewer network (and the routing of the diverted 375mm combined sewer) is into the existing 525mm combined sewer, west of the A473, at manhole SS96813301. The location is shown in Figure 3-2.

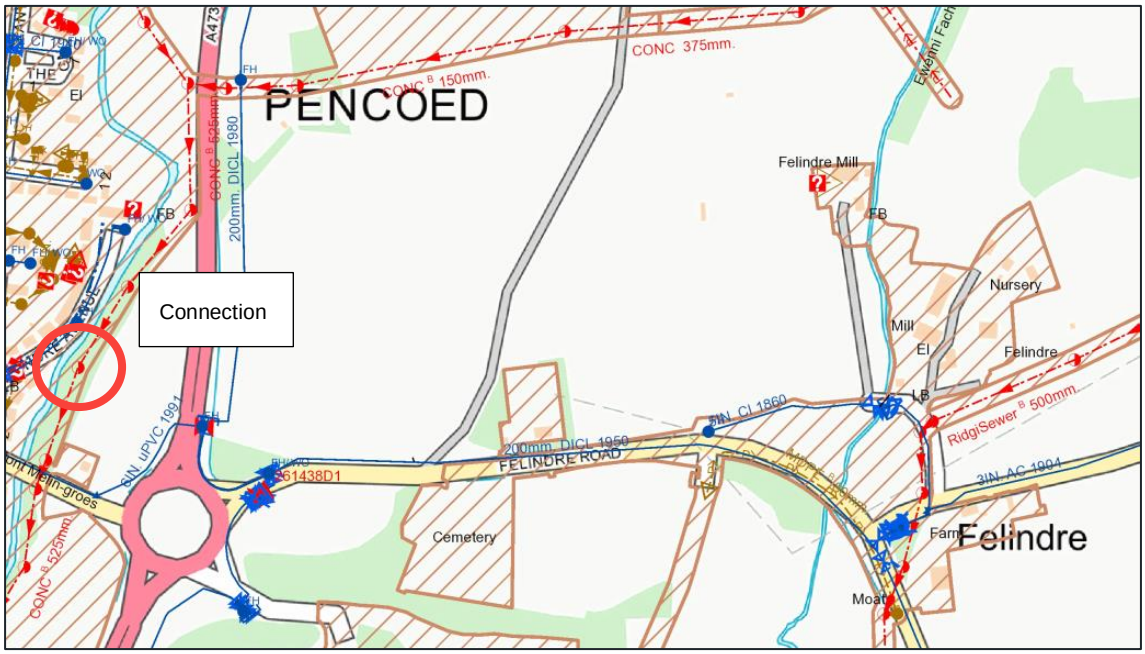


Figure 5-1 – Foul Connection Point

5.1.10. At this time the depth of the existing sewer is unknown, however, it is envisaged that a gravity connection can be made from the site to the public sewer without the need for pumping. This will need to be confirmed at a later stage of the project.

5.1.11. The suggested sewer connection will be constructed beneath the A473. This will likely be carried out using trenchless construction methods, to minimise disruption to the existing highway. The land either side of the highway is within the site boundary and therefore is available to be used of this type of construction.

5.1.12. If this connection is found to be unviable in the future, then an alternative is to consider the use of a proposed adoptable pumping station to serve the lower half of the site, discharging to the existing 375mm combined sewer before it leaves to the site.

5.1.13. An initial assessment of the peak foul flow generated by the development has been undertaken, with the results given in Table 5-1

Table 5-1 – Proposed Peak Foul Flow Rate

	No.	Units	Peak Foul Flow (l/s)
Residential	770	Dwellings	35.7
1FE Primary School	80	Pupils	1.5
Total	-	-	**37.0**

5.1.14. A sewer capacity check has been submitted to DCWW to assess whether available capacity exists in the public sewer network to receive the additional flow from the proposed development. At the time of writing this report, a response had not been received from DCWW.

5.1.15. Welsh Water should be consulted as part of the planning process for the site and to confirm the appropriate point(s) of connection to the public sewer system, the suitability of connection points can be confirmed by Welsh Water ahead of the planning application via a Pre-Planning Advice application.

5.1.16. All on site sewerage system will be designed and constructed to comply with Building Regulations requirements with any adopted elements in accordance with the latest edition of “Sewers for Adoption” and any of the adopting authority’s (Welsh Water) specific requirements.

6. CONCLUSION

6.1.1. Flood Advice

6.1.2. Flood risk from fluvial sources in parts of the site is considered moderate, however, subject to completion of further work at planning application stage as recommended in Section 3.7, the majority of the site is likely to be suitable for development.

6.1.3. Whilst further work is required to support a planning application, the areas currently identified as being at risk of flooding, as shown on the masterplan, are not proposed for any inappropriate forms of development.

6.1.4. Surface Water Drainage

6.1.5. The aim of the surface water drainage strategy is to mimic the natural catchment processes as closely as possible. It is anticipated that the proposed surface water system will be adopted by the SAB and the proposed system will need to be designed in accordance with the statutory "Sustainable Drainage Systems Standards for Wales" (SDSSW) document 2018 and any local authority's SAB requirements and CIRIA's C753 SuDS Manual as well as meeting the requirements of Building Regulations, Document H.

6.1.6. In determining a suitable methodology for disposal of surface water flows from this development, it is necessary to explore the technical options outlined under Standard S1 in the statutory "Sustainable Drainage Systems Standards for Wales" (SDSSW) document 2018 published by the Welsh Government. Based on the hierarchy it is proposed to discharge surface water runoff from the development to the adjacent watercourses as per the current regime.

6.1.7. It is proposed to attenuate the runoff generated from site to the equivalent greenfield run-off rates for all rainfall events up to and including 100YRP with 40% allowance for climate change & urban-creep as given in table 4-2.

6.1.8. Given the proposed site layout and land usage overland conveyance and storage in the form of swales and ponds is likely to be achievable. Attenuation facilities have been proposed for each drainage catchment, before discharging to the watercourse.

6.1.9. All on site surface water drainage systems will be designed and constructed to comply with the (SDSSW) and building regulations requirements. The detailed design of the scheme will incorporate the philosophies outline in this report regarding standards S1-S6 listed in section 4 of this report.

6.1.10. Foul Drainage

6.1.11. The most sustainable method for the disposal of foul water discharge from the proposed development site is via the public sewerage network. It is proposed to connect the foul flow generated from the development to the public combined sewer system.

6.1.12. To facilitate the masterplan layout, an existing 375mm combined sewer will require realigning and extending to the south west corner of the site. This will act as the main sewer running through the site, allowing gravity connections to be made from each of the plots.

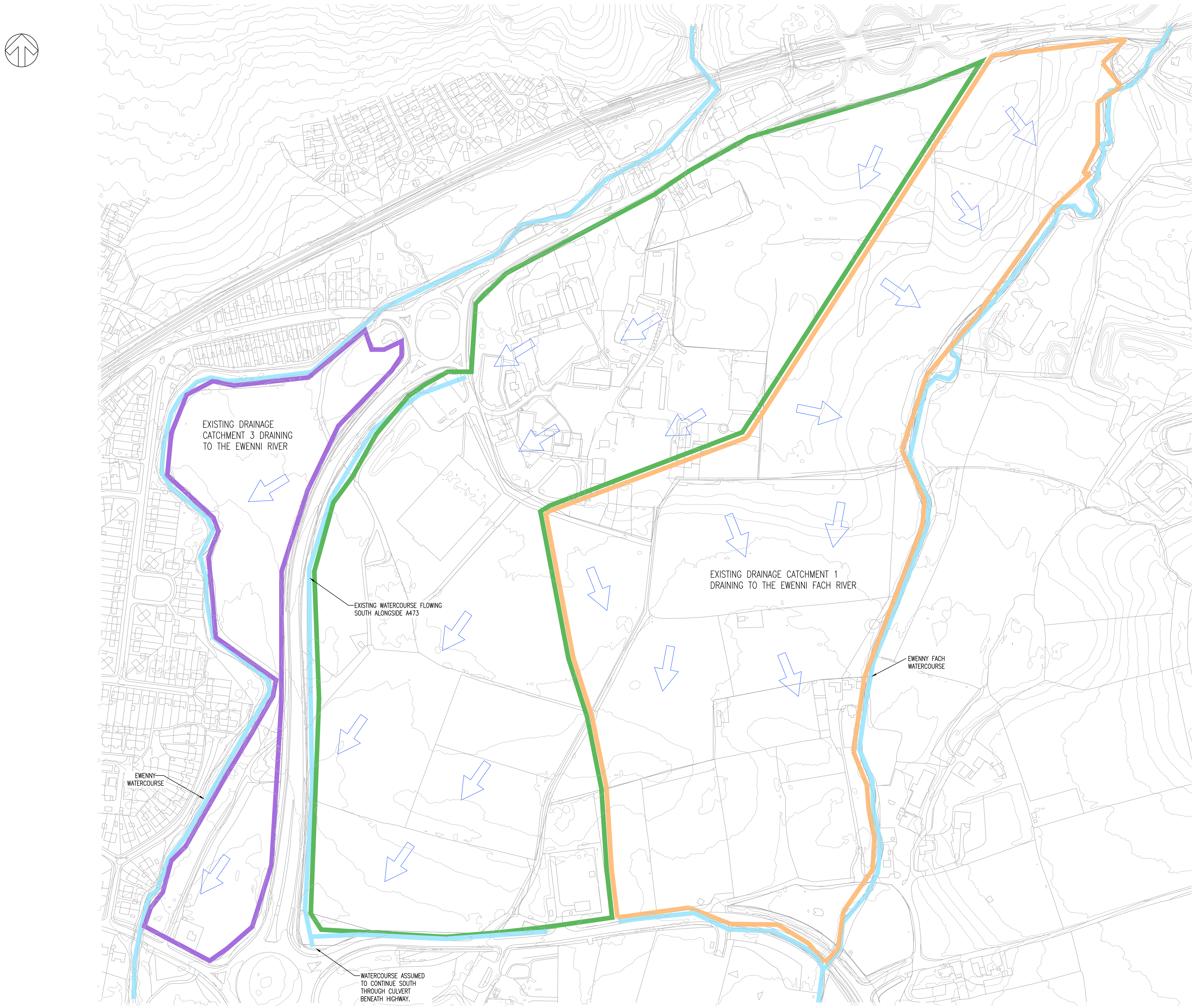
6.1.13. A new connection into the DCWW combined sewer will be required at existing manhole SS96813301 located on the west of the A473. The suitability of these connection point can be confirmed by Welsh Water ahead of the planning application via a Pre-Planning Advice application.

6.1.14. The suggested sewer connection will be constructed beneath the A473. This will likely be carried out using trenchless construction methods, to minimise disruption to the existing highway. The land either side of the highway is within the site boundary and therefore is available to be used for this type of construction. Land ownership either side of the A473 should however be checked as part of the next stage of design.

6.1.15. A sewer capacity check has been submitted to DCWW to assess whether available capacity exists in the public sewer network to receive the additional flow from the proposed development. At the time of writing this report, a response had not been received from DCWW.

Appendix A

DRAINAGE STRATEGY PLANS



DO NOT SCALE

NOTES

1. ANY LEVELS SHOWN ARE IN METRES AOD UNLESS OTHERWISE SPECIFIED.
2. THE EXISTING SURFACE WATER CATCHMENTS HAVE BEEN DERIVED FROM A DESKTOP ASSESSMENT OF THE EXISTING TOPOGRAPHY (LIDAR) AND WATERCOURSES.

KEY

- EXISTING WATERCOURSE
- DRAINAGE CATCHMENT 1
- DRAINAGE CATCHMENT 2
- DRAINAGE CATCHMENT 3
- SURFACE WATER FLOW ARROW

REV	DATE	BY	DESCRIPTION	CHK	APP
P01	14/08/2020	PG	FIRST ISSUE	WF	AW

DRAWING STATUS: S2 - FOR INFORMATION

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PROJECT: BRIDGEND COLLEGE

TITLE: SURFACE WATER DRAINAGE STRATEGY EXISTING CATCHMENT PLAN

SCALE @ A0: 1:1500	CHECKED: WF		APPROVED: AW
PROJECT No: 70074970	DESIGNED: WF	DRAWN: PG	DATE: August 20

DRAWING No: 70074970-WSP-ZZ-XX-DR-CE-500 | REV: P01

DO NOT SCALE

NOTES

1. ANY LEVELS SHOWN ARE IN METRES AOD UNLESS OTHERWISE SPECIFIED. DISCHARGE TO WATERCOURSE (SUBJECT TO RELEVANT AGREEMENTS)
2. ALL BASINS HAVE BEEN SIZED USING 2013 FEH RAINFALL DATA AND HAVE ASSUMED 1 IN 3 SIDE SLOPES UNLESS OTHERWISE STATED.VDISCHARGE TO DRAINAGE DITCH (SUBJECT TO CONFIRMATION OF DOWNSTREAM CONNECTION AND RELEVANT AGREEMENTS).
3. ALL BASINS HAVE BEEN DESIGNED TO ACCOMMODATE THE 1 IN 100 YEAR RETURN PERIOD STORM PLUS A 40% ALLOWANCE FOR CLIMATE CHANGE BELOW A 300mm FREEBOARD.
4. EXISTING FIELD DRAIN LOCATIONS TAKEN FROM A COMBINATION OF GOOGLE SATELLITE AND TERRAIN MAPPING. DISCHARGE TO WATERCOURSE (SUBJECT TO RELEVANT AGREEMENTS)
5. ATTENUATION BASINS AND SWALES HAVE NOT BEEN MODELLED IN 3D AND THEREFORE THE EXACT EXTENT OF THE EARTHWORKS ARE NOT DEFINED AND IS TO THIS CONFIRMED THROUGH DETAILED DESIGN IN CONJUNCTION WITH A DETAILED SITE LAYOUT.
6. ALL RESIDENTIAL AREAS HAVE BEEN ASSUMED TO BE 40% IMPERMEABLE PLUS A 10% ALLOWANCE FOR URBAN CREEP (66%). SPORTS PITCHES ARE ASSUMED TO BE PERMEABLE WITH NO POSITIVE DRAINAGE SYSTEM. PROPOSED EDUCATION FACILITIES ASSUME 80% IMPERMEABLE AREAS.
7. ALL AREAS OF THE SITE ARE ASSUMED TO DISCHARGE BY GRAVITY AT QBAR GREENFIELD RUNOFF RATE TO EXISTING WATERCOURSES AND DRAINAGE FEATURES UNLESS OTHERWISE STATED.
8. PROPOSED SURFACE WATER DRAINAGE SYSTEMS AND BASINS ARE ASSUMED TO BE ADOPTED AND MAINTAINED BY BRIDGEND CITY COUNCIL SAB.
9. WHERE ATTENUATION FEATURES ARE CONNECTED IN SERIES, A FLOW CONTROL IS PROVIDED AT THE OUTFALL OF EACH FEATURE (BASIN OR SWALE)
10. DRAINAGE STRATEGY SUBJECT TO CHANGE FOLLOWING RESULTS OF INFILTRATION TESTING

KEY

- ATTENUATION BASIN
- PROPOSED SWALE/ DRAINAGE ROUTES
- EXISTING WATERCOURSE
- DRAINAGE CATCHMENT 1
- DRAINAGE CATCHMENT 2
- DRAINAGE CATCHMENT 3
- DRAINAGE CATCHMENT 4
- FLOOD ZONE

CATCHMENT 4
18.7l/s ALLOWABLE DISCHARGE RATE

STORAGE VOLUME REQUIRED: 1250m³

MAX WATER DEPTH – 2.0m
SIDE SLOPES – 1 IN 3
FREEBOARD – 0.3m

LARGE ATTENUATION SWALE. TO BE LOCATED OUTSIDE OF FLOOD PLAIN.

CATCHMENT 3 FOR SPORTS PITCH USE ONLY AND ASSUMED PERMEABLE. ANY WORKS WHICH CHANGE THE PERMEABILITY IN THE AREA SHOULD BE DESIGNED APPROPRIATELY.

CATCHMENT 1
54.9l/s ALLOWABLE DISCHARGE RATE

STORAGE VOLUME REQUIRED: 3720m³

ATTENUATION PROVIDED IN LARGE SWALE, BASIN AND PERMEABLE PAVING ACROSS THE CATCHMENT.

OUTFALL LOCATION FROM CATCHMENT 1 INTO EWENNY FACH

EWENNY FACH WATERCOURSE

EWENNY WATERCOURSE

CATCHMENT 2
101.6l/s ALLOWABLE DISCHARGE RATE

STORAGE VOLUME REQUIRED: 7130m³

MAX WATER DEPTH – 2.0m
SIDE SLOPES – 1 IN 3
FREEBOARD – 0.3m

CATCHMENT 2 DISCHARGING TO EXISTING WATERCOURSE

REV	DATE	BY	DESCRIPTION	CHK	APP
P01	14/08/2020	FG	FIRST ISSUE		

DRAWING STATUS: S2 - FOR INFORMATION

wsp
1 Capital Quarter, Tyndall St, Cardiff, CF10 4BZ, UK
T+ 44 (0) 292 078 9200
wsp.com

CLIENT: BRIDGEND COLLEGE

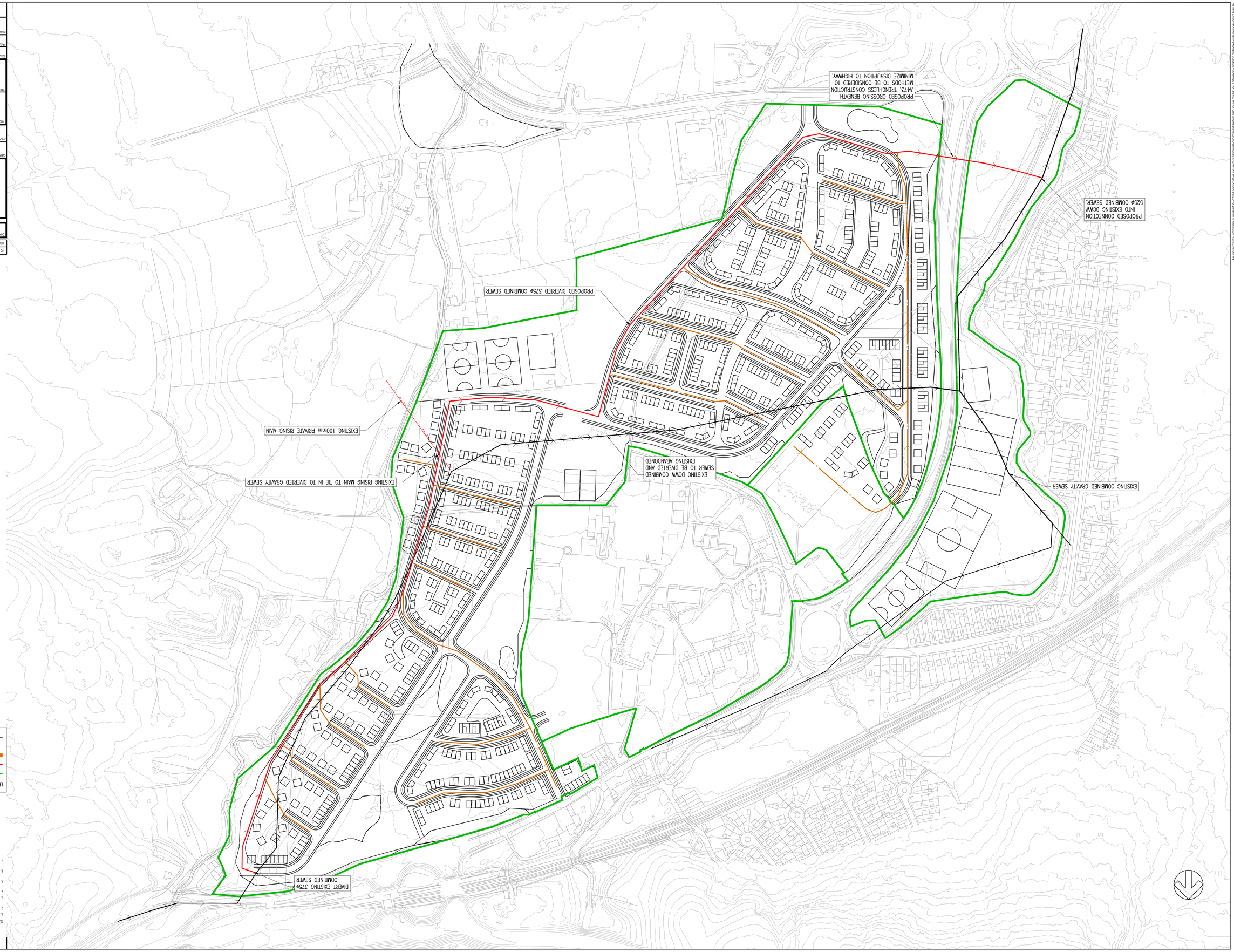
ARCHITECT: AUSTIN-SMITH: LORD

PROJECT: BRIDGEND COLLEGE

TITLE: SURFACE WATER DRAINAGE STRATEGY PROPOSED CATCHMENT PLAN

SCALE @ A2:	CHECKED:	APPROVED:
1:1500		
PROJECT No: 70074970	DESIGNED:	DRAWN:
DATE: August 20		

DRAWING No: 70074970-WSP-ZZ-XX-DR-CE-501 REV: P01



DO NOT SCALE

NOTES

1. ANY LEVELS SHOWN ARE IN METRES AOD UNLESS OTHERWISE SPECIFIED.
2. LEVEL INFORMATION IS TAKEN FROM LIDAR DATA. FROM WELSH GOVERNMENT LLE GEOPORTAL http://lle.gov.wales/catalogue/item/LidarCompositeDtm/?lang=en
3. EXISTING CONDUITS ARE SHOWN AT 1m INTERVALS.
4. GRAVITY FOUL DRAINAGE BOUNDS HAS BEEN DESIGN USING MANNING PIPE CYMRU WELSH WATER SUBJECT TO APPROVAL.
5. PROPOSED FOUL STORMS ARE ASSUMED TO BE ADOPTED AND MAINTAINED BY DWR CYMRU WELSH WATER SUBJECT TO APPROVAL.
6. PROPOSED ADOPTABLE SEWERS AND PUMPING STATIONS TO BE IN ACCORDANCE WITH SEWERS FOR ADOPTION 7.
7. CONNECTION TO DCWW PUBLIC SEWER NETWORK IS SUBJECT TO CAPACITY AND APPROVAL FROM DCWW.

REV	DATE	BY	DESCRIPTION	BF	CHK	APP
P01	11/08/2020	DJM	FIRST ISSUE			

DRAWING STATUS
S2 - FOR INFORMATION

msp
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wsp.com

CLIENT
BRIDGEND COLLEGE

ARCHITECT
AUSTIN-SMITH: LORD

PROJECT
BRIDGEND COLLEGE

TITLE
FOUL DRAINAGE STRATEGY

SCALE @ A1	DESIGNED	CHECKED	APPROVED
1:1500	MF	DJM	AW
PROJECT No.	DRAWN	DATE	
70074970	DJM	August 20	
DRAWING No.			REV.
70074970-WSP-ZZ-XX-DR-CE-502			P01

Appendix B

DRAINAGE CALCULATIONS

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	33.909	0.609	54.9	1332.5	O K
30 min Summer	34.158	0.858	54.9	1878.4	O K
60 min Summer	34.447	1.147	54.9	2508.8	O K
120 min Summer	34.601	1.301	54.9	2846.0	O K
180 min Summer	34.686	1.386	54.9	3032.6	O K
240 min Summer	34.736	1.436	54.9	3142.9	Flood Risk
360 min Summer	34.778	1.478	54.9	3234.1	Flood Risk
480 min Summer	34.781	1.481	54.9	3240.6	Flood Risk
600 min Summer	34.773	1.473	54.9	3223.0	Flood Risk
720 min Summer	34.761	1.461	54.9	3197.4	Flood Risk
960 min Summer	34.729	1.429	54.9	3127.7	Flood Risk
1440 min Summer	34.653	1.353	54.9	2960.0	O K
2160 min Summer	34.522	1.222	54.9	2673.3	O K
2880 min Summer	34.382	1.082	54.9	2366.8	O K
4320 min Summer	34.168	0.868	54.9	1898.6	O K
5760 min Summer	34.010	0.710	54.9	1553.9	O K
7200 min Summer	33.900	0.600	54.9	1312.0	O K
8640 min Summer	33.820	0.520	54.8	1136.9	O K
10080 min Summer	33.761	0.461	54.6	1008.6	O K
15 min Winter	33.984	0.684	54.9	1497.5	O K
30 min Winter	34.266	0.966	54.9	2113.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	130.809	0.0	1319.9	26
30 min Summer	92.696	0.0	1886.5	40
60 min Summer	62.700	0.0	2618.5	70
120 min Summer	36.822	0.0	3078.7	128
180 min Summer	27.090	0.0	3399.1	186
240 min Summer	21.796	0.0	3647.3	244
360 min Summer	16.003	0.0	4017.3	362
480 min Summer	12.852	0.0	4301.7	466
600 min Summer	10.841	0.0	4534.8	518
720 min Summer	9.432	0.0	4733.4	580
960 min Summer	7.568	0.0	5059.6	708
1440 min Summer	5.554	0.0	5554.4	984
2160 min Summer	4.080	0.0	6192.8	1408
2880 min Summer	3.296	0.0	6670.5	1792
4320 min Summer	2.484	0.0	7522.9	2552
5760 min Summer	2.061	0.0	8362.5	3280
7200 min Summer	1.808	0.0	9163.8	3968
8640 min Summer	1.638	0.0	9956.3	4672
10080 min Summer	1.517	0.0	10740.3	5352
15 min Winter	130.809	0.0	1483.3	26
30 min Winter	92.696	0.0	2116.3	40

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	34.592	1.292	54.9	2826.2	O K
120 min Winter	34.767	1.467	54.9	3209.4	Flood Risk
180 min Winter	34.867	1.567	54.9	3427.9	Flood Risk
240 min Winter	34.928	1.628	54.9	3562.6	Flood Risk
360 min Winter	34.985	1.685	54.9	3687.2	Flood Risk
480 min Winter	34.999	1.699	54.9	3718.0	Flood Risk
600 min Winter	34.990	1.690	54.9	3697.8	Flood Risk
720 min Winter	34.968	1.668	54.9	3649.6	Flood Risk
960 min Winter	34.926	1.626	54.9	3558.4	Flood Risk
1440 min Winter	34.817	1.517	54.9	3318.7	Flood Risk
2160 min Winter	34.623	1.323	54.9	2894.8	O K
2880 min Winter	34.404	1.104	54.9	2415.1	O K
4320 min Winter	34.053	0.753	54.9	1647.9	O K
5760 min Winter	33.824	0.524	54.9	1145.6	O K
7200 min Winter	33.690	0.390	53.8	853.0	O K
8640 min Winter	33.616	0.316	52.2	691.2	O K
10080 min Winter	33.588	0.288	49.7	630.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	62.700	0.0	2935.1	68
120 min Winter	36.822	0.0	3450.4	126
180 min Winter	27.090	0.0	3809.0	182
240 min Winter	21.796	0.0	4086.9	240
360 min Winter	16.003	0.0	4501.0	354
480 min Winter	12.852	0.0	4819.1	464
600 min Winter	10.841	0.0	5079.7	568
720 min Winter	9.432	0.0	5301.6	658
960 min Winter	7.568	0.0	5665.6	750
1440 min Winter	5.554	0.0	6214.8	1060
2160 min Winter	4.080	0.0	6937.5	1520
2880 min Winter	3.296	0.0	7473.0	1940
4320 min Winter	2.484	0.0	8432.1	2680
5760 min Winter	2.061	0.0	9367.6	3344
7200 min Winter	1.808	0.0	10265.8	3968
8640 min Winter	1.638	0.0	11154.8	4584
10080 min Winter	1.517	0.0	12037.1	5240

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 296304 181216 SS 96304 81216
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 5.643

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	1.881	4	8	1.881	8	12	1.881

Model Details

Storage is Online Cover Level (m) 35.000

Tank or Pond Structure

Invert Level (m) 33.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	2188.0	1.700	2188.0	1.701	0.1

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0298-5490-1700-5490
Design Head (m)	1.700
Design Flow (l/s)	54.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	298
Invert Level (m)	33.300
Minimum Outlet Pipe Diameter (mm)	375
Suggested Manhole Diameter (mm)	2100

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.700	54.9
Flush-Flo™	0.548	54.9
Kick-Flo®	1.185	46.1
Mean Flow over Head Range	-	46.7

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	9.1	1.200	46.4	3.000	72.2	7.000	109.1
0.200	30.6	1.400	50.0	3.500	77.8	7.500	112.8
0.300	51.7	1.600	53.3	4.000	83.0	8.000	116.4
0.400	53.9	1.800	56.4	4.500	87.9	8.500	119.9
0.500	54.8	2.000	59.4	5.000	92.6	9.000	123.3
0.600	54.8	2.200	62.2	5.500	97.0	9.500	126.6
0.800	53.7	2.400	64.8	6.000	101.2		
1.000	51.5	2.600	67.4	6.500	105.2		

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	33.900	0.600	101.3	2518.1	O K
30 min Summer	34.146	0.846	101.3	3546.6	O K
60 min Summer	34.429	1.129	101.3	4736.5	O K
120 min Summer	34.585	1.285	101.3	5388.1	O K
180 min Summer	34.674	1.374	101.3	5761.1	O K
240 min Summer	34.728	1.428	101.3	5987.5	Flood Risk
360 min Summer	34.776	1.476	101.3	6192.4	Flood Risk
480 min Summer	34.786	1.486	101.3	6232.6	Flood Risk
600 min Summer	34.783	1.483	101.3	6218.9	Flood Risk
720 min Summer	34.776	1.476	101.3	6189.2	Flood Risk
960 min Summer	34.752	1.452	101.3	6088.5	Flood Risk
1440 min Summer	34.686	1.386	101.3	5813.2	O K
2160 min Summer	34.563	1.263	101.3	5298.4	O K
2880 min Summer	34.434	1.134	101.3	4754.2	O K
4320 min Summer	34.233	0.933	101.3	3912.1	O K
5760 min Summer	34.083	0.783	101.3	3284.5	O K
7200 min Summer	33.976	0.676	101.3	2836.7	O K
8640 min Summer	33.898	0.598	101.3	2509.6	O K
10080 min Summer	33.840	0.540	100.8	2263.7	O K
15 min Winter	33.974	0.674	101.3	2828.0	O K
30 min Winter	34.251	0.951	101.3	3988.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	130.809	0.0	2412.7	26
30 min Summer	92.696	0.0	3469.3	40
60 min Summer	62.700	0.0	4888.6	70
120 min Summer	36.822	0.0	5751.9	128
180 min Summer	27.090	0.0	6352.3	186
240 min Summer	21.796	0.0	6817.2	244
360 min Summer	16.003	0.0	7509.5	362
480 min Summer	12.852	0.0	8040.9	472
600 min Summer	10.841	0.0	8475.5	522
720 min Summer	9.432	0.0	8845.0	584
960 min Summer	7.568	0.0	9449.7	712
1440 min Summer	5.554	0.0	10356.9	986
2160 min Summer	4.080	0.0	11633.2	1408
2880 min Summer	3.296	0.0	12529.0	1792
4320 min Summer	2.484	0.0	14115.1	2556
5760 min Summer	2.061	0.0	15733.4	3288
7200 min Summer	1.808	0.0	17238.0	3976
8640 min Summer	1.638	0.0	18722.5	4680
10080 min Summer	1.517	0.0	20181.0	5360
15 min Winter	130.809	0.0	2717.8	26
30 min Winter	92.696	0.0	3897.2	40

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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	34.572	1.272	101.3	5335.8	O K
120 min Winter	34.749	1.449	101.3	6076.4	Flood Risk
180 min Winter	34.851	1.551	101.3	6504.6	Flood Risk
240 min Winter	34.915	1.615	101.3	6774.1	Flood Risk
360 min Winter	34.978	1.678	101.3	7038.3	Flood Risk
480 min Winter	34.998	1.698	101.4	7123.0	Flood Risk
600 min Winter	34.995	1.695	101.3	7108.9	Flood Risk
720 min Winter	34.978	1.678	101.3	7038.2	Flood Risk
960 min Winter	34.944	1.644	101.3	6893.8	Flood Risk
1440 min Winter	34.848	1.548	101.3	6492.0	Flood Risk
2160 min Winter	34.668	1.368	101.3	5737.0	O K
2880 min Winter	34.463	1.163	101.3	4878.2	O K
4320 min Winter	34.132	0.832	101.3	3490.6	O K
5760 min Winter	33.909	0.609	101.3	2552.5	O K
7200 min Winter	33.772	0.472	99.7	1981.0	O K
8640 min Winter	33.693	0.393	97.3	1649.3	O K
10080 min Winter	33.662	0.362	93.1	1518.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	62.700	0.0	5483.0	68
120 min Winter	36.822	0.0	6449.1	126
180 min Winter	27.090	0.0	7121.2	184
240 min Winter	21.796	0.0	7641.4	240
360 min Winter	16.003	0.0	8415.8	354
480 min Winter	12.852	0.0	9009.8	464
600 min Winter	10.841	0.0	9495.3	570
720 min Winter	9.432	0.0	9907.7	664
960 min Winter	7.568	0.0	10581.3	752
1440 min Winter	5.554	0.0	11582.6	1062
2160 min Winter	4.080	0.0	13034.1	1520
2880 min Winter	3.296	0.0	14038.7	1940
4320 min Winter	2.484	0.0	15827.7	2684
5760 min Winter	2.061	0.0	17626.6	3360
7200 min Winter	1.808	0.0	19313.8	4032
8640 min Winter	1.638	0.0	20980.4	4592
10080 min Winter	1.517	0.0	22625.6	5248

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 296304 181216 SS 96304 81216
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 10.628

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	3.543	4	8	3.543	8	12	3.543

Model Details

Storage is Online Cover Level (m) 35.000

Tank or Pond Structure

Invert Level (m) 33.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4194.0	1.700	4194.0	1.701	0.1

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0388-1016-1700-1016
Design Head (m)	1.700
Design Flow (l/s)	101.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	388
Invert Level (m)	33.300
Minimum Outlet Pipe Diameter (mm)	450
Suggested Manhole Diameter (mm)	Site Specific Design (Contact Hydro International)

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.700	101.4
Flush-Flo™	0.636	101.3
Kick-Flo®	1.256	87.6
Mean Flow over Head Range	-	84.3

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	10.8	1.200	90.9	3.000	133.7	7.000	202.3
0.200	38.5	1.400	92.3	3.500	144.1	7.500	209.3
0.300	73.7	1.600	98.5	4.000	153.9	8.000	216.0
0.400	97.5	1.800	104.3	4.500	163.0	8.500	222.5
0.500	100.3	2.000	109.8	5.000	171.6	9.000	228.8
0.600	101.3	2.200	115.0	5.500	179.8	9.500	235.0
0.800	100.4	2.400	119.9	6.000	187.6		
1.000	97.5	2.600	124.7	6.500	195.1		

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	33.915	0.615	18.7	452.2	O K
30 min Summer	34.168	0.868	18.7	638.0	O K
60 min Summer	34.460	1.160	18.7	852.4	O K
120 min Summer	34.609	1.309	18.7	962.3	O K
180 min Summer	34.691	1.391	18.7	1022.1	O K
240 min Summer	34.737	1.437	18.7	1056.4	Flood Risk
360 min Summer	34.772	1.472	18.7	1081.9	Flood Risk
480 min Summer	34.769	1.469	18.7	1079.4	Flood Risk
600 min Summer	34.755	1.455	18.7	1069.3	Flood Risk
720 min Summer	34.738	1.438	18.7	1057.1	Flood Risk
960 min Summer	34.699	1.399	18.7	1028.4	O K
1440 min Summer	34.616	1.316	18.7	967.2	O K
2160 min Summer	34.485	1.185	18.7	871.2	O K
2880 min Summer	34.349	1.049	18.7	771.0	O K
4320 min Summer	34.115	0.815	18.7	598.8	O K
5760 min Summer	33.952	0.652	18.7	478.9	O K
7200 min Summer	33.839	0.539	18.7	396.4	O K
8640 min Summer	33.759	0.459	18.7	337.5	O K
10080 min Summer	33.701	0.401	18.5	294.7	O K
15 min Winter	33.992	0.692	18.7	508.5	O K
30 min Winter	34.277	0.977	18.7	718.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	130.809	0.0	461.1	26
30 min Summer	92.696	0.0	655.7	40
60 min Summer	62.700	0.0	898.0	70
120 min Summer	36.822	0.0	1055.2	128
180 min Summer	27.090	0.0	1164.7	186
240 min Summer	21.796	0.0	1249.6	244
360 min Summer	16.003	0.0	1376.2	362
480 min Summer	12.852	0.0	1473.7	468
600 min Summer	10.841	0.0	1553.7	520
720 min Summer	9.432	0.0	1621.9	580
960 min Summer	7.568	0.0	1734.4	710
1440 min Summer	5.554	0.0	1906.6	986
2160 min Summer	4.080	0.0	2112.7	1408
2880 min Summer	3.296	0.0	2275.8	1820
4320 min Summer	2.484	0.0	2569.4	2556
5760 min Summer	2.061	0.0	2849.3	3288
7200 min Summer	1.808	0.0	3122.8	3968
8640 min Summer	1.638	0.0	3393.9	4672
10080 min Summer	1.517	0.0	3664.0	5352
15 min Winter	130.809	0.0	517.2	26
30 min Winter	92.696	0.0	734.8	40

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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	34.605	1.305	18.7	959.4	O K
120 min Winter	34.778	1.478	18.7	1086.6	Flood Risk
180 min Winter	34.876	1.576	18.7	1158.1	Flood Risk
240 min Winter	34.934	1.634	18.7	1201.3	Flood Risk
360 min Winter	34.986	1.686	18.7	1239.0	Flood Risk
480 min Winter	34.994	1.694	18.7	1245.3	Flood Risk
600 min Winter	34.980	1.680	18.7	1234.9	Flood Risk
720 min Winter	34.954	1.654	18.7	1215.4	Flood Risk
960 min Winter	34.904	1.604	18.7	1179.1	Flood Risk
1440 min Winter	34.786	1.486	18.7	1092.4	Flood Risk
2160 min Winter	34.590	1.290	18.7	948.0	O K
2880 min Winter	34.383	1.083	18.7	796.4	O K
4320 min Winter	33.997	0.697	18.7	512.1	O K
5760 min Winter	33.766	0.466	18.7	342.3	O K
7200 min Winter	33.635	0.335	18.2	245.9	O K
8640 min Winter	33.560	0.260	17.4	190.7	O K
10080 min Winter	33.515	0.215	16.7	158.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	62.700	0.0	1006.1	68
120 min Winter	36.822	0.0	1182.2	126
180 min Winter	27.090	0.0	1304.8	182
240 min Winter	21.796	0.0	1399.8	240
360 min Winter	16.003	0.0	1541.6	354
480 min Winter	12.852	0.0	1650.7	464
600 min Winter	10.841	0.0	1740.1	568
720 min Winter	9.432	0.0	1816.5	658
960 min Winter	7.568	0.0	1942.2	750
1440 min Winter	5.554	0.0	2134.0	1062
2160 min Winter	4.080	0.0	2366.4	1520
2880 min Winter	3.296	0.0	2549.2	1988
4320 min Winter	2.484	0.0	2878.8	2684
5760 min Winter	2.061	0.0	3191.5	3344
7200 min Winter	1.808	0.0	3497.9	3976
8640 min Winter	1.638	0.0	3801.7	4664
10080 min Winter	1.517	0.0	4105.0	5256

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 296304 181216 SS 96304 81216
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.921

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.640	4	8	0.640	8	12	0.640

Model Details

Storage is Online Cover Level (m) 35.000

Tank or Pond Structure

Invert Level (m) 33.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	735.0	1.700	735.0	1.701	0.1

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0183-1870-1700-1870
Design Head (m)	1.700
Design Flow (l/s)	18.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	183
Invert Level (m)	33.300
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.700	18.7
Flush-Flo™	0.498	18.7
Kick-Flo®	1.075	15.0
Mean Flow over Head Range	-	16.2

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.4	1.200	15.8	3.000	24.5	7.000	36.8
0.200	16.4	1.400	17.0	3.500	26.4	7.500	38.1
0.300	17.9	1.600	18.2	4.000	28.1	8.000	39.3
0.400	18.5	1.800	19.2	4.500	29.8	8.500	40.5
0.500	18.7	2.000	20.2	5.000	31.3	9.000	41.6
0.600	18.6	2.200	21.1	5.500	32.8	9.500	42.7
0.800	17.9	2.400	22.0	6.000	34.2		
1.000	16.3	2.600	22.9	6.500	35.6		

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