HUMBER CIVILS

SMARTER BENEATH THE SURFACE

Site-specific Flood Risk Assessment

Proposed Residential Development,
Driffield, East Riding of Yorkshire

November 2020

P20-29-SsFRA_B

Contents

1. Document Control

1.1 Project Information

Project Reference: P20-29

Client: Z B Services Ltd

Project Description: Proposed residential development

Location: Land off Cranwell Road, Driffield

Document Ref: SsFRA_B

1.2 Current Revision

	Name, Position, Qualifications	Signature	Date
Author / Approver	John Peyman Bsc (Hons) Principal Civil Engineer		04/10/2022

1.3 Revision History

B	Report updated to suit amended architectural layout		JsP	04/10/2022
A	First issue, issued in Draft		JsP	23/11/2020
Rev.	Description	By	Checked/App.	Date

2. Introduction

2.1 Who

2.1.1 Humber Civils have been commissioned to produce a Site-specific Flood Risk Assessment (SsFRA) by Z B Services Ltd.

2.2 What

2.2.1 The SsFRA is required in relation to a proposed residential development.

2.3 Why

2.3.1 The need for a SsFRA has been identified by the Local Planning Authority (LPA) in their pre-application enquiry response dated 15 July 2020 given that the development site lies within an area at risk of flooding.

2.3.1..1. The National Planning Policy Framework (NPPF) [1] was originally published on 27 March 2012 and was most recently updated on 20 July 2021. This publication sets out the government's planning policies for England and how these are expected to be applied.

2.3.1..2. The NPPF is supported by several Planning Practice Guidance Categories (PPGCs) [2]. The Flood Risk and Coastal Change PPGC [3], originally published on 06 March 2014 and most recently updated on 27 May 2022, *'Advises how to take account of and address the risks associated with flooding and coastal change in the planning process'*.

2.3.1..3. The NPPF sets strict tests which, in summary, are designed to ensure that if there are better sites in terms of flood risk, or a proposed development cannot be made safe, it should not be permitted. These tests comprise:

- Assess flood risk.
- Avoid flood risk.
- Manage and mitigate flood risk.

2.3.1..4. In the context of the NPPF flood risk is a combination of the probability and potential consequences of flooding.

2.3.1..5. The NPPF requires flooding from all sources to be considered in assessing flood risk, including from:

- The sea.
- Rivers.
- Rainfall on the ground.
- Rising ground water.
- Overwhelmed or failed sewers and drainage systems.
- Reservoirs, canals, lakes and other artificial sources.

2.3.1..6. The NPPF provides guidance for Local Authorities (LA) in the preparation of Local Planning Policies, Strategic Food Risk Assessments (SFRA) and Local Plans.

2.3.1..7. A SsFRA is required to assess the risk to and from a development and should accompany the planning application for the development. The SsFRA should demonstrate how flood risk will be managed over the lifetime of the development taking climate change and the vulnerability of its users into account.

2.3.1..8. The NPPF requires that a SsFRA should establish:

- Whether the proposed development is likely to be affected by flooding from any source, both now and in the future.
- Whether the development will increase flood risk elsewhere.
- Whether the measures proposed in the SsFRA to deal with any effects and risks are appropriate.
- The evidence for the LPA to apply the Sequential Test if necessary.
- Whether the development will be safe and pass the Exception Test if applicable.

2.4 Report format

2.4.1..1. The NPPF Flood risk and coastal change PPGC provides details relating to the format of SsFRAs, however there are also various other national and local guidelines. This assessment report is generally based on the NPPF guidance but has been modified over time to reflect our experience in producing flood risk assessments, it covers the requirements set out in the NPPF and is broken down into the following format:

- Introduction
- Policy and guidance
- Proposed development site
- Development proposals
- Description of study area
- Flood information
- Consultations
- Climate change
- Sequential test
- Wastewater management
- Inherent flood risk
- Residual flood risk
- Exceptions test
- Conclusions and recommendations

2.5 Limitations

2.5.1..1. This SsFRA has been produced with the sole intention of accompanying a formal planning application for the project as described in the introduction and is not suitable for any other purpose.

2.5.1..2. It provides an assessment of flood risk to and from the proposed development on the development site in order to establish if and where suitable flood mitigation measures may be required.

2.5.1..3. It is based on the following:

- Government Guidance outlined through the NPPF and other relevant guidance documents and policies.
- Consultations with the following bodies where relevant:
  - Environment Agency (EA)
  - Local Lead Flood Authority (LLFA)
  - Local Planning Authority (LPA)
  - Internal Drainage Board (IDB)
  - Sewerage Undertaker

2.5.1..4. The findings are based on flood mapping and modelling information obtained from the above consultees at the time that this report was written, extracts of which are included in this report. Humber Civils cannot accept liability for any errors or inadequacies associated with this flood information or for any future updates to this flood information which may deem the recommendations of this report to be unsuitable.

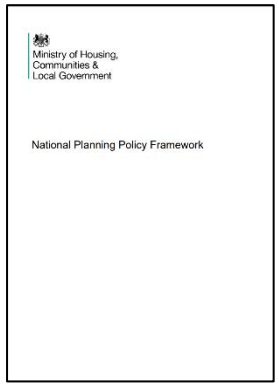
2.5.1..5. This report does not undertake flood modelling and is based entirely on flood modelling from third party organisations.

2.5.1..6. This report should not be used for any purposes other than those stated above and should not be used for any other proposed development, either on the development site or any adjacent sites.

3. Policy and guidance

The following section outlines some of the national and local policies and guidance that are relevant to flood risk and briefly explains their relevance:

3.1 National

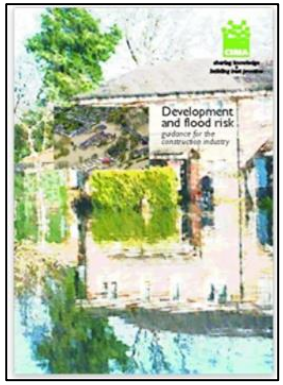


National Planning Policy Framework

The National Planning Policy Framework sets out the government's planning policies for England and how these are expected to be applied.

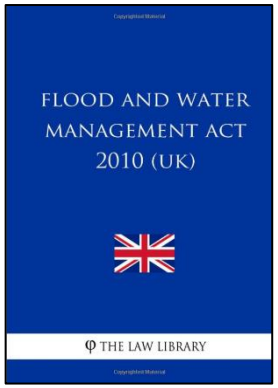
Planning Practice Guidance Flood Risk and Coastal Change

Advises how to take account of and address the risks associated with flooding and coastal change in the planning process.



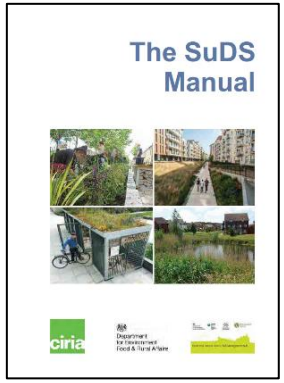
CIRIA C624 Developments and Flood Risk – Guidance for the Construction Industry

This document sets out practical guidance in assessing flood risk as part of the development process. It describes the mechanisms and impacts of flooding. It covers UK planning policy guidance for development and flood risk and is aimed at achieving a consistent approach to the implementation of that guidance.



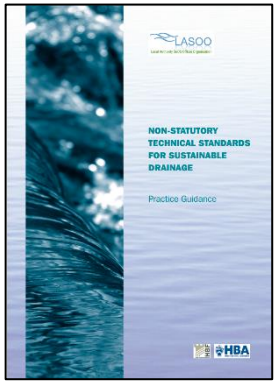
Flood and Water Management Act

This Act became law in April 2010 in England and Wales. It is intended to create a simpler and more effective means for managing flood and coastal erosion and help improve the sustainability of water resources and protect against drought.



The SuDS Manual, CIRIA (C753)

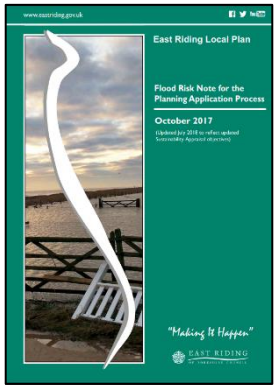
This publication covers the planning, design, construction and maintenance of Sustainable Urban Drainage Systems (SuDS) to assist with their effective implementation within both new and existing developments.



Non-statutory Technical Standards for Sustainable Drainage Systems

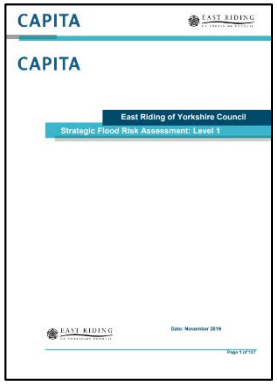
This document sets out non-statutory technical standards for sustainable drainage systems. They should be used in conjunction with the National Planning Policy Framework and Planning Practice Guidance.

3.2 Local



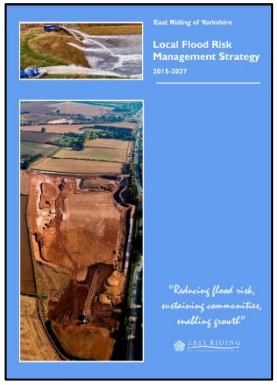
East Riding Flood Risk Note for the Planning Application Process

This Note has been prepared to provide assistance to developers, applicants, and Local Planning Authority officers on how to apply local and national planning policy using various pieces of evidence. It aims to promote transparency and consistency in the approach East Riding of Yorkshire Council will take to applying the flood risk Sequential and Exception Tests.



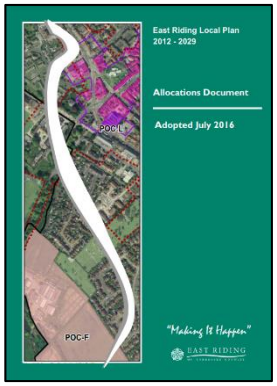
Level 1 Strategic Flood Risk Assessment (SFRA)

An SFRA is part of the evidence base for the Local Plan and collates information on all known sources of flooding that may affect existing or future development in the area. The SFRA identifies and maps areas that have a 'low', 'medium' and 'high' probability of flooding within the East Riding, in accordance with national policy and recommends appropriate land uses that will not unduly place people or property at risk of flooding.



East Riding Local Flood Risk Management Strategy (LFRMS)

The LFRMS sets out how the ERYC intend to work with partners to manage the risk of flooding in the area up to 2027 and beyond. This was formally adopted by the council on 18 November 2015.



East Riding Local Plan and Local Planning Policies

The East Riding Local Plan comprises of several different documents with policies to address key planning issues, as well policies that allocate land for specific uses. It is the starting point for determining planning applications.

Sustainable Drainage Systems (SuDS) Combined Planning Note and Standing Advice September 2016

This note aids developers when preparing applications for full planning permission and reserved matters for major development, in respect of SuDS and Surface Water Drainage Design. It is a supplementary note to support Objective 9 of the ERYC Local Flood Risk Management Strategy.

4. The development site and study area

4.1 Site location and existing use

Site location

4.1.1 The full address for the development site is as follows:

Address: Land North Of 32A, Exchange Street, Driffield, East Riding of Yorkshire, YO25 6LL.

Grid reference: TA 02427 57844, Easting 502427, Northing 457844.

Existing use

4.1.2 The existing site is currently unused and comprises an area of derelict land finished with stone surfacing. Previously the site was used as a gas storage facility and is believed to have since been decommissioned and remediated.

Aerial Maps

Figure 5.1a –Small scale image showing the development site and wider surrounding area, Bing Maps [4].

Figure 5.1b –Large scale image showing the development site and immediate surrounding area, Bing Maps [(4)].

4.2 Existing features

General

4.2.1 The development site is bounded; to the north-east by the Driffield Beck, with a parcel of development land owned by the applicant, along with industrial and residential properties and the East Gate North public highway beyond; to the south-east by a carpark and office buildings, with the Exchange Street public highway beyond; to the south-west by a private access road with industrial and retail properties and the Market Place public highway beyond; and to the north-west by the Cranwell Road public highway with a carpark beyond.

Area

4.2.2 The development site comprises an area of land with an approximate area of 1500 square metres or 0.15 hectares.

Topography

4.2.3 Existing ground levels around the property have been taken from the DEFRA Data Services Website [5] and their Composite LIDAR 2019 TA0257 50CM DSM. Figure 4.2a below shows the LIDAR overlaid onto satellite mapping for the area.

4.2.4 An assessment of the LIDAR level data shows approximate levels as follows; existing road frontage levels along Cranwell Road (along the north-west boundary of the site) varying from 16.1 to 15.3, averaging at 15.7mAOD; existing road frontage levels along the private road to the south-west boundary varying from 16.15 to 16.60, averaging at 16.4mAOD; general site levels are at around 16.6mAOD other than an area to the south-east corner which ramps up to an existing bridge over the beck, levels in this area are sown to be as high as 18.0mAOD.

Figure 4.2a – LiDAR image for the site.

5. Development Proposals

5.1 General

5.1.1 The development comprises the erection of 8 number 3 storey, 2 and 3 bedroomed town houses and associated infrastructure works.

5.1.2 An extract from the Proposed Site Layout Plan, Piercy Design drawing number 2022-01/S01 can be seen be seen in Figure 5.1a below. Figure 5.1b shows extracts from the Proposed Plans and Elevations - Blocks 1 & 2 and Proposed Site Section, Piercy Design drawing number 2022-01/P01. A copy of these architectural drawings are included in Appendix A.

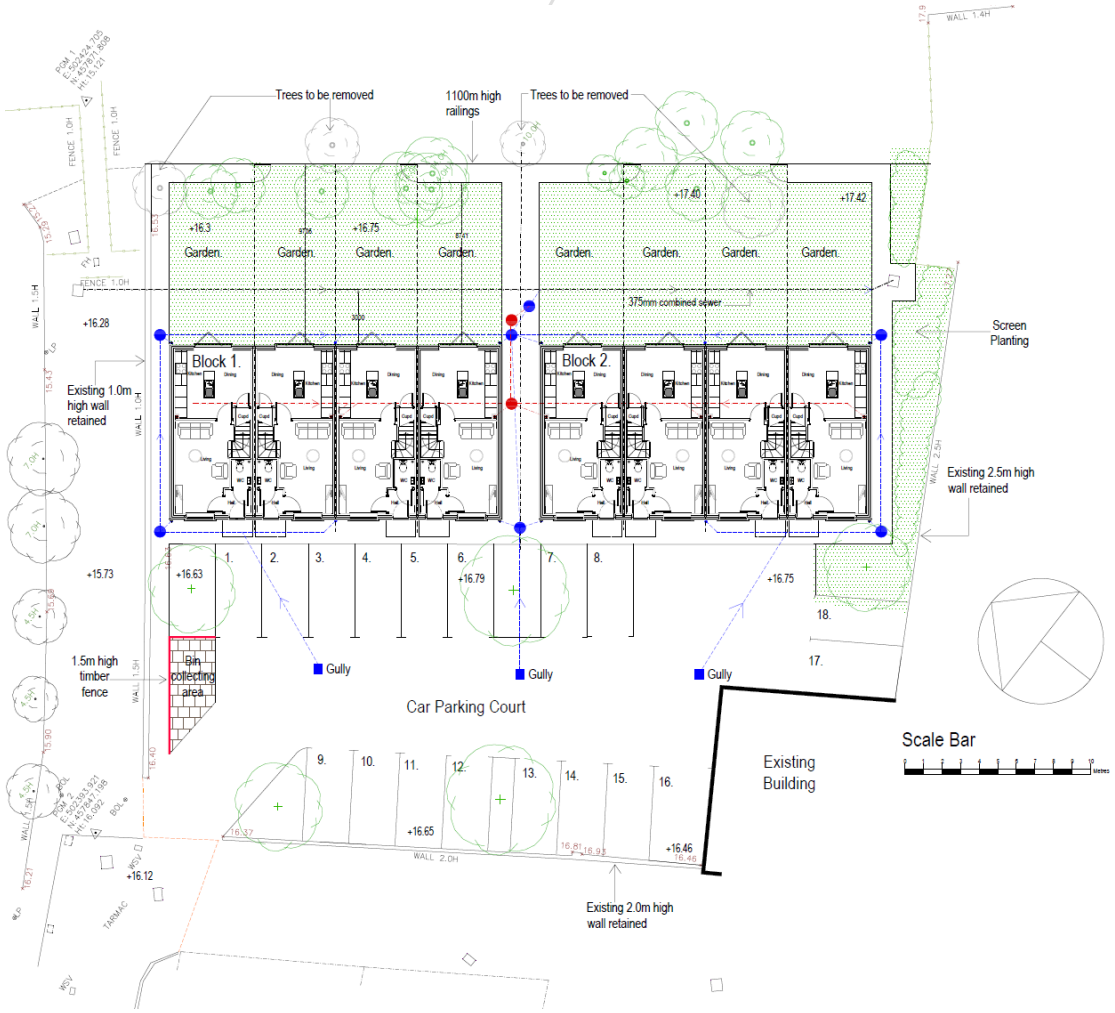
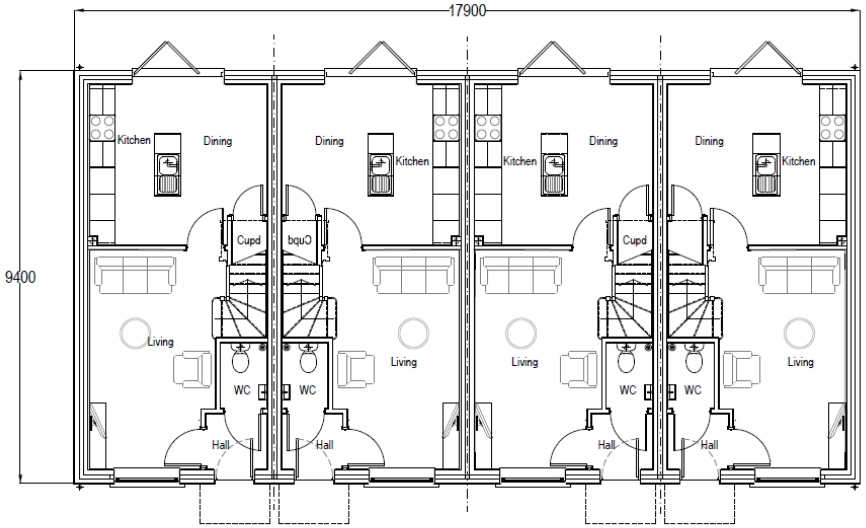
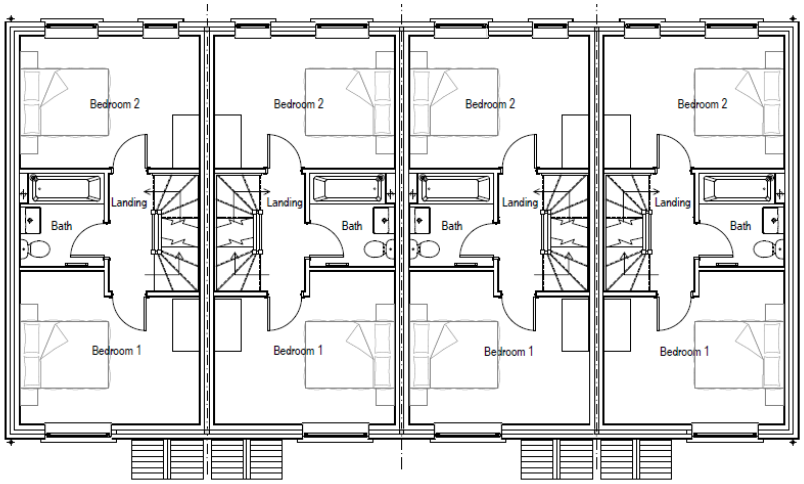


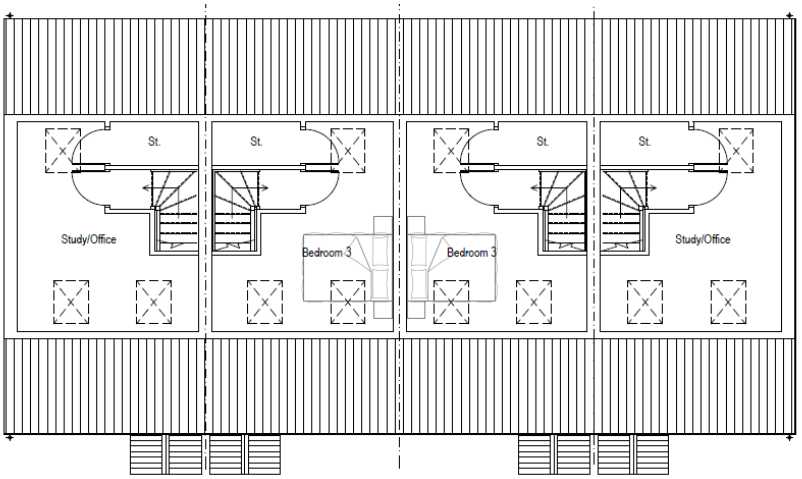
Figure 5.1a – Extract from Piercy Design drawing number 2022-01/S01.



Proposed Ground Floor Plans



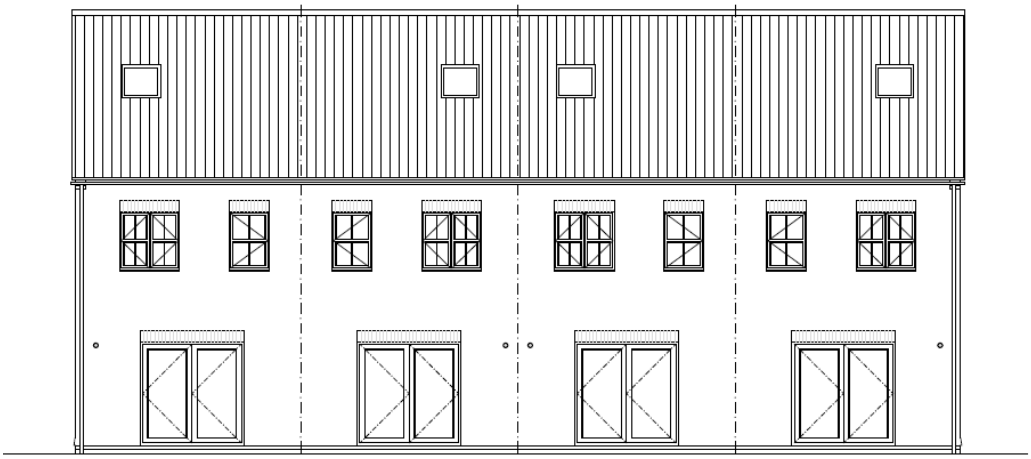
Proposed First Floor Plans



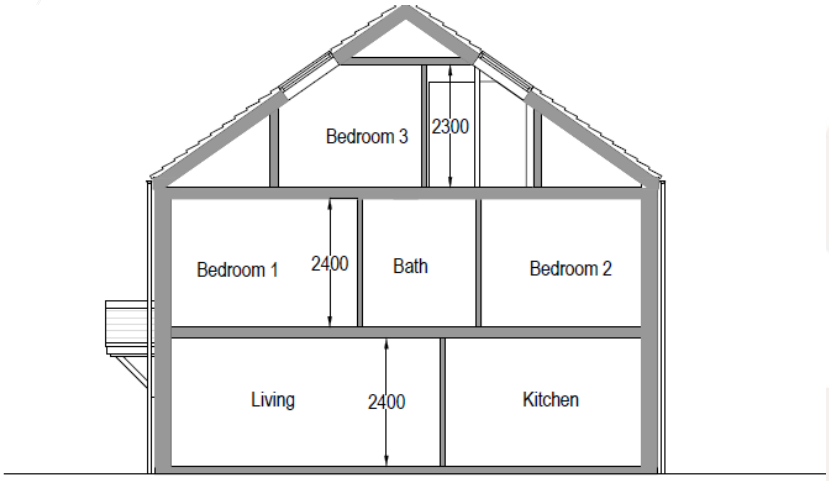
Proposed Second Floor Plans

Figure 5.1b – Extract from Piercy Design drawing number 2022-01/P01.

Proposed Front Elevation



Proposed Rear Elevation



Proposed Side Elevation

Figure 5.1c – Extract from Piercy Design drawing number 2022-01/P01.

5.2 Vulnerability classification

5.2.1 Residential dwellings have a vulnerability classification under the NPPF of 'More Vulnerable' in accordance with Table 2 Flood Risk Vulnerability Classifications, refer to Figure 5.2a below.

More vulnerable

- Hospitals
- Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels.
- Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels.
- Non–residential uses for health services, nurseries and educational establishments.
- Landfill* and sites used for waste management facilities for hazardous waste.
- Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.

Figure 5.2a - Showing an extract from the NPPF, Table 2 Flood Risk Vulnerability Classifications.

5.3 Design life

5.3.1 The design life for the proposed development, being residential, is taken as being 100 years.

6. Description of study area

Salient flood risk features within the study area for the site are outlined below.

6.1 Watercourses

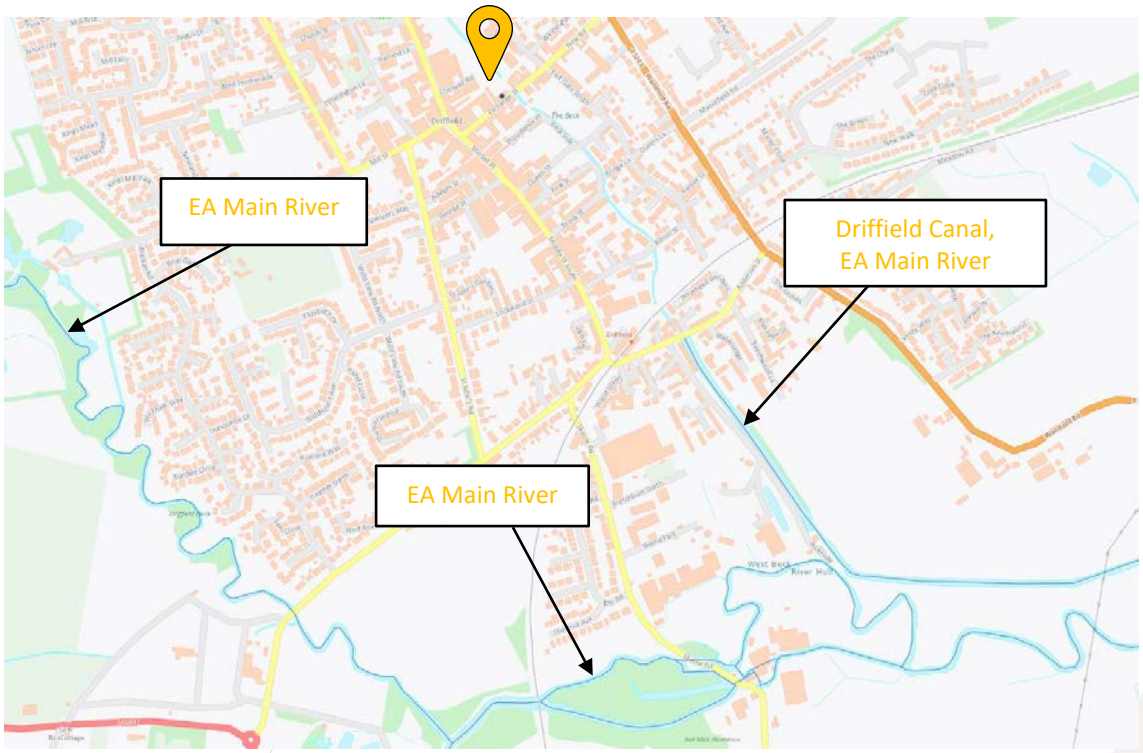


Figure 6.1a –EA main rivers map (6)

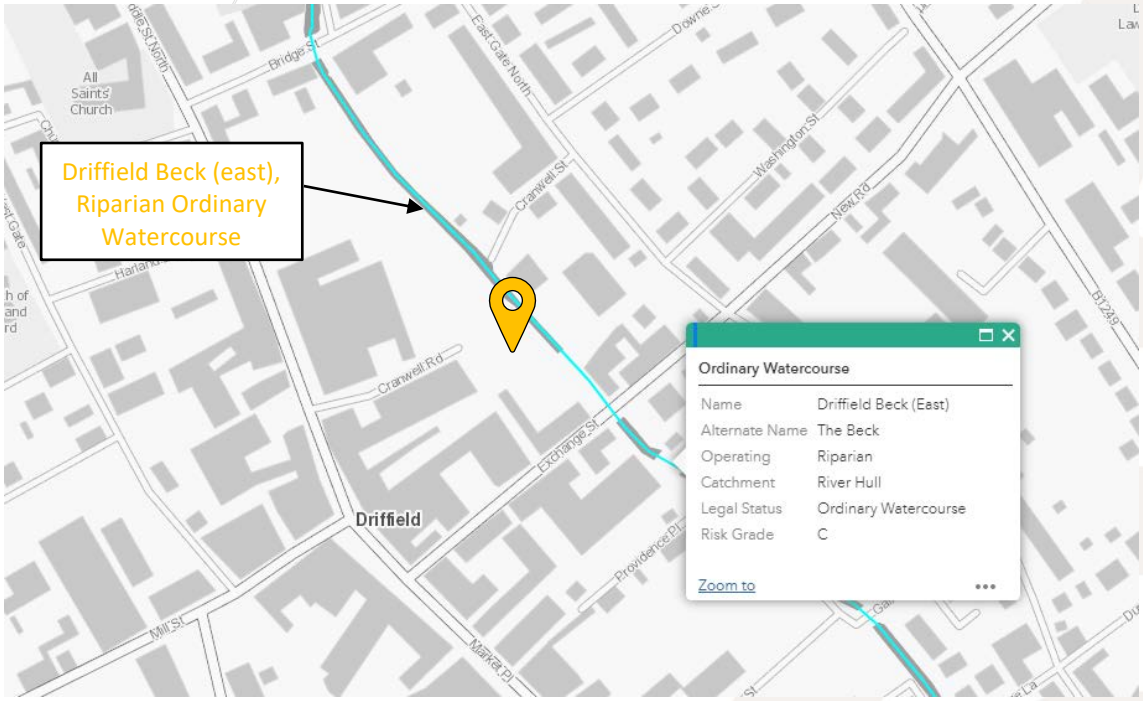


Figure 6.1b –ERYC SFRA Interactive Map (7)

6.1.1 Figure 6.1a above shows an extract from the EA Main Rivers website [6] and Figure 6.1b shows an extract from the ERYC SFRA interactive map [7]. This mapping shows that Driffield Beck (east) runs along the north-eastern boundary of the site, the beck is a riparian operated Ordinary Watercourse which changes designation approximately 0.41 miles (0.67 kilometres) south-east from the development site where it becomes an EA Main River, being the Driffield Canal. It can be seen from the mapping that the development site also lies approximately 0.70 miles (1.14 kilometres) to the north and 0.60 miles (0.98 kilometres) to the east of other EA Main Rivers.

6.2 Geology

6.2.1 Figure 6.2a below shows an extract from the British Geological Survey (BGS) website which confirms the mapped superficial geology of the site comprises either Till, Devensian or Glaciofluvial deposits of sand and gravel over the Flamborough Chalk Formation bedrock.

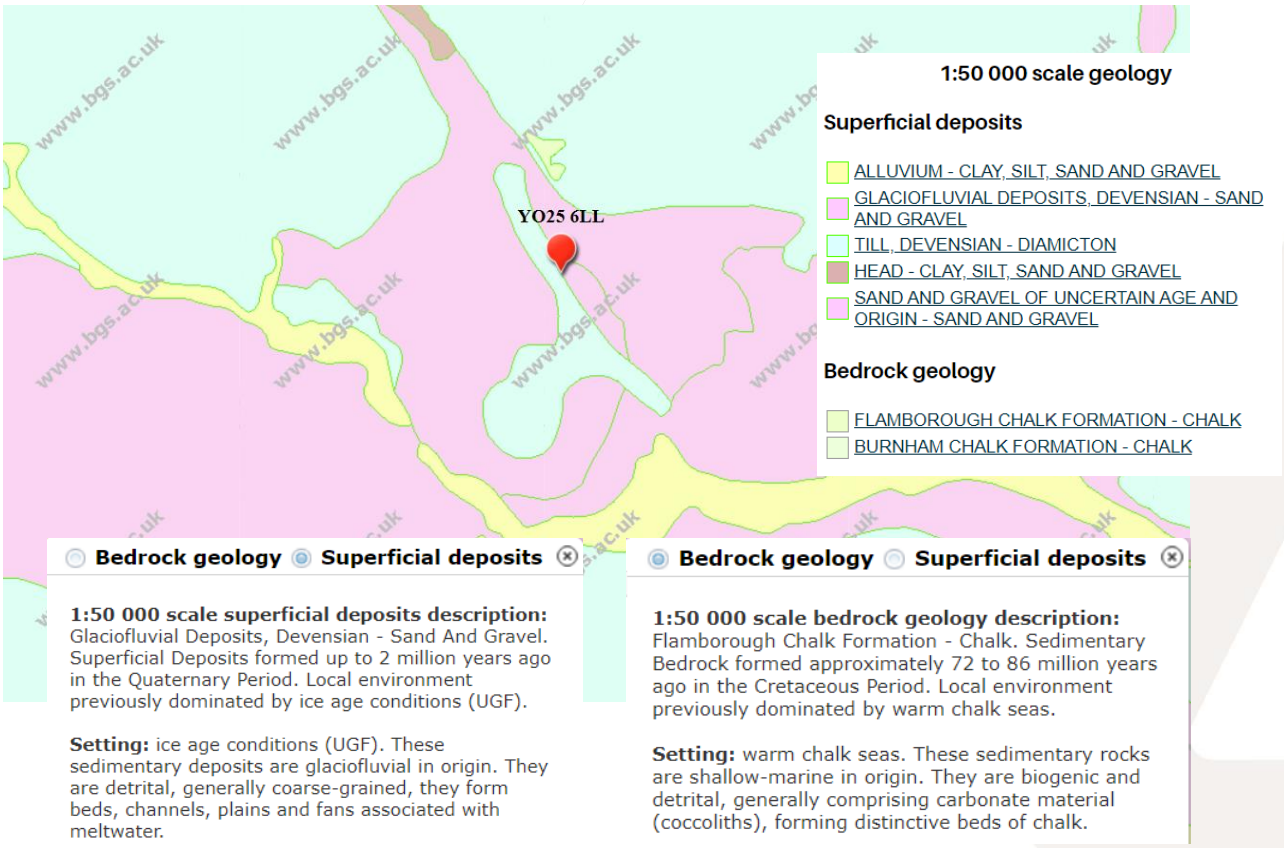


Figure 6.2a– BGS Geological Mapping website [8].

6.3 Ground Investigation

6.3.1 A geo-environmental report has been undertaken for the development site in relation to the site's former use as a gas storage facility. The report confirms significant contamination was present in the underlying superficial geology in connection with the previous site use. Consequently, the site has undergone a scheme of remediation works. In addition, the geo-environmental report confirms that the development site would not be suitable for the disposal of wastewater to ground via infiltration due to risks associated with contamination.

6.4 Source Protection Zone (SPZ)

6.4.1 The EA's Magic Map website [9] has been used to check whether the site is located over a Source Protection Zone (SPZ) or within a Designated Sensitive Area.

6.4.2 Designated Sensitive Areas include the following; Ramsar Sites; Sites of Special Scientific Interest units (England) (SSSI); sites of special scientific interest (England) (SSSI); Special Protection Areas (England)(SPA); potential special protection areas (England); and Special Areas of Conservation (SAC).

6.4.3 Definitions for these sites are stated below:

- Ramsar sites: wetlands considered to be of international importance.
- SSSI: formal conservation designation, likely to contain important geological or physiological features.

6.4.4 SPA: areas of conservation for wild, rare and vulnerable birds.

6.4.5 SAC: includes the land designated under Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora.

6.4.6 Figure 6.4a below shows an extract from the EA Magic Map which confirms the site is not within a SPZ. Figure 6.4b below shows an extract from the EA Magic Map confirming the area is not within a Designated Sensitive Area, although it is in an area classified as an SSSI Impact Risk Zone and is in an area classed as a Drinking Water Safeguard Zone (Surface Water), which are defined by the EA as:

'Drinking Water Safeguard Zones (Surface Water) are catchment areas that influence the water quality for their respective Drinking Water Protected Area (Surface Water), which are at risk of failing the drinking water protection objectives. These non-statutory.'

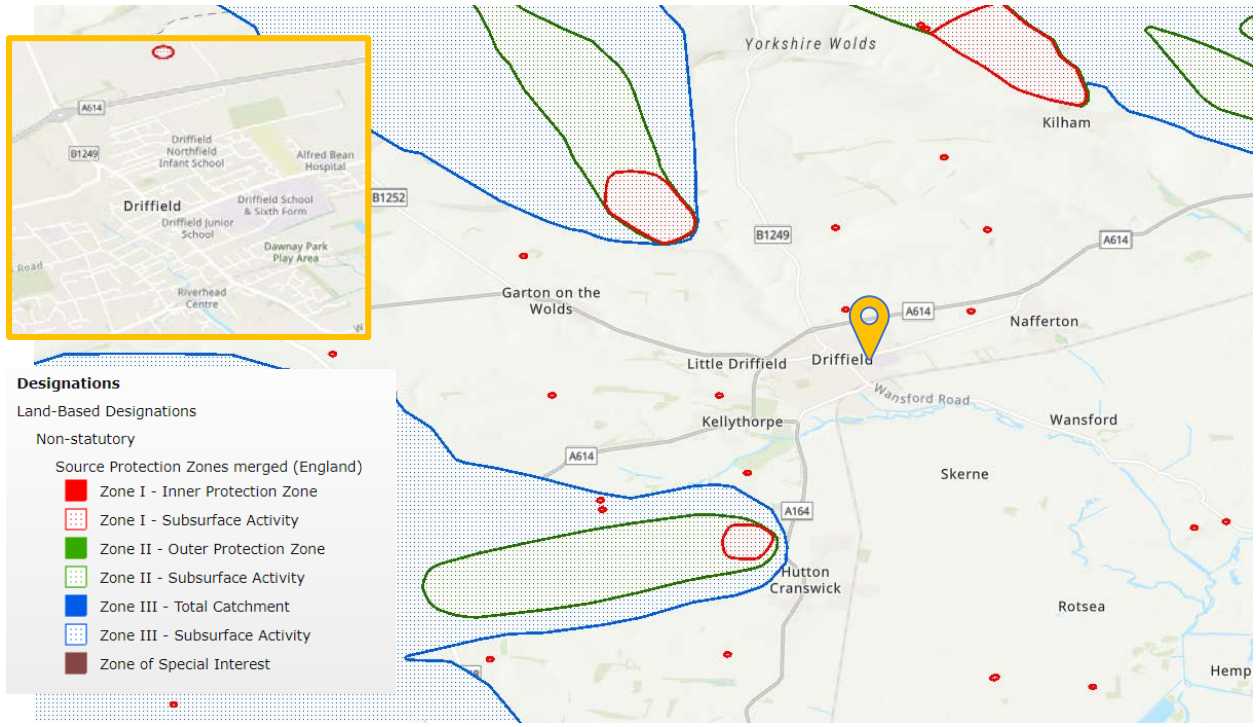


Figure 6.4a – EA Magic Map, SPZs.

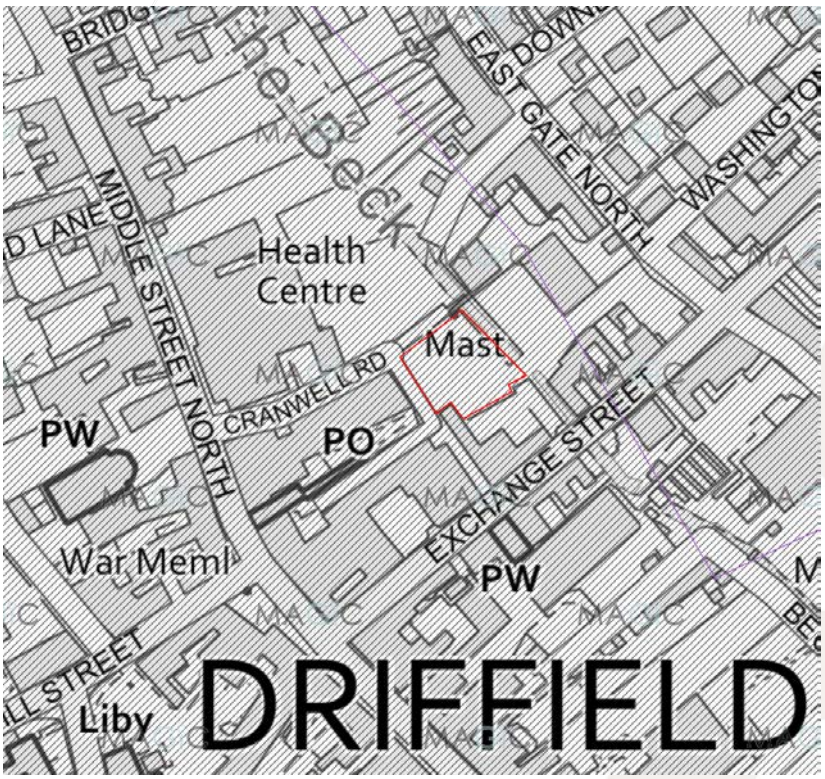


Figure 6.4b – EA Magic Map, Designated Sensitive Areas.

6.5 Wastewater Infrastructure

6.5.1 Yorkshire Water asset maps shown in Figure 6.5a below confirm that there are combined and surface water public sewers within the vicinity of the development site. Twin 300mm diameter surface water sewers run under Cranwell Road to the north-west of the development site and a 375mm diameter combined water sewer runs through the existing development site.

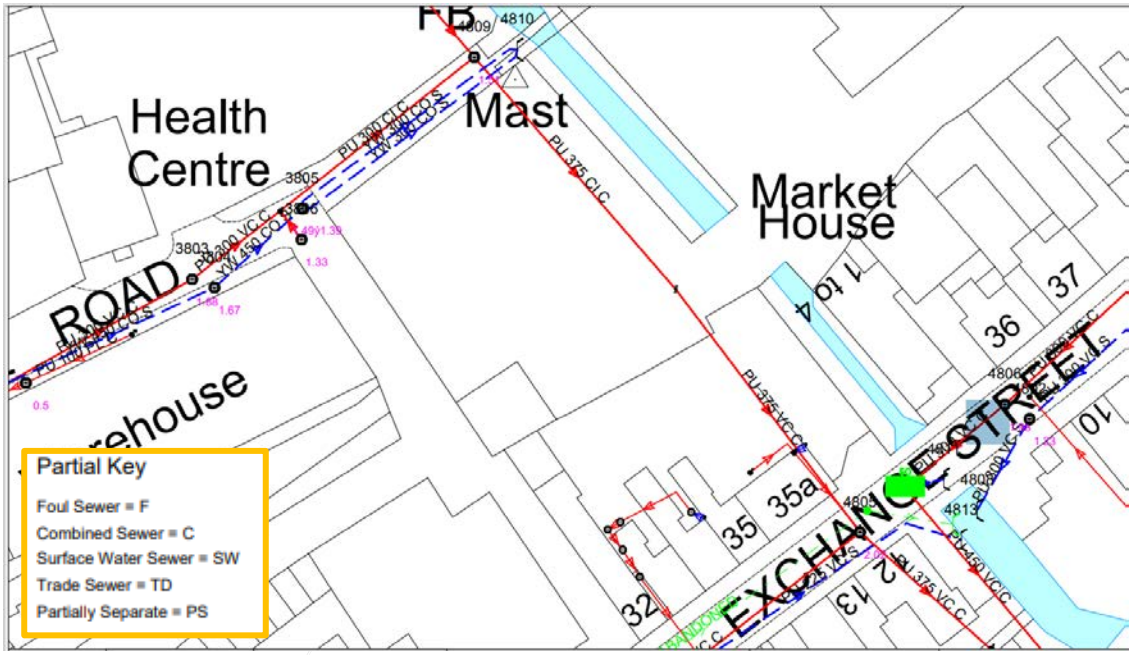


Figure 6.5a – Yorkshire Water Sewer Network Map

7. Flood information

7.1 Online EA flood mapping

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map)
Zone 3b The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map

7.1.1 The EA's Flood map for planning website [10] categorises the development site as being in Flood Zones (FZ) 1, 2 and 3 without the benefit of flood defences.

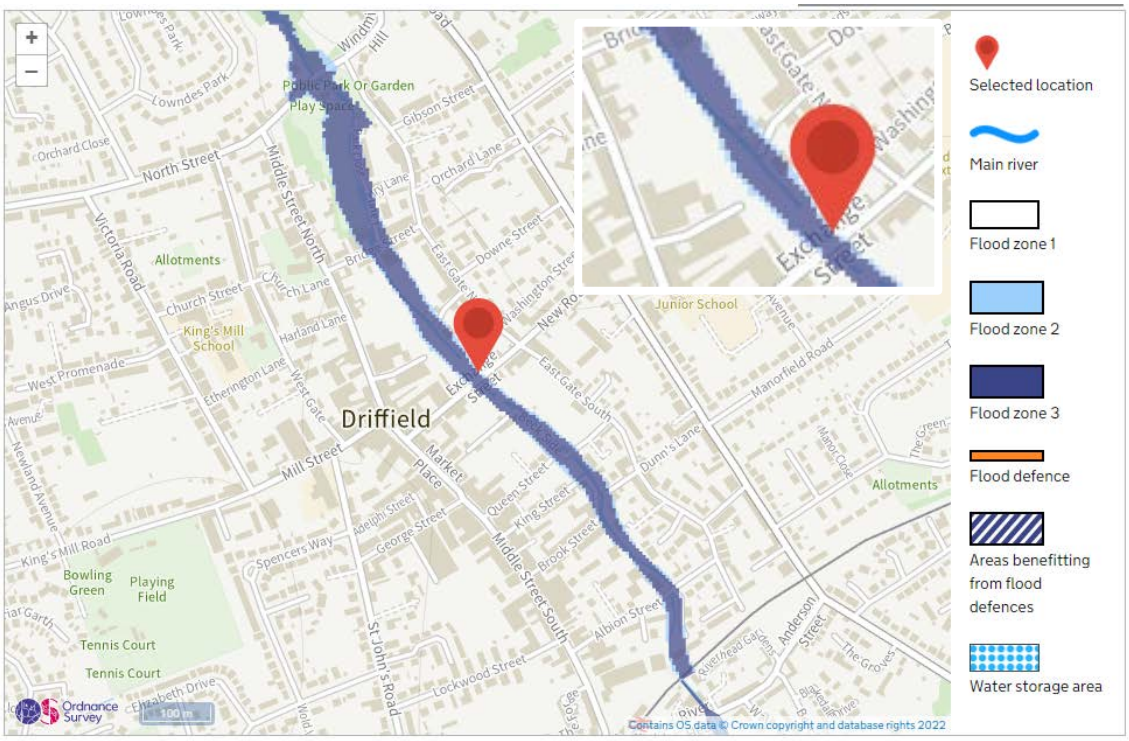


Figure 7.1a – Extract from the EA's Flood map for planning website

7.2 Long term flood planning

7.2.1 The EA's 'Check the long-term flood risk for an area in England' website [11] has been used to obtain flood mapping information relating to flood risk for the development site from the following sources:

- Rivers and the sea – Figure 7.2a below, the north-eastern side of the development site is shown to be in an area with a chance of flooding of between 1% and 3.3% being categorised as **Medium risk.** The remainder of the development site to the south-west is shown to be in an area with a chance of flooding of less than 0.1% being categorised as **Very Low risk.** The beck is shown to have a chance of flooding of greater than 3.3% being categorised as **High Risk** however this appears to be limited to the within the banks of the watercourse. This mapping considers the effect of any flood defences in the area. These defences reduce but do not completely stop the chance of flooding as they can be overtopped or fail.
- Surface water – Figure 7.2b below, the development site is shown to be in an area with a chance of flooding of less than 0.1% being categorised as **Very Low risk.** However, surface water flooding varying in frequency, depth and velocity is shown to occur in the area surrounding the development site, most noticeably Cranwell Road and the private road. Figures 7.2c to 7.2i show the expected depth and velocity from this flooding. Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding.
- Reservoirs – Figure 7.2j below, shows that the development site is not shown to be in an area at risk of flooding from reservoirs.

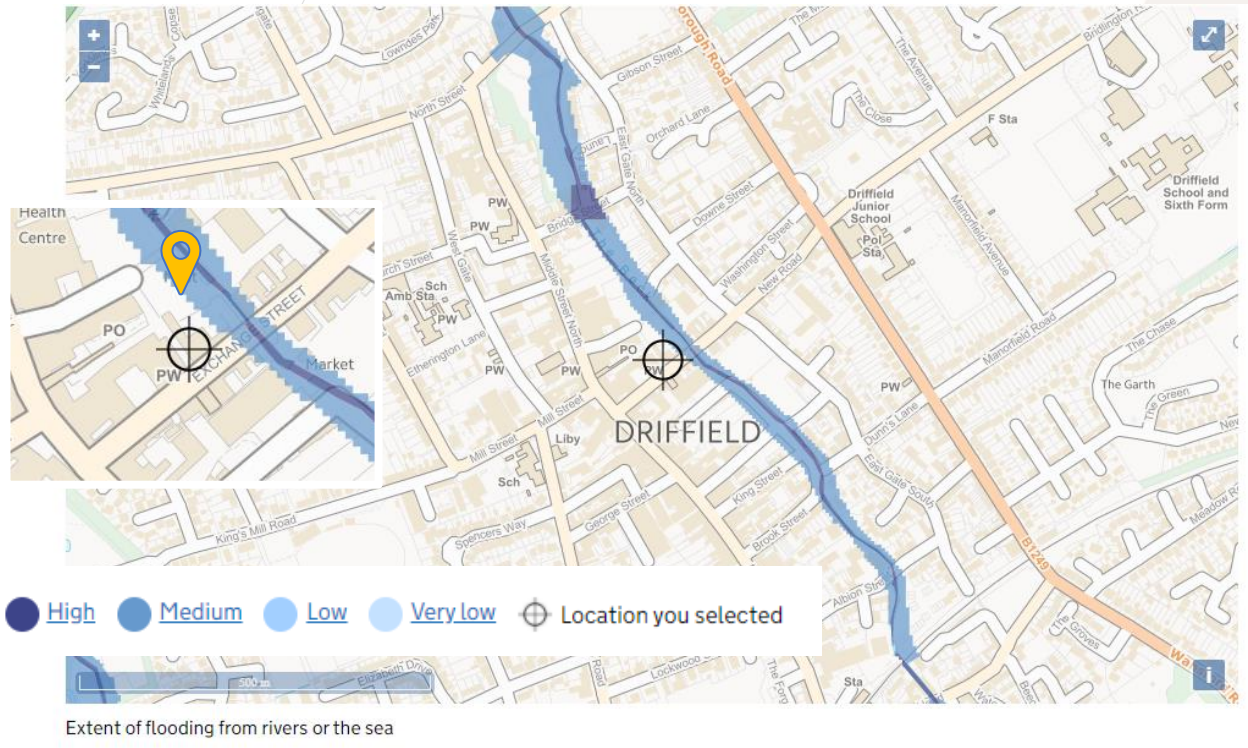


Figure 7.2a – Extract from the EA's long-term flood risk website, rivers & the sea flood extents

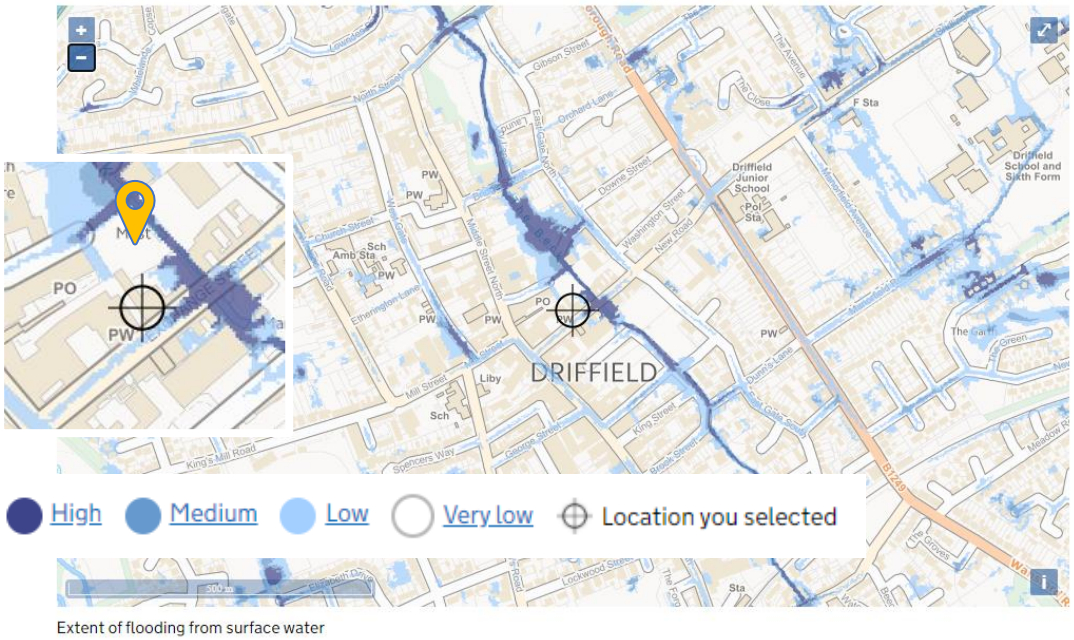


Figure 7.2b - Extract from the EA's long-term flood risk website, extent of flooding from surface water

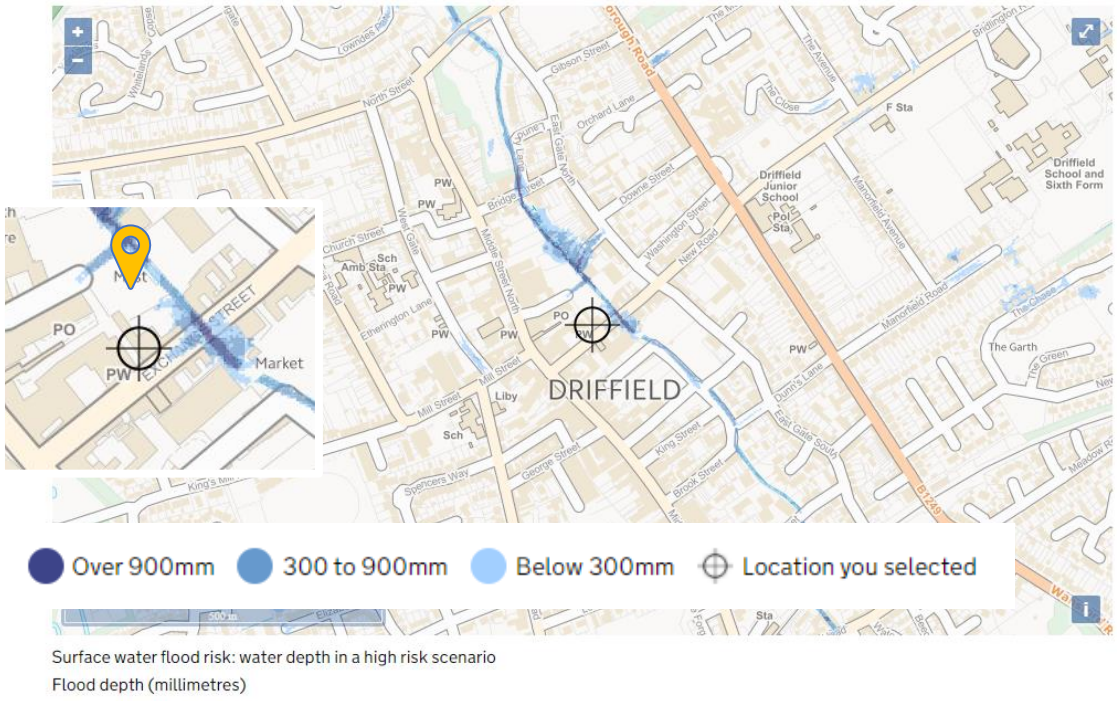


Figure 7.2c - Extract from the EA's long-term flood risk website, surface water depth in a high risk scenario

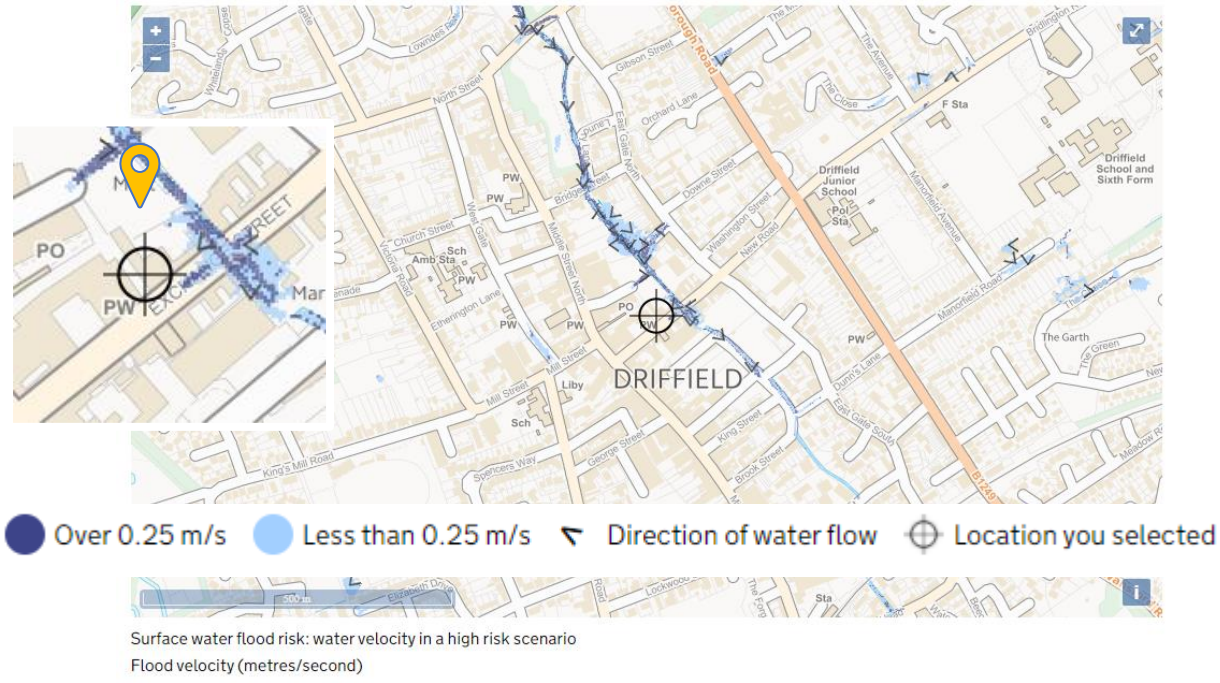


Figure 7.2d - Extract from the EA's long-term flood risk website, surface water velocity in a high risk scenario

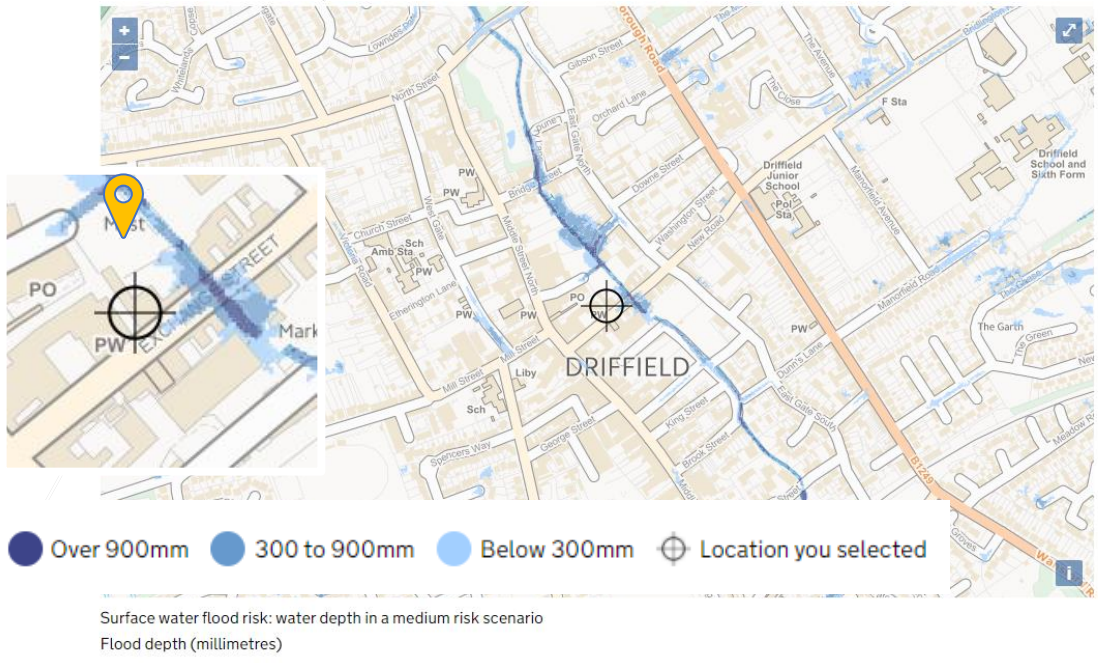


Figure 7.2e - Extract from the EA's long-term flood risk website, surface water depth in a medium risk scenario

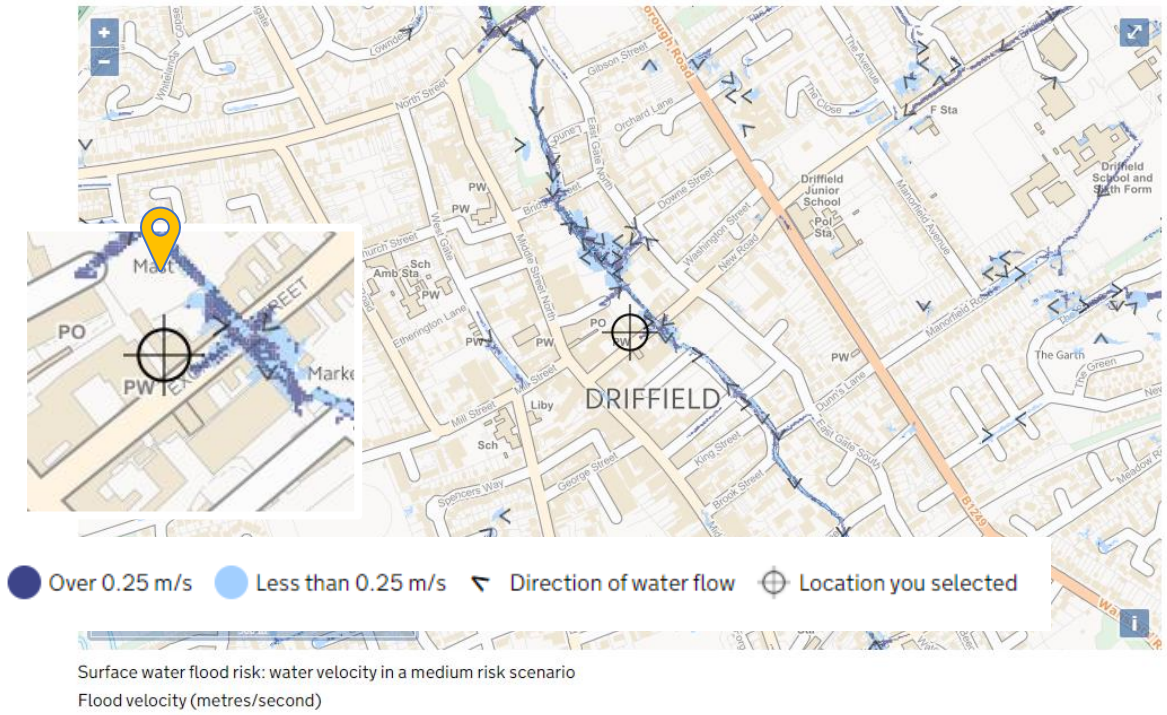


Figure 7.2f - Extract from the EA's long-term flood risk website, surface water velocity in a medium risk scenario

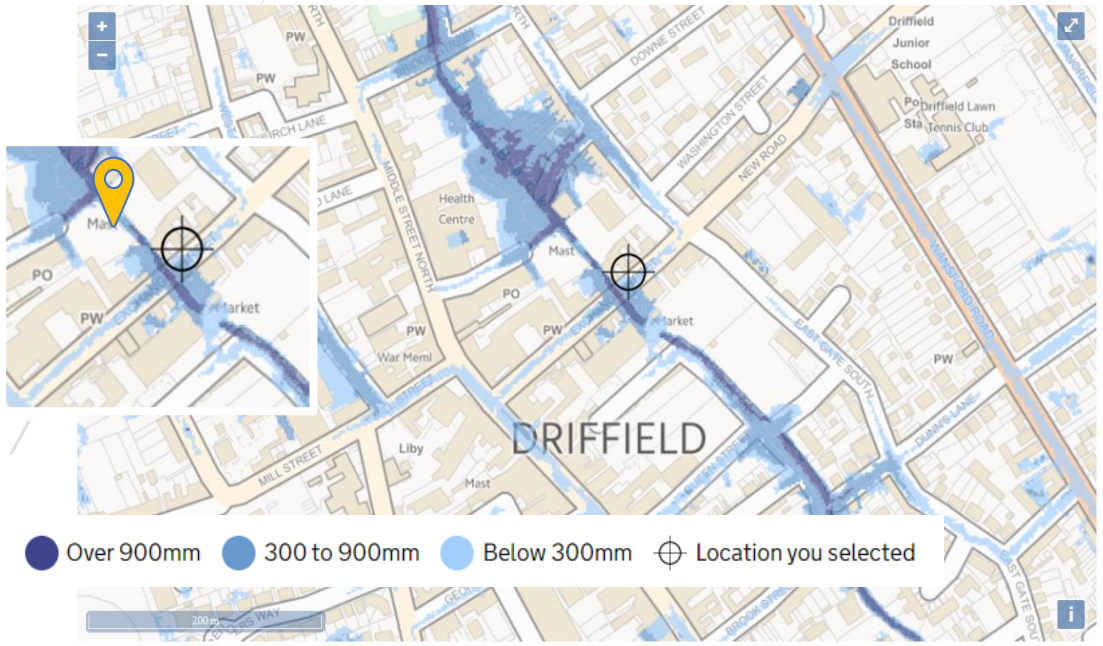


Figure 7.2g - Extract from the EA's long-term flood risk website, surface water depth in a low risk scenario.

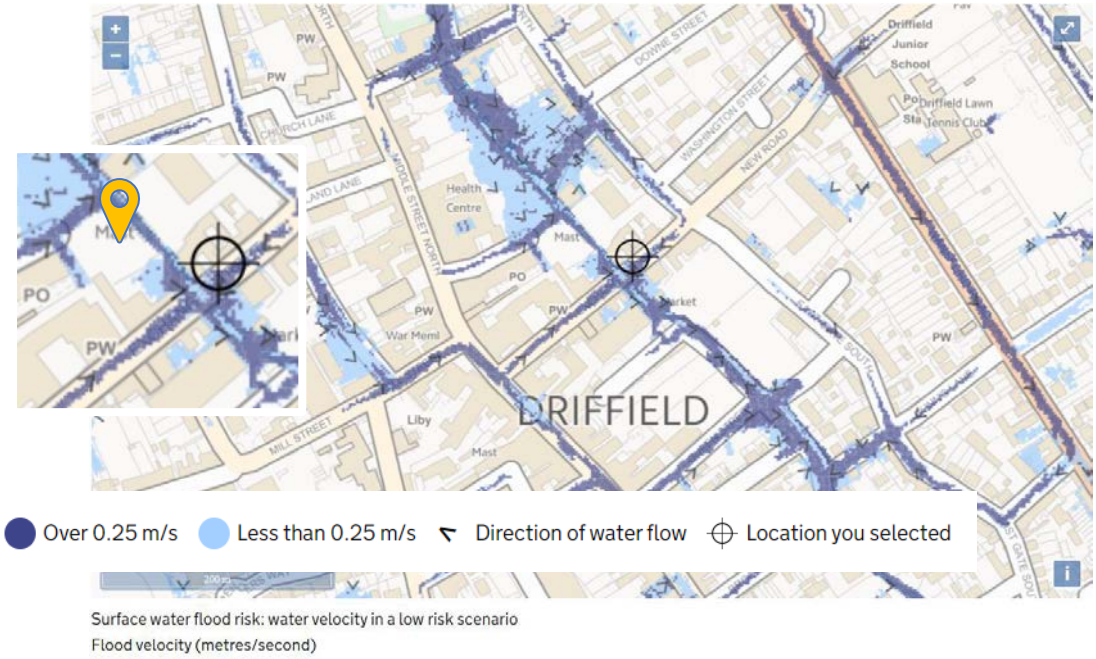


Figure 7.2h - Extract from the EA's long-term flood risk website, surface water velocity in a low risk scenario

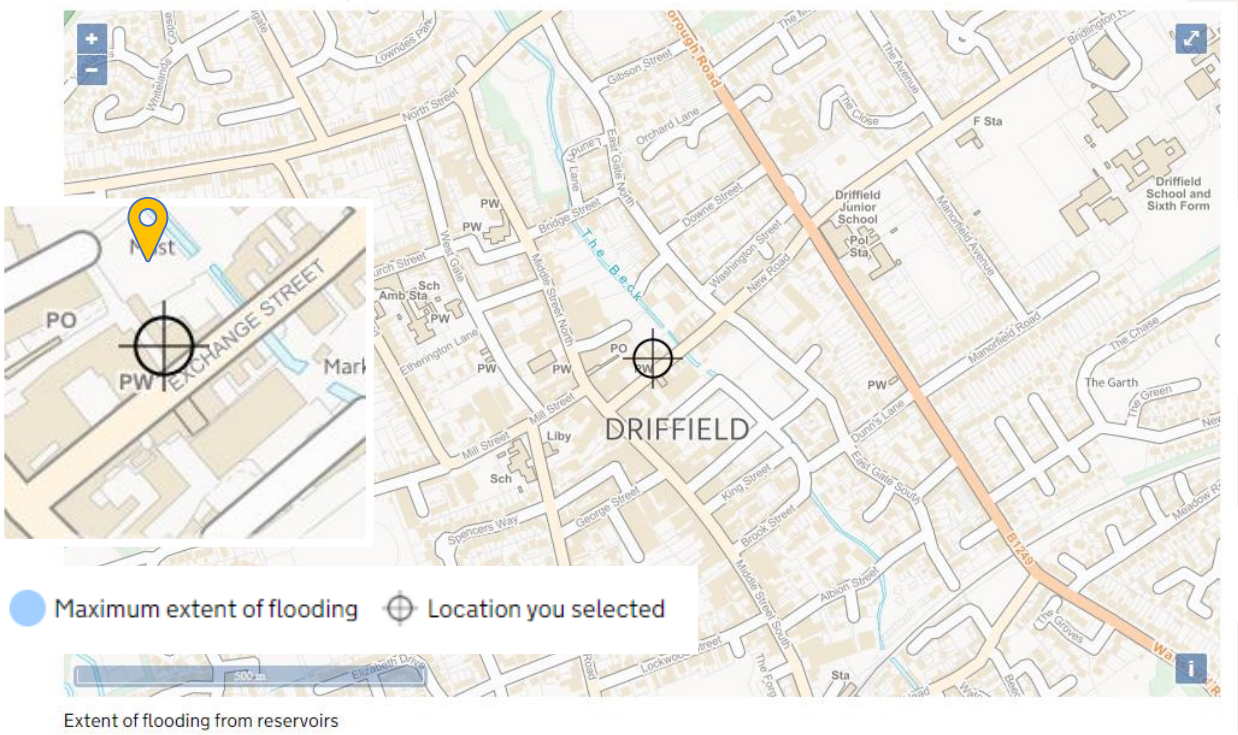


Figure 7.2i - Extract from the EA's long-term flood risk website, extent of flooding from reservoirs

7.3 Local Strategic Flood Risk Assessment

7.3.1 The ERYC SRFA Interactive Map has been used to obtain further flood mapping data beyond that which is available from the EA sources.

7.3.2 Figures 7.3a to 7.3c show extracts from the interactive map and confirm that; an area of the site to the north-east, similar in extents to FZ2 on the EA mapping, is shown to be within the Future Flood Zone 3a category; the site is potentially susceptible to ground water flooding having a >75% susceptibility; and the site is not shown to have been flooded during historic flood events.

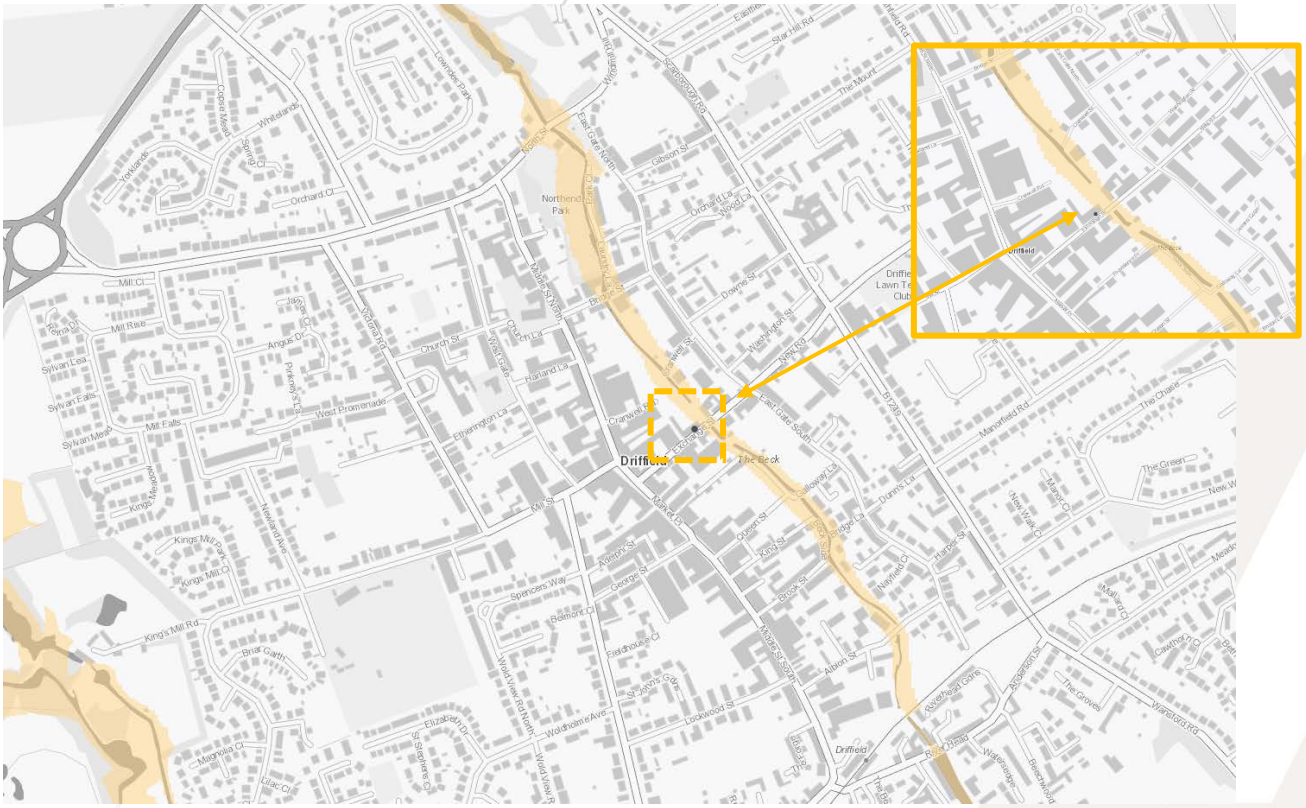


Figure 7.3a – Extract from the Level 1 SFRA, future flood zone 3a

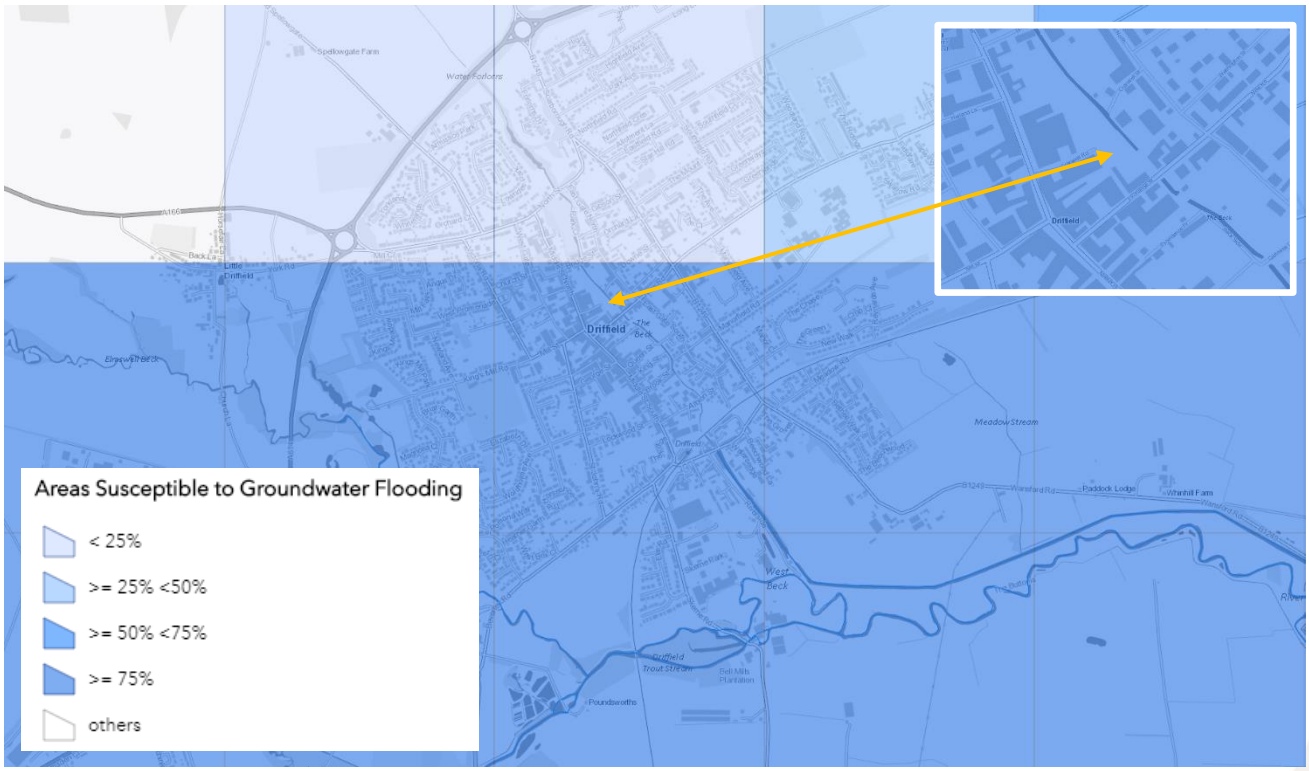


Figure 7.3b – Extract from the Level 1 SFRA, areas susceptible to groundwater flooding

Figure 7.3c – Extract from the Level 1 SFRA, historic flooding

8. Consultations

8.1 Yorkshire Water (YW)

8.1.1 YW were consulted via email on 19/10/20 in relation to new sewer connections for foul and surface water from the development.

8.1.2 An initial response was received via email on 07/10/20 with further discussions taking place and an additional response received via email on 25/10/20, the responses from YW are summarised below:

- Foul water domestic waste can discharge to the 375 mm diameter public combined sewer recorded crossing the site.
- No objection to the site discharging surface water at a maximum rate of 3.5 l/s through a 75 mm orifice to the 300 mm public surface water sewer.
- There is a 375 mm diameter public combined water sewer recorded crossing the site. No buildings, or other obstructions, are to be erected within 3 (three) metres, nor trees planted within 5 (five) metres of this public sewer. It may not be acceptable to raise or lower ground levels over the sewer, nor to restrict access to the manholes on the sewer.
- There is a 300 mm diameter public surface water sewer recorded close to the site. No buildings, or other obstructions, are to be erected within 3 (three) metres, nor trees planted within 5 (five) metres of this public sewer. It may not be acceptable to raise or lower ground levels over the sewer, nor to restrict access to the manholes on the sewer.

8.2 The Environment Agency (EA)

8.2.1 The EA were consulted via email on 01/09/20 in relation to obtaining flood information.

8.2.2 A response was received via email on 19/10/20, attaching two documents to the email. These were the 'Planning advice for developers – FAQs' and 'The Flood Map for Planning' document.

8.2.3 The EA also stated that there is no detailed modelling study applicable to this site. Hence, there are no products 5, 6, 7 and 8 to be provided.

8.3 The Lead Local Flood Authority (LLFA)

8.3.1 The ERYC LLFA were consulted on 09/09/2020 in relation to whether the development site was in an area with 'critical drainage problems' and the proposed means of surface water disposal, a response was received the same day and is summarised below:

- The LLFA are not aware of any 'critical drainage problems' in the area.
- Disposal of surface water to the Beck at a restricted discharge rate of 3.5 litres per second would be acceptable if disposal via infiltration is proven not to be practicable.

9. Climate Change

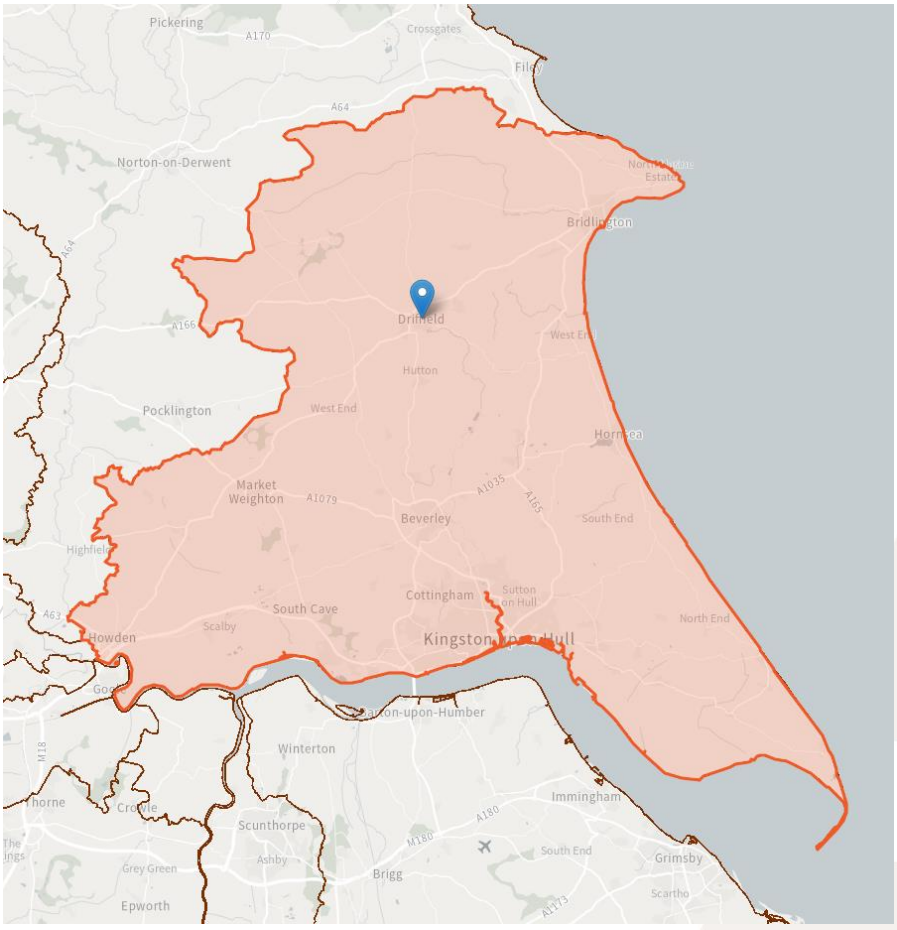
9.1 Climate Change

9.1.1 Based on the site characteristics and NPPF guidance climate change allowances should be added for the following sources:

- Peak river flows.
- Peak rainfall intensities.

9.1.2 Climate change allowances should generally be based on the vulnerability classification and design life of the development.

9.1.3 Using the NPPF climate change guidance Tables 1 to 4 [12] the following allowances would apply for a 'More Vulnerable' development with a 100-year Design Life for a site in the Humber River Basin District in FZ2;



Hull and East Riding Management Catchment peak river flow allowances

	Central	Higher	Upper
2020s	9%	15%	33%
2050s	9%	17%	37%
2080s	20%	33%	66%

- Peak river flows –central – '2080s' 2061 to 2125 epoch - 20% allowance.

Hull and East Riding Management Catchment peak rainfall allowances

3.3% annual exceedance rainfall event

Epoch	Central allowance	Upper end allowance
2050s	20%	35%
2070s	25%	35%

1% annual exceedance rainfall event

Epoch	Central allowance	Upper end allowance
2050s	20%	40%
2070s	25%	40%

*Use '2050s' for development with a lifetime up 2060 and use the 2070s epoch for development with a lifetime between 2061 and 2125.

- Peak rainfall intensities –upper end allowances – '2070s' 2061 to 2125 – 1% AEP 40% allowance.

9.1.4 Where modelling is not being undertaken within this assessment and is provided by third parties without the application of climate change, a practical approach will need to be found to consider the impact of climate change. Given the SFRA does not directly address climate change and this SsFRA is based on flood modelling data provided by the EA. The above climate change allowances, with the exception of peak rainfall intensities, cannot be retrospectively applied to peak river flows, sea levels, offshore wind speed and extreme wave height and storm surge model inputs in this assessment.

9.1.5 Climate change allowances for peak rainfall intensities should be taken into consideration in the Surface Water Management section later in this report.

10. Sequential Test

10.1 Sequential Test

10.1.1 Paragraph 158 of the NPPF requires a sequential approach be applied to steer new development to areas with the lowest risk of flooding.

10.1.2 Unless the site has been allocated for development in the Local Plan, any development in; FZ1 which is at risk of flooding from other sources of flooding or has critical drainage problems; FZ2; or FZ3 are required to pass the sequential test in order to be deemed suitable for development by the LPA.

10.1.3 The applicant made a Pre-Application Planning Enquiry to the ERYC and a response was received on 15/07/2020. The response confirmed:

'the site forms part of a wider mixed-use allocation under Policy DRFL. Paragraph 162 of the NPPF states that proposals on sites allocated in development plans, applicant's need not apply the Sequential Test. Though the site is a mixed-use allocation, the Policy accompanying the allocation does not place any restriction on where the more or less vulnerable uses should be relocated in relation to flood risk. The allocation as a whole has been deemed acceptable for residential development.'

10.1.4 On the basis of the above response, there is no requirement to provide evidence to satisfy the LPA that the sequential test has been passed.

10.2 Sequential Approach on site

10.2.1 Generally, the development proposals identified earlier in this report have applied a sequential approach to locating development within the development site boundary.

10.2.2 The proposed site layout seeks to located both the pedestrian and vehicular access point as well as the proposed dwellings as far to the south-west of the site as practically possible and therefore as far away from the mapped flood zone extents.

11. Wastewater Management

11.1 Surface water

11.1.1 The disposal of surface water runoff from the development will be assessed against the disposal hierarchy outlined in Approved Document H of the Building Regulations (ADH) [13] and the SuDs Manual [14] which is that:

'surface water shall be disposed of to one of the following, listed in order of priority:

- *an adequate soakaway or some other adequate infiltration system; or, when that is not reasonably practicable,*
- *a watercourse: or, when that is not reasonably practicable,*
- *a sewer.'*

Soakaway or other infiltration system

11.1.2 As identified earlier in this report, the site has previously been utilised as a gas storage facility. The applicant has advised that, prior to their purchase of the site, a scheme of remediation was undertaken following the decommissioning of the previous use.

11.1.3 However, whilst remediation has been undertaken, due to contamination risks associated with the previous use the use of infiltration features has been prohibited as a means of surface water disposal on the site. This has been confirmed in the geo-environmental report.

Watercourse

11.1.4 The north-eastern boundary of the development site is formed by the Driffield Beck, further details and mapping are included earlier in this report.

11.1.5 The beck is a riparian watercourse and is classed as an Ordinary Watercourse.

11.1.6 The beck has masonry walls forming the embankments as can be seen in the photo in Figure 11.1b below which was provided by the applicant.

Discharge to sewer

11.1.7 The sewer asset mapping provided earlier in this report identified twin 300mm diameter surface water sewers running under Cranwell Road to the north-west of the development site.

11.1.8 A consultation with YW has confirmed that, due to the twin 300mm diameter sewers discharging into the beck at the north-western corner of the site a discharge into the sewer, at a restricted rate of 3.5 litres per second would be acceptable. This is on the basis the connection would be at the downstream end of their sewer system and it would prevent the need to create another outfall in the Beck in close proximity to their outfall.

11.1.9 The picture in Figure 11.1b below shows the location of the twin 300mm diameter sewers discharging into the beck complete with flap valves on the outlets.

Figure 11.1b – Photo showing the Driffield Beck & existing YW twin outfalls.

Summary

11.1.10 The preferred means of surface water disposal from the site is a disposal to the beck via one of the twin 300mm diameter surface water sewers located under Cranwell Road. YW have confirmed adequate capacity within the sewer based on a maximum discharge rate of 3.5 litres per second for storm events up to and including 1 in 100 years plus climate change.

11.1.11 The LLFA have confirmed the same discharge rate to be acceptable for a discharge directly into the beck.

11.1.12 The use of the existing 300mm diameter sewer eliminates the need to form another outfall in close proximity to the existing sewer outfalls and also prevents the need to disturb the masonry structure forming the beck embankments.

11.1.13 A discharge to ground by way of infiltration features is not a practicable solution given the risks associated with contamination from the previous use of the development site.

The preferred solution in more detail (SuDs)

Designing for water Quality

11.1.14 The sources of surface water runoff from the development are summarised below along with their pollution hazard level taken from the SuDs Manual Table 4.3, refer to the extract below:

- Dwelling; runoff from the dwelling roof is classed as Very Low risk
- Carparking area; runoff from the carparking area is classed as Low risk.

TABLE 4.3 Minimum water quality management requirements for discharges to receiving surface waters and groundwater

Land use	Pollution hazard level	Requirements for discharge to surface waters, including coasts and estuaries[2]	Requirements for discharge to groundwater
Residential roofs	Very low	Removal of gross solids and sediments only	
Individual property driveways, roofs (excluding residential), residential car parks, low traffic roads (eg cul de sacs, home zones, general access roads), non-residential car parking with infrequent change (eg schools, offices)	Low	Simple index approach[3] *Note: extra measures may be required for discharges to protected resources[1]*	

Figure 11.1c - Showing an extract from The SuDs Manual, Table 4.3.

11.1.15 The SuDs Manual identifies protected groundwater resources as those being in SPZ1. The Desk study discussed earlier in this report, confirmed that the site is not within a SPZ.

11.1.16 Therefore, based on Table 4.3 the following water quality management requirements are required:

- Residential roofs; removal of gross solids and sediments only.
- Carparking; Simple index approach.

11.1.17 The simple index approach requires that, for areas not classed as protected resources; the allocation of suitable pollution hazard indices for the proposed land use; and select SuDs with a total pollution mitigation index that equals or exceeds the pollution hazard index.

11.1.18 Table 26.2 of the SuDs Manual (refer to the extract in Figure 11.1d, below) provides pollution hazard indices for different land use classifications, for this development these are summarised below:

- Residential roofs; Total suspended solids 0.2; Metals 0.2; and Hydrocarbons 0.05.
- Carparking areas; Total suspended solids 0.5; Metals 0.4; and Hydrocarbons 0.4.

TABLE 26.2 Pollution hazard indices for different land use classifications

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydro-carbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/ industrial roofs)	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4

Figure 11.1d - Showing an extract from The SuDs Manual, Table 26.2.

11.1.19 It is proposed to utilise a Type C (lined) permeable paving system for the entrance and carparking areas as part of the development. In addition, roof water from the dwellings will be taken into the permeable paving sub-base to make use of the attenuation potential within the pavement.

11.1.20 Permeable pavements provide treatment of runoff by way of; sedimentation; filtration; adsorption; biodegradation; and volatilisation. They provide high potential for the treatment of; total suspended solids; heavy metals; nutrients; bacteria; and fine suspended sediments and dissolved pollutants.

11.1.21 Table 26.4 of the SuDs Manual (refer to the extract in Figure 11.1e, below) provides indicative mitigation indices for discharges to surface water, these are summarised below for the proposed SuDs techniques:

- Permeable paving; TSS 0.7; Metals 0.6; Hydrocarbons 0.7.

TABLE 26.3 Indicative SuDS mitigation indices for discharges to surface waters

	Mitigation indices[1]		
Type of SuDS component	**TSS**	**Metals**	**Hydrocarbons**
Filter strip	0.4	0.4	0.5
Filter drain	0.4[2]	0.4	0.4
Swale	0.5	0.6	0.6
Bioretention system	0.8	0.8	0.8
Permeable pavement	0.7	0.6	0.7
Detention basin	0.5	0.5	0.6
Pond[4]	0.7[3]	0.7	0.5
Wetland	0.8[3]	0.8	0.8
Proprietary treatment systems[5,6]	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		

Figure 11.1e - Showing an extract from The SuDs Manual, Table 26.3.

11.1.22 In addition to the above standard SuDs components, where runoff from the dwelling roofs enters the permeable paving sub-base it is proposed to provide pre-treatment for sediment removal to ensure the performance of the pavement does not deteriorate over time due to siltation. The pre-treatment components can take the form of a proprietary silt trap, suitable for maintaining by hand.

11.1.23 On the basis of the above Simple Index Approach the proposed SuDs techniques provide mitigation indices greater than the pollution hazard indices and therefore the proposed SuDs techniques are considered satisfactory from a Water Quality perspective.

Designing for Water Quantity

11.1.24 As outlined above, it is proposed to provide the following SuDS features in the development:

- Lined, Type C, permeable paving system to the entrance and carpark areas, collected via fin drain or diffuser.
- Piped discharge from dwelling roofs into the permeable paving sub-base via proprietary silt trap.
- Flow control chamber.

11.1.25 Permeable pavements are an effective means of source control, they provide detention and infiltration potential and a means of interception storage by preventing the first 5mm of runoff from leaving the feature.

11.1.26 It is proposed to provide all attenuation for the development within the permeable paving sub-base.

11.1.27 The proposed SuDs systems will be designed to adequately dispose of surface water runoff from the respective sources for a range of storms, varying in duration from 15 to 10080 minutes, for return periods of up to and including 100 years plus climate change. The climate change requirements applicable to rainfall intensities calculated earlier in this report require a 40% allowance to applied to storm events with a return period of 1/100 years. An additional allowance of 10% has been included to cater for the creep of impermeable areas under permitted development, known as Urban Creep.

11.1.28 The impermeable areas for the development, as outlined earlier in this report, are:

- Dwellings = 325m^2
- Front carparking and paving area = 500m^2

11.1.29 A practical discharge rate of 3.5 litres per second has been agreed with YW and the LLFA for the public surface water sewer and the Beck, respectively.

11.1.30 Based on the above, hydraulic calculations have been undertaken using the Innovyze MicroDrainage 2019.1 Source Control module, a copy of the hydraulic calculations can be found in Appendix B, the results are summarised below:

- 1/2yr RP = critical storm 60min summer, 5.7m^3, 0.042m Deep, half drain 15mins.
- 1/30yr RP = critical storm 60min summer, 15.4m^3, 0.114m Deep, half drain 53mins.
- 1/100yr RP + 40% cc = critical storm 120min winter, 37.4m^3, 0.277m Deep, half drain 101mins.

11.1.31 In addition to designing the SuDs features to attenuate runoff for storm events with return periods of up to 1/100 years plus climate change, consideration of exceedance events must also be made. In order to ensure that flooding of the development does not occur as a result of exceedance events, system failure or blockage suitably designed external levels and system overflows should be provided within the SuDs features to direct exceedance flows away from the proposed dwellings and towards the beck where overland flows would have existed prior to the development.

11.1.32 On the basis of the above, this assessment has demonstrated that appropriate solutions for water quantity design for both the Design and Exceedance events can be provided.

Designing for amenity and biodiversity

11.1.33 In the context of this SsFRA designing for amenity and biodiversity are not essential requirements for addressing flood risk nor are they fundamental to ensuring that a suitable means of surface water disposal can be provided for the proposed development. Therefore, the following section will identify some relevant amenity and biodiversity design criteria that can be considered by the applicants and the designers undertaking the detailed design of the surface water drainage for the development.

11.1.34 Amenity and biodiversity design criteria taken from Sections 5 and 6 of the SuDs Manual are outlined below:

- Amenity; Maximise multi-functionality; Enhance visual character; Deliver safe surface water management systems; Support development resilience / adaptability to future change; and Maximise legibility.
- Biodiversity; support and protect natural local habitat and species; contribute to the delivery or local biodiversity objectives; contribute to habitat connectivity; and create diverse, self-sustaining and resilient ecosystems.

11.1.35 The use of SuDs features enables the opportunity for integration with landscape and planting design which, at detailed design stage, could maximise the opportunity to achieve a number of the above design criteria. It is advised that the design team that progresses the detailed design beyond planning stage integrate the drainage and landscape design together with the applicant's requirements for amenity and biodiversity to maximise the potential that the SuDs features can offer.

Operation and maintenance

11.1.36 The operation and maintenance of the system will be the responsibility of the applicant, a management company and any future occupiers or owners of the properties.

11.1.37 Any drainage components utilised in the detailed design of the proposed scheme must be suitable for achieving the Design Life of the development, in this instance being 100 years.

11.1.38 The maintenance of the SuDs components specified in this assessment have been taken from the SuDs Manual [15] and are provided below.

Maintenance schedule	Required action	Frequency
Regular maintenance	Brushing and vacuuming.	Three times/year at end of winter, mid-summer, after autumn leaf fall, or as required based on site-specific observations of clogging or manufacturers' recommendations.
Occasional maintenance	Stabilise and mow contributing and adjacent areas.	As required.
	Removal of weed.	As required.
Remedial actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving.	As required.
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users.	As required.
	Rehabilitation of surface and upper sub-structure.	As required (if infiltration performance is reduced as a result of significant clogging).
Monitoring	Initial inspection.	Monthly for three months after installation
	Inspect for evidence of poor operation and/or weed growth. If required take remedial action.	3-monthly, 48 h after large storms.
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually.
	Monitor inspection chambers.	Annually.

Operation and maintenance requirements for the permeable pavements

11.2 Foul water

11.2.1 The disposal of foul water runoff from the development will be assessed against the disposal hierarchy outlined in Part H1 of Approved Document H of the Building Regulations which is that:

'An adequate system of drainage shall be provided to carry foul water appliances within the building to one of the following, listed in order of priority:

- *a public sewer; or, where that is not reasonably practicable,*
- *a private sewer communicating with a public sewer; or, where that is not reasonably practicable,*
- *either a septic tank which has an appropriate form of secondary treatment or another wastewater treatment system; or, where that is not reasonably practicable,*
- *a cesspool.'*

11.2.2 In addition, whilst Government and EA requirements do not give preference to either option, the ERYC Guidance taken from their 'Foul drainage assessment form' confirms that the LA give preference to the use of a package treatment plants over the use of a septic tanks given these treat sewerage to a higher standard.

11.2.3 Furthermore, in the event non-mains drainage cannot be utilised assessment of alternative means of disposal to one of the following sources should be assessed prior to the option of a cesspool being considered:

- *the ground; or,*
- *a surface water.*

Public Sewer

11.2.4 The Government guidance requires that, for the construction of dwellings, the site should be assessed to determine if a discharge to public sewer is feasible. If a public sewer exists within a distance from the proposed development of 30 metres multiplied by the number of proposed dwellings, then a discharge to ground or a surface water may not be permitted.

11.2.5 In the context of this site this would require a public sewer to be within 210 metres (7 x 30 metres) of the site.

11.2.6 YW asset maps obtained for the area and discussed earlier in this report confirm that there is a combined water public sewer crossing the site. In addition, YW have confirmed that there is adequate capacity for the development in their consultation response.

11.2.7 The applicant has also confirmed that the depth of the existing combined water sewer is sufficiently deep enough to enable a gravity discharge from the development site to be made.

Summary

11.2.8 On the basis of the above, the preferred solution for the disposal of the foul water from the development is via a connection to the existing combined water sewer.

The preferred solution in more detail

11.2.9 Discharge to foul water sewer surrounding the site will take the form of a piped discharge from the dwellings, by way of private foul water drains of 100mm diameter where serving no more than 10 dwellings and 150mm diameter where serving more than 10 dwellings. Drains should be laid at minimum gradients required to comply with ADH, generally no flatter than 1 in 40 serving a single dwelling and no flatter than 1 in 80 thereafter.

11.2.10 In accordance with ADH the foul water system should run separately to the surface water system to at least the edge of the development site.

Operation and maintenance of the system

11.2.11 The responsibility for the operation and maintenance of the foul water drainage system will be with the applicant, a management company and any future occupiers or owners of the respective dwellings.

11.2.12 Individual dwelling occupiers should adhere to local water authority guidelines when disposing effluent into the foul water system to minimise the risk of blockages and pollution. In addition, occupiers should undertake routine monitoring and inspection of their systems to ensure that they are working correctly.

11.2.13 Individual dwelling occupiers may need to have the drainage systems cleaned and have blockages removed depending on what is found during inspection routines. It is considered good practice to have foul water systems jetted on a semi-regular basis to ensure the build-up of solids does not impact on the long-term performance of the system.

12. Inherent risk

12.1 Assessment of risks

12.1.1 The NPPF requires Inherent Flood Risk to be assessed within the context of Design Storm Events for different sources of flooding.

12.1.2 The Design Storm Events are listed as follows:

- Tidal (the sea) – 1 in 200-year event (0.5% chance of occurring in any given year).
- Fluvial (rivers) – 1 in 100-year event (1% chance of occurring in any given year).
- Pluvial (surface water) – 1 in 100-year event (1% chance of occurring in any given year).

12.1.3 The EA 'check the long-term flood risk' website, extracts of which have already been provided earlier in this report, provides an assessment of flood risk from various sources and takes flood defences into account. In terms of the design storm events the flood risk from various sources associated with the proposed development site is summarised below:

- Tidal (the sea) – the proposed development is not at risk from direct tidal flooding.
- Fluvial (rivers) - the north-eastern side of the development site is shown to be at risk of flooding from the Driffield Beck, the flooding is categorised as Medium risk with a chance of flooding of between 1 and 3.3% each year (between 1/100 and 1/30).
- Pluvial (surface water) – the development site is in an area shown as having a Very Low risk, that is with a chance of flooding of less than 0.1% each year (less than 1/1000).
- Reservoirs – the development site is in an area shown not to be at risk of flooding from reservoirs.

12.1.4 In addition, the LA SFRA interactive mapping has been assessed earlier in this report and confirms the following:

- That part of the site lies within the Future Flood Zone 3a category, which is intended to represent the potential impact of climate change on the extents of Flood Zone 3a. This broadly follows the extent of Flood Zone 2 on the Flood Map for Planning and the Medium risk fluvial flooding on the EA Long-term flood risk mapping.
- Ground water – The site is in an area that is susceptible to groundwater flooding being in the >= 75% category.
- The site is not in an area shown to have been affected by historic flooding.

12.1.5 In relation to fluvial flood risk associated with the development site, all sources of mapping appear consistent and generally show flooding associated with the Driffield Beck to run parallel with and extend out from the beck. The mapping indicates this to be consistent both upstream and downstream of the development site. The consistent, narrow band of flooding suggests that generally the areas surrounding the beck slope down towards the beck, the limited flood corridor and close proximity between FZ2 and 3a also suggests a relatively steep catchment corridor.

12.1.6 However, the LIDAR data presented earlier in this report does not reflect the flooding indicated on the flood mapping. The development site and adjacent sites that have been

developed previously appear to be higher than adjacent highways which suggests that levels in these areas may have been raised historically.

12.1.7 Generally, levels along public highways around the beck are significantly lower than both the development site, the adjacent Medical Centre carpark and the development site to the north-east over the beck.

12.1.8 LIDAR levels along Cranwell Road and Cranwell Street at the beck are circa 15.3mAOD and along Exchange Street over the beck (culverted) are approximately 15.6mAOD. Whereas site levels appear to be approximately; 16.5mAOD on the proposed development site; varying from 16.2 up to 16.7mAOD on the proposed Medical Centre carpark; between 18 and 19mAOD on the development site to the north-east over the beck.

12.1.9 This would suggest the only practical means of obtaining an approximate flood level for the fluvial flooding is to base this on the flood mapping extents and the LIDAR levels for the public highways which are unlikely to have been altered significantly since the fluvial flood mapping was produced.

12.1.10 On the basis of the above, the levels along Cranwell Road along the north-western boundary of the site vary between 15.3 and 16.1mAOD along the site boundary. The flood mapping extents show the FZ2 and Medium Risk flooding to extend approximately halfway along the north-western boundary of the development site, the level along Cranwell Road being approximately 15.7mAOD at this location.

12.1.11 Average site levels on the development site are approximately 16.6mAOD which is 0.90m higher than estimated flood level of 15.7mAOD.

12.1.12 In respect of surface water flooding, the development site is not shown to be at risk of flooding for Design Events. However, the adjacent highway network is; Cranwell Road shows High and Medium risk flooding occurring along the north-western boundary of the site, depths and velocities associated with this flooding are up to 900mm deep and over 0.25 metres per second and over 900mm deep and over 0.25 metres per second respectively.

12.1.13 Whilst the site is shown to be in an area at risk from ground water flooding, risks associated with this type of flooding are generally less of a concern than other forms of flooding. This is due to ground water flooding occurring gradually and being, generally, shallow in depth with low velocities. The risks associated with fluvial and surface water flooding present greater hazards and any mitigation measures applied to mitigate these sources of flooding will likely provide adequate protection from the risks associated with ground water flooding.

12.2 Making the development safe

Ground floor levels (GFLs)

12.2.1 The EA standing advice for vulnerable development confirms that GFLs should be a minimum of whichever is the higher of:

- 300 mm above the general ground level of the site; or,
- 600mm above the estimated river or sea flood level

12.2.2 The ERYC's SFRA states that the GFL should be raised 300mm and 600mm above the higher of average road frontage level, average site level or flood level for FZs 2 and 3, respectively.

12.2.3 Given the above assessment it is not considered practicable to raise the proposed GFLs of the dwellings significantly above the existing average site level. It has been demonstrated that the

site levels may have already been raised previously, and in addition, any further raising may have significant impacts on adjacent properties and general aesthetics associated with the development.

12.2.4 A GFL of 16.90mAOD would be 300mm above the existing average site level of 16.6mAOD (ignoring the local rise towards the bridge over the beck). This represents a practical solution given the site-specific constraints and, in comparison to other relevant parameters, is:

- 1.2m above the estimated flood level and Cranwell Road average frontage level of 15.7mAOD;
- 0.5 metres above the average road frontage level of the private access road to the south-west boundary of the site and 0.3 metres above the high point along this road (south-east end).

12.2.5 It is felt that the above approach presents a practical solution to GFLs given the site-specific constraints and also provides a robust defence against flooding given the estimated flood level and discrepancies between the flood mapping and LIDAR level data.

12.2.6 In respect of climate change, the climate change requirements for the development site have been calculated earlier in this report. However, it is not possible to accurately apply fluvial climate change increases without building a hydraulic model of the Beck which is not considered appropriate for the scale of the proposed development.

12.2.7 Furthermore, the impact of climate change on fluvial flooding has been applied in the ERYC SFRA by using FZ2 as a proxy. This has demonstrated a nominal impact in relation to this development site and would be mitigated by the proposed GFL of the dwellings being 1.2 metres above the estimated flood level.

12.2.8 It should also be noted that, as identified earlier in this report, a sequential approach to development within the development site has been adopted and the proposed dwellings and vehicular access and parking arrangements have been located as far south-west as possible away from FZs 2 and 3 and towards FZ1 were the standing advice is far less onerous.

Extra flood resistance and flood resilience

12.2.9 Given the above assessment and that the proposed GFLs are significantly higher than adjacent road levels, it is not considered necessary to provide extra flood resistance or resilience measures.

Occupants and users of the development

12.2.10 The pre-development site comprises a derelict parcel of land and a former gas storage facility prior to that. Therefore, the proposed development will result in a greater number of occupants and users for longer periods of time then the existing site.

12.2.11 The proposed development will provide living accommodation, comprising a total of 7 residential units each providing 4 bedrooms, therefore a total of 28 bedrooms will be provided by the development.

12.2.12 In addition, general visitors to the properties associated with normal domestic use would be expected.

12.2.13 Dwellings will likely be occupied both during the day and night as would be expected from normal residential use.

Access and egress

12.2.14 Safe access and egress to the development should be provided during Inherent Flood Risk conditions for the lifetime of the development. In addition, safe access for Emergency Vehicles should be provided where possible, preferably above design flood water levels although shallow flood water depths may be acceptable dependant on velocity.

12.2.15 Given the above assessment of the inherent flood risks there is the potential for surface water flooding to occur along Cranwell Road during design storm events. Both High and Medium risk flooding is predicted with depths of over 900mm at the beck and less than 300mm deep at the opposite end at the western corner of the development site where the proposed vehicular access will be located.

12.2.16 As would be expected, the depth of flooding is less the more frequent the flood event, however in the context of the Design Events it is likely that Cranwell Road will experience some surface water flooding during design storm events.

12.2.17 It is not possible to accurately predict exact depths of flooding, however from the mapping it is expected this be up to 600mm deep across the front half of the site where the proposed means of pedestrian and vehicular access will be taken off Cranwell Road.

12.2.18 Given the significant level differences between the existing site and Cranwell Road it is expected that a ramp will be needed at the site entrance to provide access up to existing site levels. This should prevent any surface water flooding associated with Cranwell Road from spilling on to the development.

12.2.19 It is recommended that vehicular and pedestrian access to the site be taken off the private access road running along the south-western boundary of the site instead of Cranwell Road as the private access road is not predicted to be at risk of surface water flooding for Design events.

12.2.20 If access cannot be taken from the private access road then it is advised that access off Cranwell Road be located as far south-west as possible where predicted flood depths and velocities are at their lowest. In addition, a secondary means of pedestrian access and egress should be provided to the southern corner of the site and the south-eastern end of the private access road, to enable safe pedestrian access and egress during inherent risk scenarios.

Compensatory Storage

12.2.21 ERYC's SFRA standing advice requires compensatory storage to be assessed against the 1% AEP Flood Level with an allowance for climate change.

12.2.22 However, based on the above assessment of inherent flood risk and that the proposed development is unlikely to displace flood water for Design Events when compared to the existing derelict parcel of land, an assessment of compensatory storage in not considered necessary.

Flood risk off-site

12.2.23 The proposed surface water management strategy for the site will be designed for a return period of 1/100 years with a 10% allowance for urban creep and a 40% allowance for climate change. This solution ensures that under Design Storm Events, the potential runoff from the impermeable areas of the development will be confined to the proposed drainage system. This ensures that runoff from the development is directed off-site to the beck in a controlled

manner and reduces the risk to the surrounding area from overland flow resulting from ground saturation during extreme or heavy rainfall.

12.2.24 The post development site should offer increased protection in terms of the risk associated with runoff from the site. The pre-development site would not have offered the same standard of protection given the current stone surface would likely become saturated during heavy rainfall events.

12.2.25 On the basis of the above the proposed development should not increase flood risk off-site.

Reduce the causes and impacts of flooding

12.2.26 The development is small-scale and is therefore limited in its ability to influence the wider causes and impacts of flooding.

12.2.27 At site level the development has demonstrated that the surface water management proposals will provide a nominal reduction in the risk of overland flow from the site for storm events up to and including the 1 in 100 years plus climate change.

13. Residual risk

13.1 What risks still exist after mitigation

13.1.1 The nature of the inherent risks associated with flood risk in the area means it is not possible to fully mitigate the inherent flood risks associated with the development.

13.1.2 The following residual risks still apply to the development after the introduction of the mitigation measures included in the above section to mitigate the inherent risks of flooding:

- A severe flood event resulting in the capacity of watercourses being exceeded.
- Extreme rainfall resulting in saturation of the ground and increased overland flow across the site.
- Exceedance of the Design Storm event by means of extreme rainfall resulting in the inundation of drainage systems.
- Failure of gates and pumps serving the catchment in which the development is located.
- A blockage or failure of surface water drainage systems.

13.2 Assessment of risks

13.2.1 In respect of residual fluvial flood risk, the EA have been consulted but have confirmed that there is no detailed modelling available for the area. Therefore, it would not be possible to accurately assess the impacts of residual risk flooding associated with the Beck without undertaking detailed watercourse modelling. Given the scale of the development this is not considered practicable.

13.2.2 It may be possible that residual fluvial flooding may result in Cranwell Road, and the site entrance if located off Cranwell Road, being flooded.

13.2.3 In respect of residual surface water flood risk, the mapping provided earlier in this report confirms that the site is in an area designated as Very Low risk, being less than 0.1% or 1/1000. However, Cranwell Road and the private access road to the south-western boundary of the site are both shown to be at risk.

13.2.4 Cranwell Road is shown to have varying depths of surface water flooding from less than 300mm deep at the south-western end to over 900mm at the north-eastern end adjacent to the beck, velocities of low risk flooding are shown to be >0.25 metres per second along the full length of Cranwell Road. The private access road is shown to have lesser depths and velocities ranging from less than 300mm deep and <0.25 metres per second at the south-eastern end up to 900mm deep and >0.25 metres per second at the north-western end at the junction with Cranwell Road.

13.2.5 Whilst the site is shown to be in an area at risk from ground water flooding, risks associated with this type of flooding are generally less of a concern than other forms of flooding. This is due to ground water flooding occurring gradually and being, generally, shallow in depth with low velocities. The risks associated with fluvial and surface water flooding present greater hazards and any mitigation measures applied to mitigate these sources of flooding will likely provide adequate protection from the risks associated with ground water flooding.

Place of safety

13.2.6 The provision of a place of safety should:

- Be freely accessible to everyone within the property.
- Provide an external access point for evacuation.
- Be suitable to provide sufficient space for all occupants of the property during a flood event. This should be designed to accommodate the anticipated number of occupants within the property.

13.2.7 The proposed development comprises of 3-storey townhouses and as such provides living accommodation at first and second floor levels, based on the recommended GFL defined earlier in this report and a floor to floor height of 2.6 metres, first and second floor levels should be 19.5m and 22.1mAOD respectively.

13.2.8 All first-floor bedrooms should have an external window that provides a suitable means of escape in an emergency situation.

Access and egress

13.2.9 Based on the above residual flood risk assessment it is likely that both Cranwell Road and the private access road will experience residual risk flooding from surface water sources and possibly from fluvial sources.

13.2.10 It is not possible to accurately predict exact depths of flooding, however from the mapping it is expected this could vary up to 900mm across the front half of the site where the proposed means of pedestrian and vehicular access will be taken off Cranwell Road, although the extents of this flooding suggest this may be less deep given further flooding of both the site and more roads would occur if depths in this location where 900mm.

13.2.11 As identified in the inherent risk section, given that a ramp will be needed at the site entrance to provide access up to existing site levels, this should limit the surface water flooding associated with Cranwell Road from spilling on to the development site.

13.2.12 However, given the potential high depths and velocities associated with residual flood risk along Cranwell Road and the junction with the private access road, it is recommended that vehicular and pedestrian access to the site be taken off the private access road running along the south-western boundary of the site. This access should be located as far south-east as possible where depths and velocities are at their lowest.

13.2.13 The applicant has advised that emergency access could be provided on to Exchange Street via the private access road which would limit the potential residual surface water flood depths encountered to less than 300mm.

13.2.14 The link to Exchange Street has been removed due to traffic issues however it may be possible to alter this to provide a permanent pedestrian link to Exchange street which would provide a route from the site which generally is at a lower risk of flooding.

13.2.15 It should be noted that general velocities along Exchange Street and other public highways in the area are greater than 0.25 metres per second. It is therefore assumed that strategic and regional emergency evacuation procedures would be appropriate for the area given the proposed development would be within a town centre where other similar developments exist and thus the development does not create a unique requirement for emergency evacuation.

13.3 Mitigation and management

13.3.1 However unlikely flooding of the development site may be due to the residual risks, these risks still have to be managed appropriately.

13.3.2 In order to manage the above residual risks the following recommendations should be adhered to:

- The applicants must produce a Flood Warning and Evacuation Plan for the property, this should include:
    - Procedures for all occupants of the property to follow should flooding occur.
    - Procedures for safe access and egress for the emergency services.
    - Details of the Environment Agency Flood Warning Service.
    - The plan should be in a format that can be passed on to future owners and occupiers of the development to make them aware of any specific flood risk measures and early warning systems.
- The applicants, and occupiers of the property, should also prepare a Personal Flood Plan to help mitigate the impact of potential flooding.
- Further links to assist with the production of a Flood Warning and Evacuation Plan and a Personal Flood Plan are provided below as follows:
    - Government guidance on preparing a personal flood plan [16], https://www.gov.uk/government/publications/personal-flood-plan
- All occupants of the building should be signed up to the Environment Agency Flood Warning Service, if available [17], https://www.gov.uk/sign-up-for-flood-warnings.
- The following websites can be used to monitor flood warnings:
    - GOV.UK Flood Warnings for England [18], https://flood-warning-information.service.gov.uk/warnings
    - Flood alerts Facebook page [19], https://www.facebook.com/FloodAlerts
    - Environment Agency Facebook page [20], https://www.facebook.com/environmentagency

14. Exception Test

14.3.1 The requirement for the development to pass the Exception Test will be assessed against the proposed location of the dwellings and the EA Flood Map for planning which shows the dwelling's location to be within FZs 1 and 2.

14.3.2 The NPPF Flood Risk and Coastal Change PPGC Table 3: Flood risk vulnerability and flood zone 'compatibility' confirms that the flood vulnerability classification of the development, being 'More Vulnerable' is acceptable for FZ1 and FZ2 and that there is no requirement for an Exception Test to be undertaken.

14.3.3 It should be noted that this SsFRA report demonstrates that the development can be made safe for the duration of the design life, and as such, satisfies the requirement of Part 2 of the Exception Test.

Flood Zones	Flood Vulnerability Classifications				
	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water-compatible
Zone 1	✔	✔	✔	✔	✔
Zone 2	✔	Exception Test Reqd.	✔	✔	✔
Zone 3a†	Exception Test Reqd. †	✘	Exception Test Reqd.	✔	✔
Zone 3b*	Exception Test Reqd.*	✘	✘	✘	✔*

Notes:

- This table does not show the application of the Sequential Test which should be applied first to guide development to Flood Zone 1, then Zone 2, and then Zone 3; nor does it reflect the need to avoid flood risk from sources other than rivers and the sea;
- The Sequential and Exception Tests do not need to be applied to minor developments and changes of use, except for a change of use to a caravan, camping or chalet site, or to a mobile home or park home site;
- Some developments may contain different elements of vulnerability and the highest vulnerability category should be used unless the development is considered in its component parts.
- † In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.
- " * " In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:
    - remain operational and safe for users in times of flood;
    - result in no net loss of floodplain storage;
    - not impede water flows and not increase flood risk elsewhere.

15. Conclusions and recommendations

15.1 Conclusion

15.1.1 This SsFRA has been undertaken and this report produced in order to assess the risk of flooding to the proposed development from various sources and assess the flood risk from the development off site.

15.1.2 This report provides a detailed assessment of the development site, the development proposals and the wider study area in relation to flood risk and wastewater management. It confirms:

- The proposed development site lies with the town of Driffield in East Yorkshire.
- The existing site is a derelict parcel of land surfaced with stone. The development site was formerly a gas storage facility and has since been remediated.
- The development site area is approximately 0.15 hectares.
- The north-eastern boundary of the development site runs along the Driffield Beck, a riparian Ordinary Watercourse.
- LIDAR surface data has confirmed the general existing site level is 16.6mAOD and average road frontage levels along Cranwell Road and the private access road are 15.7m and 16.4mAOD respectively.
- The proposed development comprises a residential development of 8, 3-storey, 2 and 3 bedroomed townhouses, with a flood risk vulnerability classification of 'More Vulnerable' and a Design Life of 100 years.
- Other than the Driffield Beck, there are no other watercourses within the vicinity of the development site.
- A review of the geological mapping for the area has concluded that the superficial geology of the site comprises either Till, Devensian or Glaciofluvial deposits of sand and gravel over the Flamborough Chalk Formation bedrock.
- The development site has undergone a scheme of remediation following its previous gas storage facility use. However, the remediation undertaken does not permit the use of infiltration features for the disposal of wastewater from the development site due to contamination risks.
- The EA Magic Map confirms the site is not in a Designated Sensitive Area or within a Source Protection Zone.
- There are existing public sewers present in the vicinity of the site; a combined sewer runs across the development site whilst twin surface water sewers run adjacent to the site under Cranwell Road.

15.1.3 Flood mapping has been obtained from various sources including the EA and the LA SFRA. The development site is shown to be in an area:

- Within Flood Zones 1, 2 and 3.
- Not at risk from direct tidal flooding.

- With a Medium and High risk from fluvial flooding.
- With a very low risk from surface water flooding.
- Not at risk of reservoir flooding.
- With >=75% risk of ground water flooding.
- Not affected by historic flooding.
- To partially benefit from the EA Flood Alert service.

15.1.4 Consultations have been undertaken with YW, the EA and LLFA, in relation to flood information, and whether a surface water discharge to watercourse would be acceptable, responses were received as follows:

- YW have confirmed surface water can discharge to their surface water sewer under Cranwell Road at a restricted discharge rate of 3.5 litres per second and foul water can discharge to their combined water sewer crossing the development site.
- The LLFA have confirmed that a discharge rate of 3.5 litres per second would be acceptable into the Driffield Beck from the proposed development site.

15.1.5 The climate change requirements associated with the proposed development site have been assessed.

15.1.6 The report confirms that the requirement for the proposed development to pass the sequential test should not apply.

15.1.7 The report assesses the options for the disposal of wastewater from the proposed development. It concludes that, based on the information available, the preferred means of disposal for; surface water is to surface water sewer running under Cranwell Road at a restricted discharge rate of 3.5 litres per second; and foul water is to the combined water sewer crossing the development site.

15.1.8 The report confirms that adequate means of dealing with surface water quality and quantity have been provided in accordance with the SuDs Manual along with maintenance requirements for the proposed SuDs features.

15.1.9 The inherent flood risks associated with the development site have been assessed and are summarised below:

- Whilst the site is shown to be at risk of inherent fluvial flooding, discrepancies between the flood mapping and LIDAR surface data have been identified.
- The development site and adjacent sites may have had levels raised sometime in the past after the fluvial flood maps where produced.
- On the basis of the above, the development site is not thought to be at risk from inherent fluvial flooding, but Cranwell Road will be.
- The development site is in an area shown to have a Very Low surface water flood risk and therefore is not at risk from inherent surface water flooding. However, Cranwell Road is shown to be at risk of flooding from inherent surface water flooding.
- Average site levels of approximately 16.6mAOD are significantly higher than average road frontage levels of 15.7mAOD and 16.1mAOD adjacent to the development site.

- A practical ground floor level for the proposed dwellings has been recommended at 16.9mAOD.
- Extra flood resistance or flood resilience measures are not recommended.
- Occupiers and users of the development will increase from the current derelict site use to levels expected from residential development.
- An alternative location for the site access off the south-eastern end of the private access road along the south-western site boundary has been recommended.
- A secondary means of pedestrian access and egress should be provided to the southern corner of the site and the south-eastern end of the private access road.
- The report confirms that the requirement to provide compensatory flood storage does not apply to the proposed development.
- The report confirms that the proposed development should not increase flood risk off site and due to the development site being small scale it is limited in its ability to reduce the causes and impacts of flooding. Although the development should provide a nominal improvement to the standard of protection offered from the site in terms of surface water runoff.

15.1.10 The report identifies the potential sources of Residual Flood Risk associated with the development.

15.1.11 The report confirms that the likelihood of the development site being affected by residual flood risk is low. However, the report identifies that the road network surrounding the site is identified as being at risk from residual surface water flooding.

15.1.12 The report confirms that the proposed development comprises of 3-storey townhouses providing accommodation on ground, first and second floor levels. Thus, by virtue of the development each dwelling will have access to first and second floors which will provide a place for safe refuge should residual flood risk result in flooding of the ground floor.

15.1.13 The report also recommends:

- that vehicular and pedestrian access to the site be taken off the private access road running along the south-western boundary of the site. This access should be located as far south-east as possible.
- provide a permanent pedestrian link to Exchange Street with the option of it being opened in emergency situations to provide emergency vehicular access to the site off Exchange Street.

15.1.14 Additional measures have been identified to mitigate and manage these residual risks. These measures include:

- The applicants must produce a Flood Warning and Evacuation Plan for the development.
- The occupants of the properties should also prepare a Personal Flood Plan.
- All occupants of the building should be signed up to the Environment Agency Flood Waring Service(s).

15.1.15 The report confirms that the proposed location of development falls within Flood Zones 1 and 2 on the EA Flood Maps for Planning Website. More Vulnerable residential development is considered appropriate for Flood Zones 1 and 2 and therefore evidence does not have to be provided to demonstrate that the Exception Test has been passed.

15.2 Recommendations

15.2.1 Following the conclusions of this report the following actions have been recommended:

- This report should accompany other documentation and be submitted to the Local Planning Authority for planning approval.
- Once planning approval has been obtained, the mitigation measures, summarised above and referred to in more detail earlier in this report, should be incorporated into the proposed development design by suitably qualified persons and implemented as part of the proposed works. All works should be in accordance with any other relevant standards and guidance, i.e. such a The Building Regulations 2010.
- The architectural drawings should be amended to reflect the mitigation measures in this report, where necessary.
- A detailed design for the disposal of foul and surface water drainage for the development should be undertaken by a suitably qualified engineer. It should be based on the principles outlined in this report and the above additional information.
- The pre-planning enquiry submitted to Yorkshire Water should be refreshed to ensure agreement to the proposed means of surface and foul water disposal are still acceptable to Yorkshire Water.
- Subject to the above, a formal Section 106 application should be made to Yorkshire Water for the proposed foul and surface water sewer connections prior to the works being undertaken.
- The site layout should be amended to ensure that the easements associated with the existing public sewers, identified by Yorkshire Water in their consultation response, are adhered to by the proposed development.
- The applicants must produce:
    - A Flood Warning and Evacuation Plan for the property
    - A Personal Flood Plan

  Further details and other sources of information to assist with these actions are provided in the relevant section of this report.
- The applicants and any users or occupiers of the development should be signed up to the Environment Agency Flood Warning Service(s) for the area.

  Further details and other sources of information to assist with this action are provided in the relevant section of this report.

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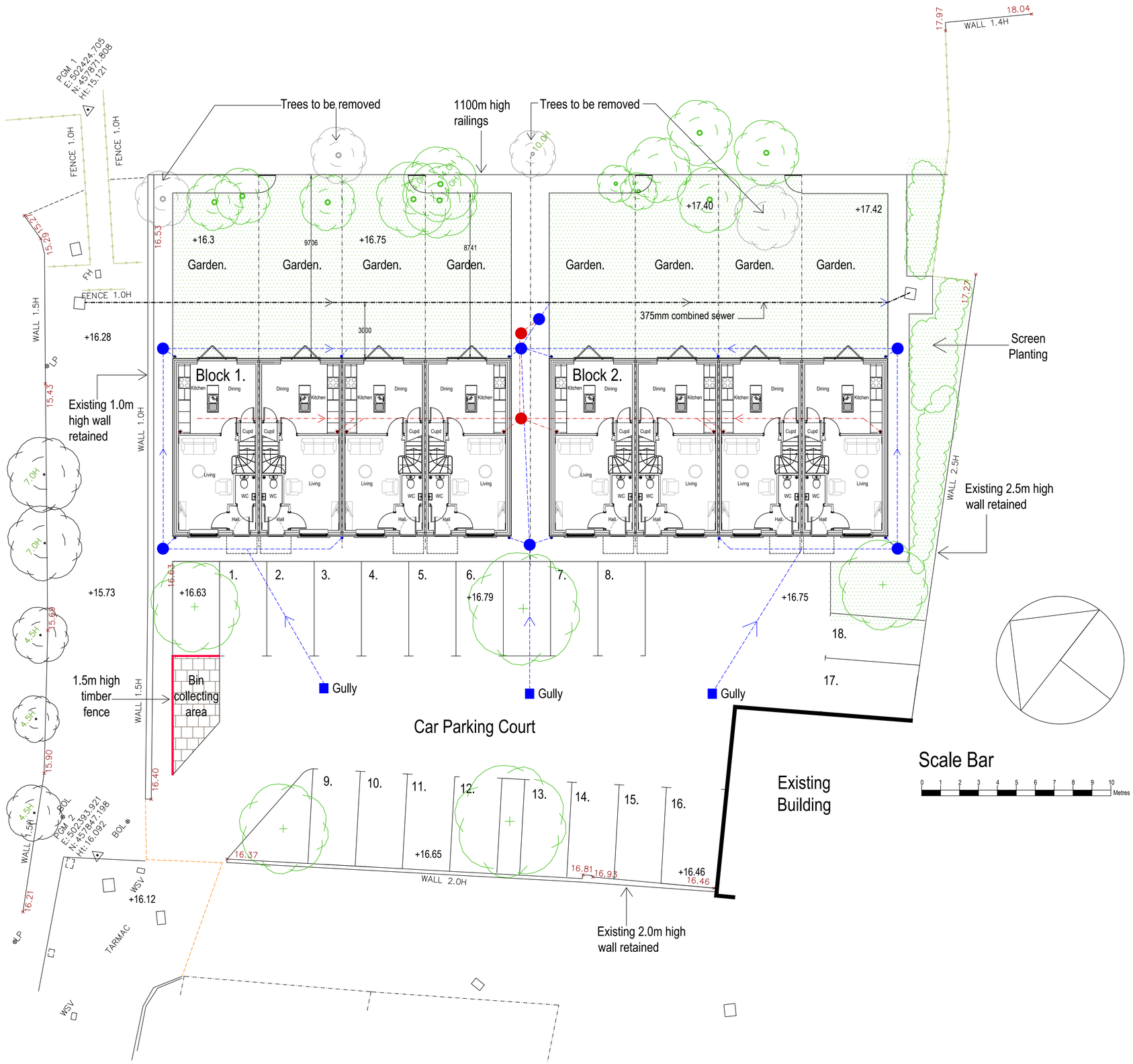
(20) Environment Agency, [Facebook page], https://www.facebook.com/environmentagency, accessed 23 October 2020.

Appendix A

Piercy Design drawings



A		
	Date	Revisions

piercy design

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Client
ZB Services Ltd

Job Title
Proposed Residential Development on land east of Cranwell Road, Driffield

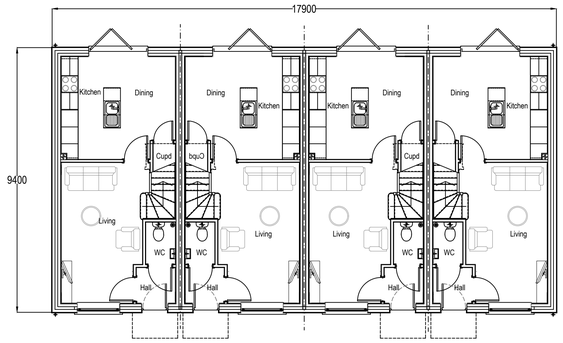
Drawing Title
Proposed Site Layout Plan

Status
Planning

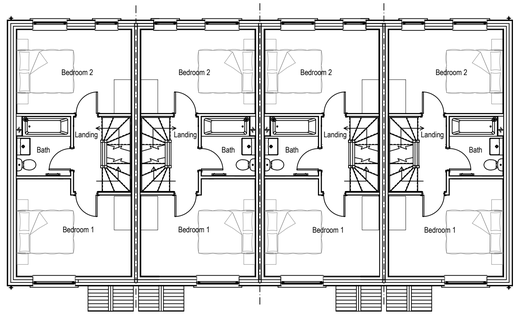
Date	Scale
Aug 2022	1:100 @ A1

Drawn	Checked	Approved
HP		

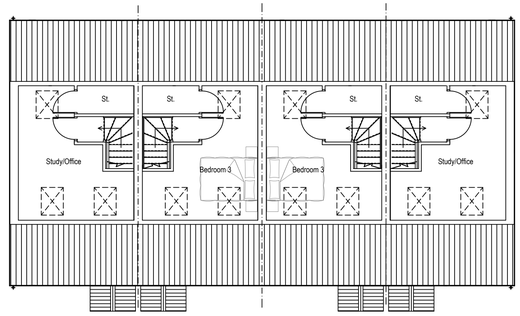
Drg No.	Rev.
2022-01/S01	



Proposed Ground Floor Plans

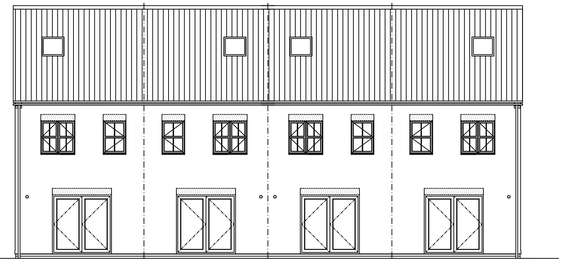


Proposed First Floor Plans

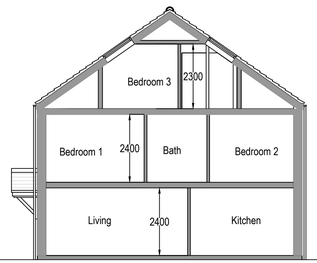


Proposed Second Floor Plans

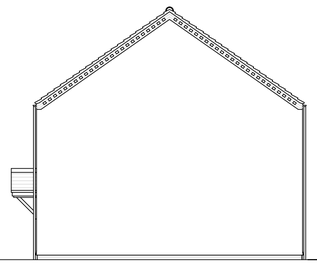
Proposed Front Elevation



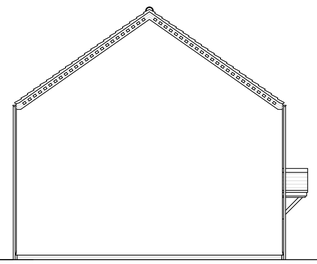
Proposed Rear Elevation



Proposed Side Elevation



Proposed Side Elevation



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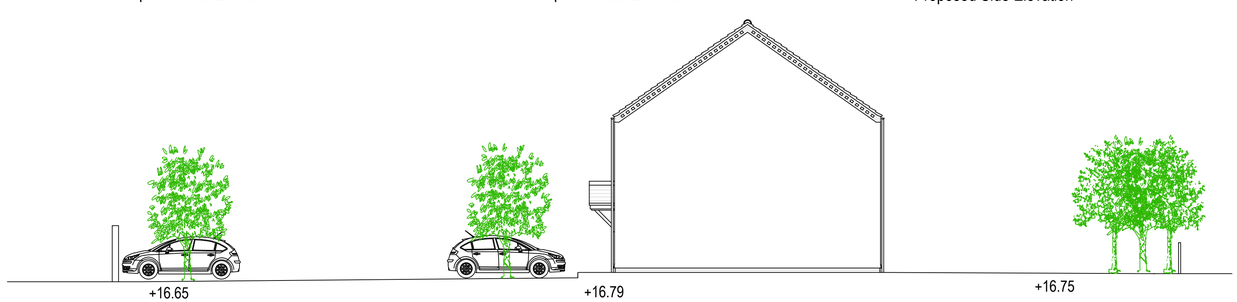

Proposed Site Section

Scale Bar
0 1 2 3 4 5 6 7 8 9 10
Metres

A		
	Date	Revisions

piercy design

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Client
ZB Services Ltd

Job Title
Proposed Residential Development on land east of Cranwell Road, Driffield

Drawing Title
Proposed Plans and Elevations - Blocks 1 & 2 and Proposed Site Section

Status
Planning

Date	Scale
Aug 2022	1:100 @ A1

Drawn	Checked	Approved
HP		

Drg No.	Rev.
2022-01/P01	

Appendix B

Surface Water MicroDrainage Source Control Calculations

Summary of Results for 2 year Return Period

Half Drain Time : 15 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	16.181	0.031	0.0	3.1	3.1	4.1	O K
30 min Summer	16.189	0.039	0.0	3.1	3.1	5.3	O K
60 min Summer	16.192	0.042	0.0	3.1	3.1	5.7	O K
120 min Summer	16.186	0.036	0.0	3.1	3.1	4.9	O K
180 min Summer	16.179	0.029	0.0	3.1	3.1	3.9	O K
240 min Summer	16.171	0.021	0.0	3.1	3.1	2.9	O K
360 min Summer	16.160	0.010	0.0	3.1	3.1	1.3	O K
480 min Summer	16.153	0.003	0.0	3.1	3.1	0.4	O K
600 min Summer	16.150	0.000	0.0	3.0	3.0	0.0	O K
720 min Summer	16.150	0.000	0.0	2.7	2.7	0.0	O K
960 min Summer	16.150	0.000	0.0	2.2	2.2	0.0	O K
1440 min Summer	16.150	0.000	0.0	1.6	1.6	0.0	O K
2160 min Summer	16.150	0.000	0.0	1.2	1.2	0.0	O K
2880 min Summer	16.150	0.000	0.0	1.0	1.0	0.0	O K
4320 min Summer	16.150	0.000	0.0	0.7	0.7	0.0	O K
5760 min Summer	16.150	0.000	0.0	0.6	0.6	0.0	O K
7200 min Summer	16.150	0.000	0.0	0.5	0.5	0.0	O K
8640 min Summer	16.150	0.000	0.0	0.4	0.4	0.0	O K
10080 min Summer	16.150	0.000	0.0	0.4	0.4	0.0	O K
15 min Winter	16.181	0.031	0.0	3.1	3.1	4.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	35.972	0.0	5.9	16
30 min Summer	23.792	0.0	8.5	25
60 min Summer	15.183	0.0	11.3	42
120 min Summer	9.500	0.0	14.9	76
180 min Summer	7.186	0.0	17.1	108
240 min Summer	5.887	0.0	18.9	140
360 min Summer	4.431	0.0	21.5	198
480 min Summer	3.615	0.0	23.6	252
600 min Summer	3.087	0.0	25.3	0
720 min Summer	2.712	0.0	26.7	0
960 min Summer	2.212	0.0	29.1	0
1440 min Summer	1.660	0.0	32.6	0
2160 min Summer	1.245	0.0	36.5	0
2880 min Summer	1.015	0.0	39.4	0
4320 min Summer	0.761	0.0	43.6	0
5760 min Summer	0.621	0.0	46.6	0
7200 min Summer	0.530	0.0	48.9	0
8640 min Summer	0.466	0.0	50.7	0
10080 min Summer	0.417	0.0	52.1	0
15 min Winter	35.972	0.0	5.9	16

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	16.189	0.039	0.0	3.1	3.1	5.2	O K
60 min Winter	16.189	0.039	0.0	3.1	3.1	5.2	O K
120 min Winter	16.178	0.028	0.0	3.1	3.1	3.8	O K
180 min Winter	16.166	0.016	0.0	3.1	3.1	2.2	O K
240 min Winter	16.156	0.006	0.0	3.1	3.1	0.9	O K
360 min Winter	16.150	0.000	0.0	2.8	2.8	0.0	O K
480 min Winter	16.150	0.000	0.0	2.3	2.3	0.0	O K
600 min Winter	16.150	0.000	0.0	2.0	2.0	0.0	O K
720 min Winter	16.150	0.000	0.0	1.7	1.7	0.0	O K
960 min Winter	16.150	0.000	0.0	1.4	1.4	0.0	O K
1440 min Winter	16.150	0.000	0.0	1.0	1.0	0.0	O K
2160 min Winter	16.150	0.000	0.0	0.8	0.8	0.0	O K
2880 min Winter	16.150	0.000	0.0	0.6	0.6	0.0	O K
4320 min Winter	16.150	0.000	0.0	0.5	0.5	0.0	O K
5760 min Winter	16.150	0.000	0.0	0.4	0.4	0.0	O K
7200 min Winter	16.150	0.000	0.0	0.3	0.3	0.0	O K
8640 min Winter	16.150	0.000	0.0	0.3	0.3	0.0	O K
10080 min Winter	16.150	0.000	0.0	0.3	0.3	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	23.792	0.0	8.6	26
60 min Winter	15.183	0.0	11.5	46
120 min Winter	9.500	0.0	15.1	80
180 min Winter	7.186	0.0	17.2	112
240 min Winter	5.887	0.0	18.9	140
360 min Winter	4.431	0.0	21.6	0
480 min Winter	3.615	0.0	23.6	0
600 min Winter	3.087	0.0	25.3	0
720 min Winter	2.712	0.0	26.7	0
960 min Winter	2.212	0.0	29.1	0
1440 min Winter	1.660	0.0	32.7	0
2160 min Winter	1.245	0.0	36.5	0
2880 min Winter	1.015	0.0	39.4	0
4320 min Winter	0.761	0.0	43.6	0
5760 min Winter	0.621	0.0	46.7	0
7200 min Winter	0.530	0.0	49.0	0
8640 min Winter	0.466	0.0	50.8	0
10080 min Winter	0.417	0.0	52.3	0

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	2	Cv (Summer)	1.000
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	18.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.091

Time (mins) From:	To:	Area (ha)
0	4	0.091

Model Details

Storage is Online Cover Level (m) 16.600

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	15.0
Membrane Percolation (mm/hr)	1000	Length (m)	30.0
Max Percolation (l/s)	125.0	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	16.150	Membrane Depth (m)	0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0086-3500-1200-3500
Design Head (m)	1.200
Design Flow (l/s)	3.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	86
Invert Level (m)	15.250
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	3.5
Flush-Flo™	0.367	3.5
Kick-Flo®	0.746	2.8
Mean Flow over Head Range	-	3.1

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	2.6	1.200	3.5	3.000	5.4	7.000	8.0
0.200	3.3	1.400	3.8	3.500	5.8	7.500	8.3
0.300	3.5	1.600	4.0	4.000	6.1	8.000	8.5
0.400	3.5	1.800	4.2	4.500	6.5	8.500	8.8
0.500	3.4	2.000	4.4	5.000	6.8	9.000	9.0
0.600	3.3	2.200	4.6	5.500	7.1	9.500	9.2
0.800	2.9	2.400	4.8	6.000	7.4		
1.000	3.2	2.600	5.0	6.500	7.7		

Summary of Results for 30 year Return Period

Half Drain Time : 53 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control Σ (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	16.232	0.082	0.0	3.2	3.2	11.1	O K
30 min Summer	16.254	0.104	0.0	3.2	3.2	14.0	O K
60 min Summer	16.264	0.114	0.0	3.2	3.2	15.4	O K
120 min Summer	16.262	0.112	0.0	3.2	3.2	15.1	O K
180 min Summer	16.254	0.104	0.0	3.2	3.2	14.0	O K
240 min Summer	16.244	0.094	0.0	3.2	3.2	12.7	O K
360 min Summer	16.225	0.075	0.0	3.2	3.2	10.1	O K
480 min Summer	16.207	0.057	0.0	3.2	3.2	7.6	O K
600 min Summer	16.191	0.041	0.0	3.1	3.1	5.6	O K
720 min Summer	16.178	0.028	0.0	3.1	3.1	3.8	O K
960 min Summer	16.160	0.010	0.0	3.1	3.1	1.4	O K
1440 min Summer	16.150	0.000	0.0	2.8	2.8	0.0	O K
2160 min Summer	16.150	0.000	0.0	2.1	2.1	0.0	O K
2880 min Summer	16.150	0.000	0.0	1.6	1.6	0.0	O K
4320 min Summer	16.150	0.000	0.0	1.2	1.2	0.0	O K
5760 min Summer	16.150	0.000	0.0	1.0	1.0	0.0	O K
7200 min Summer	16.150	0.000	0.0	0.8	0.8	0.0	O K
8640 min Summer	16.150	0.000	0.0	0.7	0.7	0.0	O K
10080 min Summer	16.150	0.000	0.0	0.6	0.6	0.0	O K
15 min Winter	16.231	0.081	0.0	3.2	3.2	10.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	68.069	0.0	13.2	17
30 min Summer	45.321	0.0	18.3	31
60 min Summer	28.921	0.0	23.9	50
120 min Summer	17.925	0.0	30.2	84
180 min Summer	13.401	0.0	34.2	118
240 min Summer	10.848	0.0	36.9	154
360 min Summer	8.028	0.0	41.1	218
480 min Summer	6.481	0.0	44.5	282
600 min Summer	5.486	0.0	47.1	342
720 min Summer	4.786	0.0	49.4	398
960 min Summer	3.856	0.0	52.9	510
1440 min Summer	2.840	0.0	58.4	0
2160 min Summer	2.088	0.0	64.1	0
2880 min Summer	1.678	0.0	68.3	0
4320 min Summer	1.231	0.0	74.3	0
5760 min Summer	0.987	0.0	78.6	0
7200 min Summer	0.832	0.0	81.8	0
8640 min Summer	0.723	0.0	84.4	0
10080 min Summer	0.643	0.0	86.5	0
15 min Winter	68.069	0.0	13.1	17

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	16.254	0.104	0.0	3.2	3.2	14.1	O K
60 min Winter	16.264	0.114	0.0	3.2	3.2	15.4	O K
120 min Winter	16.258	0.108	0.0	3.2	3.2	14.6	O K
180 min Winter	16.244	0.094	0.0	3.2	3.2	12.7	O K
240 min Winter	16.228	0.078	0.0	3.2	3.2	10.6	O K
360 min Winter	16.199	0.049	0.0	3.1	3.1	6.6	O K
480 min Winter	16.175	0.025	0.0	3.1	3.1	3.4	O K
600 min Winter	16.158	0.008	0.0	3.1	3.1	1.1	O K
720 min Winter	16.150	0.000	0.0	3.0	3.0	0.0	O K
960 min Winter	16.150	0.000	0.0	2.4	2.4	0.0	O K
1440 min Winter	16.150	0.000	0.0	1.8	1.8	0.0	O K
2160 min Winter	16.150	0.000	0.0	1.3	1.3	0.0	O K
2880 min Winter	16.150	0.000	0.0	1.1	1.1	0.0	O K
4320 min Winter	16.150	0.000	0.0	0.8	0.8	0.0	O K
5760 min Winter	16.150	0.000	0.0	0.6	0.6	0.0	O K
7200 min Winter	16.150	0.000	0.0	0.5	0.5	0.0	O K
8640 min Winter	16.150	0.000	0.0	0.4	0.4	0.0	O K
10080 min Winter	16.150	0.000	0.0	0.4	0.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	45.321	0.0	18.3	30
60 min Winter	28.921	0.0	23.9	54
120 min Winter	17.925	0.0	30.0	90
180 min Winter	13.401	0.0	34.0	128
240 min Winter	10.848	0.0	37.1	162
360 min Winter	8.028	0.0	41.3	228
480 min Winter	6.481	0.0	44.4	286
600 min Winter	5.486	0.0	47.0	336
720 min Winter	4.786	0.0	49.3	0
960 min Winter	3.856	0.0	53.0	0
1440 min Winter	2.840	0.0	58.4	0
2160 min Winter	2.088	0.0	64.1	0
2880 min Winter	1.678	0.0	68.3	0
4320 min Winter	1.231	0.0	74.4	0
5760 min Winter	0.987	0.0	78.6	0
7200 min Winter	0.832	0.0	81.9	0
8640 min Winter	0.723	0.0	84.5	0
10080 min Winter	0.643	0.0	86.7	0

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	1.000
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	18.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.091

Time (mins) From:	To:	Area (ha)
0	4	0.091

Model Details

Storage is Online Cover Level (m) 16.600

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	15.0
Membrane Percolation (mm/hr)	1000	Length (m)	30.0
Max Percolation (l/s)	125.0	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	16.150	Membrane Depth (m)	0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0086-3500-1200-3500
Design Head (m)	1.200
Design Flow (l/s)	3.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	86
Invert Level (m)	15.250
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	3.5
Flush-Flo™	0.367	3.5
Kick-Flo®	0.746	2.8
Mean Flow over Head Range	-	3.1

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	2.6	1.200	3.5	3.000	5.4	7.000	8.0
0.200	3.3	1.400	3.8	3.500	5.8	7.500	8.3
0.300	3.5	1.600	4.0	4.000	6.1	8.000	8.5
0.400	3.5	1.800	4.2	4.500	6.5	8.500	8.8
0.500	3.4	2.000	4.4	5.000	6.8	9.000	9.0
0.600	3.3	2.200	4.6	5.500	7.1	9.500	9.2
0.800	2.9	2.400	4.8	6.000	7.4		
1.000	3.2	2.600	5.0	6.500	7.7		

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

Half Drain Time : 101 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	16.321	0.171	0.0	3.3	3.3	23.1	Flood Risk
30 min Summer	16.373	0.223	0.0	3.4	3.4	30.1	Flood Risk
60 min Summer	16.413	0.263	0.0	3.4	3.4	35.6	Flood Risk
120 min Summer	16.425	0.275	0.0	3.5	3.5	37.1	Flood Risk
180 min Summer	16.417	0.267	0.0	3.5	3.5	36.1	Flood Risk
240 min Summer	16.407	0.257	0.0	3.4	3.4	34.7	Flood Risk
360 min Summer	16.385	0.235	0.0	3.4	3.4	31.7	Flood Risk
480 min Summer	16.363	0.213	0.0	3.4	3.4	28.7	Flood Risk
600 min Summer	16.341	0.191	0.0	3.3	3.3	25.8	Flood Risk
720 min Summer	16.320	0.170	0.0	3.3	3.3	22.9	Flood Risk
960 min Summer	16.281	0.131	0.0	3.3	3.3	17.6	O K
1440 min Summer	16.219	0.069	0.0	3.2	3.2	9.3	O K
2160 min Summer	16.165	0.015	0.0	3.1	3.1	2.0	O K
2880 min Summer	16.150	0.000	0.0	2.9	2.9	0.0	O K
4320 min Summer	16.150	0.000	0.0	2.1	2.1	0.0	O K
5760 min Summer	16.150	0.000	0.0	1.7	1.7	0.0	O K
7200 min Summer	16.150	0.000	0.0	1.4	1.4	0.0	O K
8640 min Summer	16.150	0.000	0.0	1.2	1.2	0.0	O K
10080 min Summer	16.150	0.000	0.0	1.1	1.1	0.0	O K
15 min Winter	16.321	0.171	0.0	3.3	3.3	23.1	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	123.193	0.0	25.7	18
30 min Summer	82.833	0.0	35.3	32
60 min Summer	53.188	0.0	46.2	60
120 min Summer	32.997	0.0	57.8	102
180 min Summer	24.597	0.0	64.6	134
240 min Summer	19.830	0.0	69.7	168
360 min Summer	14.573	0.0	77.0	236
480 min Summer	11.712	0.0	82.5	304
600 min Summer	9.877	0.0	87.1	372
720 min Summer	8.589	0.0	90.7	436
960 min Summer	6.883	0.0	97.0	562
1440 min Summer	5.028	0.0	106.3	796
2160 min Summer	3.665	0.0	115.8	1128
2880 min Summer	2.925	0.0	122.8	0
4320 min Summer	2.125	0.0	132.9	0
5760 min Summer	1.691	0.0	140.1	0
7200 min Summer	1.416	0.0	145.6	0
8640 min Summer	1.225	0.0	150.2	0
10080 min Summer	1.085	0.0	154.1	0
15 min Winter	123.193	0.0	25.7	18

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	16.374	0.224	0.0	3.4	3.4	30.3	Flood Risk
60 min Winter	16.416	0.266	0.0	3.5	3.5	35.9	Flood Risk
120 min Winter	16.427	0.277	0.0	3.5	3.5	37.4	Flood Risk
180 min Winter	16.416	0.266	0.0	3.5	3.5	35.9	Flood Risk
240 min Winter	16.401	0.251	0.0	3.4	3.4	33.9	Flood Risk
360 min Winter	16.367	0.217	0.0	3.4	3.4	29.3	Flood Risk
480 min Winter	16.332	0.182	0.0	3.3	3.3	24.6	Flood Risk
600 min Winter	16.299	0.149	0.0	3.3	3.3	20.2	O K
720 min Winter	16.269	0.119	0.0	3.2	3.2	16.1	O K
960 min Winter	16.217	0.067	0.0	3.2	3.2	9.0	O K
1440 min Winter	16.153	0.003	0.0	3.1	3.1	0.4	O K
2160 min Winter	16.150	0.000	0.0	2.3	2.3	0.0	O K
2880 min Winter	16.150	0.000	0.0	1.9	1.9	0.0	O K
4320 min Winter	16.150	0.000	0.0	1.3	1.3	0.0	O K
5760 min Winter	16.150	0.000	0.0	1.1	1.1	0.0	O K
7200 min Winter	16.150	0.000	0.0	0.9	0.9	0.0	O K
8640 min Winter	16.150	0.000	0.0	0.8	0.8	0.0	O K
10080 min Winter	16.150	0.000	0.0	0.7	0.7	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	82.833	0.0	35.3	32
60 min Winter	53.188	0.0	46.1	60
120 min Winter	32.997	0.0	57.6	112
180 min Winter	24.597	0.0	64.7	140
240 min Winter	19.830	0.0	69.6	180
360 min Winter	14.573	0.0	76.8	254
480 min Winter	11.712	0.0	82.6	324
600 min Winter	9.877	0.0	87.1	392
720 min Winter	8.589	0.0	90.7	458
960 min Winter	6.883	0.0	97.1	578
1440 min Winter	5.028	0.0	106.2	764
2160 min Winter	3.665	0.0	115.8	0
2880 min Winter	2.925	0.0	122.8	0
4320 min Winter	2.125	0.0	132.9	0
5760 min Winter	1.691	0.0	140.1	0
7200 min Winter	1.416	0.0	145.7	0
8640 min Winter	1.225	0.0	150.3	0
10080 min Winter	1.085	0.0	154.2	0

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	1.000
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	18.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.091

Time (mins) From:	To:	Area (ha)
0	4	0.091

Model Details

Storage is Online Cover Level (m) 16.600

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	15.0
Membrane Percolation (mm/hr)	1000	Length (m)	30.0
Max Percolation (l/s)	125.0	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	16.150	Membrane Depth (m)	0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0086-3500-1200-3500
Design Head (m)	1.200
Design Flow (l/s)	3.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	86
Invert Level (m)	15.250
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	3.5
Flush-Flo™	0.367	3.5
Kick-Flo®	0.746	2.8
Mean Flow over Head Range	-	3.1

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	2.6	1.200	3.5	3.000	5.4	7.000	8.0
0.200	3.3	1.400	3.8	3.500	5.8	7.500	8.3
0.300	3.5	1.600	4.0	4.000	6.1	8.000	8.5
0.400	3.5	1.800	4.2	4.500	6.5	8.500	8.8
0.500	3.4	2.000	4.4	5.000	6.8	9.000	9.0
0.600	3.3	2.200	4.6	5.500	7.1	9.500	9.2
0.800	2.9	2.400	4.8	6.000	7.4		
1.000	3.2	2.600	5.0	6.500	7.7		

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