



NPPF: Flood Risk Assessment

Land off Henthorn Road, Clitheroe

Gladman Developments Ltd

SHF.1132.159.HY.R.001.A



Contact Details:

Samuel House
1st Floor
5 Fox Valley Way
Stockbridge
Sheffield
S36 2AA

tel: 0114 321 5151
www: enzygo.com

Land off Henthorn Road, Clitheroe

Project:	NPPF: Flood Risk Assessment
For:	Gladman Developments Ltd
Status:	Draft for Client Comment
Date:	July 2018
Author:	Ian Hopkinson BSc (Hons), MSc, MCIWEM - Consultant Hydrologist
Reviewer:	Daniel Alstead BSc (Hons), MSc, MCIWEM. C.WEM - Principal Hydrologist
Approver:	Paul Hardwick BSc (Hons), PhD, FGS - Director of Water Sciences

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Enzygo Limited Registered in England No. 6525159

Registered Office Stag House Chipping Wotton-Under-Edge Gloucestershire GL12 7AD

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Executive Summary

This report presents an FRA in accordance with the NPPF and NPPG ID: 7 guidance, for a proposed residential development, located on land off Henthorn Road, Clitheroe.

The FRA has demonstrated the following:

- The Site is 5.20ha, which comprises an agricultural field.
- The risk of flooding is assessed as followed:
 - The risk of fluvial flooding is assessed as negligible.
 - The risk of surface water flooding is assessed as mostly negligible with areas at high risk within the eastern part and along the south-eastern boundary of the Site.
 - The risk of groundwater flooding is assessed as mostly negligible with the southern part of the Site at low risk.
 - The risk of flooding from all other sources is negligible.
- Surface water, groundwater, and residual flood risk from Drain 1/culvert surcharging can be mitigated to a negligible level through the following approach:
 - Sequentially develop the Site, limiting the built development outside the mapped extent of surface water flow pathways.
 - Set finished floor levels above external levels.
 - Adoption of a surface water management strategy.
 - No below surface buildings (i.e. basements)
 - Provide an easement free from development either side of Drain 1.
 - Introduction of a bund feature on the right bank of Drain 1 at the Henthorn Road culvert to prevent floodwater that backs-up at the culvert from flooding the Site.
 - Undertake maintenance to keep Drain 1 and the Henthorn Road culvert free from debris and overgrown vegetation.

The proposed residential development is classified as 'more vulnerable', which is considered acceptable in Flood Zone 1. As such, the Sequential Test will be passed, and the Exception Test would not be required.

The FRA has considered the potential impact of the development on surface water runoff rates, given the increase in impermeable areas post-development. It has been demonstrated that surface water can be managed, such that flood risk to and from the Site following development will not increase. This will be achieved through restricted discharge rates (using complex controls) and an appropriately sized detention basin, with outfall to watercourse.

The FRA demonstrates the proposed development would be operated with minimal risk from flooding and would not increase flood risk elsewhere. The development should therefore not be precluded on the grounds of flood risk and surface water drainage.

1.0 Introduction

1.1 Background

- 1.1.1 Enzygo Ltd was commissioned by Gladman Developments Ltd to carry out a site-specific Flood Risk Assessment (FRA) including a surface water drainage strategy in support of an outline planning application for a proposed residential development, located on land north-west off Henthorn Road, Clitheroe (hereafter referred to as 'the Site').
- 1.1.2 The proposal is for up to 110 residential dwellings with associated landscaping, open spaces and vehicle access from Henthorn Road.
- 1.1.3 Planning applications for development in England require an FRA¹, when:
- In Flood Zone 2 or 3 including minor development and change of use.
 - More than 1 hectare (ha) in Flood Zone 1.
 - Less than 1 ha in Flood Zone 1, including a change of use in development type to a more vulnerable class (for example from commercial to residential), where they could be affected by sources of flooding other than rivers and the sea (for example surface water, drains, reservoirs).
 - In an area within Flood Zone 1 which has critical drainage problems as notified by the Environment Agency.
- 1.1.4 Environment Agency indicative flood mapping shows that the Site is located within Flood Zone 1 but is more than 1 hectare (ha) in area (5.20ha). As such, an FRA is required.
- 1.1.5 The purpose of this FRA is to provide sufficient flood risk information to demonstrate that the future users of the development remain safe throughout its lifetime, that the development would not increase flood risk on Site and elsewhere and, where practicable, that the development would reduce flood risk overall.

1.2 Scope of the Assessment

- 1.2.1 Government policy on development and flood risk is set out in the National Planning Policy Framework (NPPF)² and the supporting National Planning Practice Guidance: Flood Risk and Coastal Change [NPPG ID7]³.
- 1.2.2 NPPF paragraphs 99-104 set out the need for an appropriate assessment of flood risk at all levels of the planning process and requires the application of a sequential risk-based approach to assess the suitability of land for development in flood risk areas.
- 1.2.3 The FRA should also consider the effects of climate change⁴. The climate change allowances are predictions of anticipated change for:
- Peak river flow by river basin district;
 - Peak rainfall intensity;
 - Sea level rise; and

¹ <https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications>

² Department for Communities and Local Government (2012) National Planning Policy Framework.

³ Department for Communities and Local Government (2014) Planning Practice Guidance ID7-030-20140306; Flood Risk & Coastal Change.

⁴ <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

- Offshore wind speed and extreme wave height.
- 1.2.4 They are based on climate change projections and different scenarios of carbon dioxide emissions to the atmosphere. There are different allowances for different periods of time over the next century.
- 1.2.5 Site-specific FRAs provide an assessment of the flood risk to and from a development site, over its lifetime, to satisfy the requirements of the local planning authority. They are categorised as Level 1 screening studies to give a general indication of the potential flood risk to a site and identify whether more detailed Level 2 scoping assessment is required. A Level 2 assessment is a qualitative appraisal to develop understanding of flood risk to a site and the effects of the site on flooding elsewhere including recommended mitigation measures. Level 2 reporting is the minimum required to accord with the NPPF. Level 3 assessments are more detailed quantitative studies, for example modelling to establish flood levels at a site in the absence of Environment Agency data or providing detailed outline drainage designs.
- 1.2.6 This report is a Level 2 qualitative FRA but includes a Level 3 assessment of the surface water drainage requirements for the proposed development.

1.3 Aims

- 1.3.1 This FRA aims to provide sufficient flood risk information to satisfy the requirements of the NPPF, NPPG ID: 7 and regional/local government plans and policies. It describes the potential for the Site to be impacted by flooding, the impacts of the proposed development on flooding elsewhere near the Site, and the proposed measures that could be incorporated into the development to mitigate the identified risks.

1.4 Planning Context

National Policy

- 1.4.1 The FRA was prepared in accordance with the NPPF and NPPG ID: 7.

Regional/Local Policy

- 1.4.2 The FRA also considers the following Core Strategy 2008 - 2028⁵ policy of the Ribble Valley Borough Council:
- Policy DME6 – Water Management.

1.5 Report Structure

- 1.5.1 This report is structured as follows:
- Section 2 identifies the sources of information that were consulted;
 - Section 3 describes the Site and the existing and proposed development;
 - Section 4 outlines the flood risk to the existing site and proposed development;
 - Section 5 details the proposed mitigation measures against identified flooding sources;
 - Section 6 assesses the potential impacts of the proposed development on surface water drainage and proposes mitigation for those effects; and
 - Section 7 presents a summary and conclusions.

⁵ https://www.ribblevalley.gov.uk/download/downloads/id/10010/adopted_core_strategy.pdf

2.0 Sources of Information

2.1 Sources of Information

2.1.1 The following information was used in preparation of this FRA:

- Ordnance Survey 1:25,000 mapping (Explorer OL41: Forest of Bowland & Ribblesdale).
- Detailed topographic survey (Appendix 1).
- Environment Agency online flood maps (Flood Map for Planning⁶, Long Term Flood Risk Assessment for Locations in England⁷, Operational Catchment data⁸ and Environment Agency – What’s in Your Backyard?⁹).
- River Basin District (RBD) Maps¹⁰ (North West RBD) together with guidance on climate change allowances¹¹.
- National River Flow Archive¹².
- Ribble Valley Borough Council Level 1 Strategic Flood Risk Assessment (SFRA) and associated mapping (Appendix 2).
- River Ribble Catchment Flood Management Plans (CFMP)¹³.
- North West River Basin Management Plan (RBMP)¹⁴.
- National Soils Resources Institute: Soilscape online mapping¹⁵.
- British Geological Survey [BGS] online mapping: Geology of Britain Viewer¹⁶.
- Landmark’s Promap: Flood Data package: Additional flood mapping.
- Geosmart 1 in 100-year groundwater flood risk map.
- United Utilities sewer asset plans (Appendix 3).
- DEFRA’s Magic Map¹⁷ for identifying Designated Sites.
- BHS Chronology of British Hydrological Events.

2.2 Consultation and Discussion with Regulators

2.2.1 Consultation and discussions were undertaken with the Environment Agency, the Local Planning Authority (LPA)/Lead Local Flood Authority (LLFA), and Water Utility Company.

⁶ <https://flood-map-for-planning.service.gov.uk/>

⁷ <https://flood-warning-information.service.gov.uk/long-term-flood-risk/>

⁸ <http://environment.data.gov.uk/catchment-planning/OperationalCatchment/3459>

⁹ http://maps.environment-agency.gov.uk/wiyby/wiybyController?ep=maptopics&lang=_e

¹⁰ <https://www.gov.uk/government/publications/flood-risk-assessments-river-basin-district-maps>

¹¹ <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

¹² <http://nrfa.ceh.ac.uk>

¹³ <https://www.gov.uk/government/publications/river-tees-catchment-flood-management-plan>

¹⁴ <https://www.gov.uk/government/publications/river-basin-management-plan-northumbria-district>

¹⁵ <http://www.landis.org.uk/soilscape/>

¹⁶ <http://mapapps.bgs.ac.uk/geologyofbritain/home.html>

¹⁷ <http://www.natureonthemap.naturalengland.org.uk/>

Environment Agency

- 2.2.2 The Environment Agency is a statutory consultee on flood risk and planning and is directly responsible for the prevention, mitigation and remediation of flood damage for main rivers and coastal areas; and it has a strategic overview for all forms of flooding.
- 2.2.3 Environment Agency Standing Advice¹⁸ and the NPPF/NPPG ID: 7 was consulted and reviewed.
- 2.2.4 Correspondence with the Environment Agency is included in Appendix 4.

Ribble Valley Borough Council

- 2.2.5 Ribble Valley Borough Council as the LLFA responsible for surface water, groundwater and ordinary watercourses was consulted on flood risk issues at this Site. The consultation response is included in Appendix 5.

United Utilities Water Utility Company

- 2.2.6 All Water Companies have a statutory obligation to maintain the DG5 Flood Register of properties which are at risk of flooding from the public sewerage system.
- 2.2.7 United Utilities is responsible for the disposal of wastewater within the area.

2.3 Site Walkover

- 2.3.1 Enzygo staff conducted a walkover of the Site in July 2018. Observations made were used to inform the Site description and technical assessment.

¹⁸ <https://www.gov.uk/guidance/flood-risk-assessment-standing-advice>

3.0 Site Location and Description

3.1 Location

- 3.1.1 The Site is located on land off Henthorn Road, Clitheroe, Lancashire, BB7 2QF and is centred on National Grid Reference (NGR) 372929, 440832.
- 3.1.2 The Site location is shown in Drawing 001 and in more detail in Drawing 002 with the study area enclosing an area of 5.20ha.

3.2 Land Use

- 3.2.1 The Site comprises a single agricultural field bisected by a watercourse in the eastern extent (Figure 3.1).

Figure 3.1: Photograph of the Site



View to south-eastern boundary

- 3.2.2 The Site is bounded by hedgerows on all sides with agricultural land beyond to the north-west, new residential development to the north-east, Henthorn Road and new residential development beyond to the south-east and Siddows Hall to the south-west.
- 3.2.3 The Site is currently accessed from Henthorn Road via the south-east boundary.

3.3 Topographic Information

- 3.3.1 The topographic survey shows the Site slopes from north to south with a depression running through north-south through the eastern corner associated with the watercourse.
- 3.3.2 The Site falls from 66mAOD (located on the north-west boundary) to 53.52mAOD (southern corner). The fall of 12.5m over 260m gives a gradient of approximately 1:21.

3.4 Soils and Geology

- 3.4.1 The Soilsmap online soils map viewer (Figure 3.2) shows that the Site is underlain by slowly permeable, seasonally wet, loamy and clayey soils. The loamy and clayey soils are indicative of low infiltration potential.

Figure 3.2: Soils Mapping



Soils Data © Cranfield University (NSRI) and for the Controller of HMSO [2018].

- 3.4.2 The Geology of Britain online map viewer (Figure 3.3) shows that there are Devensian Till (diamicton) superficial deposits beneath the entire Site. The bedrock is Clitheroe Limestone Formation and Hodder Mudstone Formation (undifferentiated) - mudstone. The superficial and bedrock geology is indicative of mixed infiltration potential with moderate potential for limestone and till, and low for mudstone.

Figure 3.3: Geology Mapping

Left: Superficial deposits. **Right:** Bedrock. Contains British Geological Survey materials © NERC [2018]

3.4.3 The Geology of Britain online map viewer shows no boreholes located within 500m of the Site. The nearest borehole is 1.3km north-east. The borehole log shows made ground (silty clay) to a depth of 3.15m above limestone (Appendix 6). Although the borehole is over 1km from the Site, it is from the same bedrock geology and gives a rough indication of the nature of the bedrock at the Site.

3.5 Hydrogeology

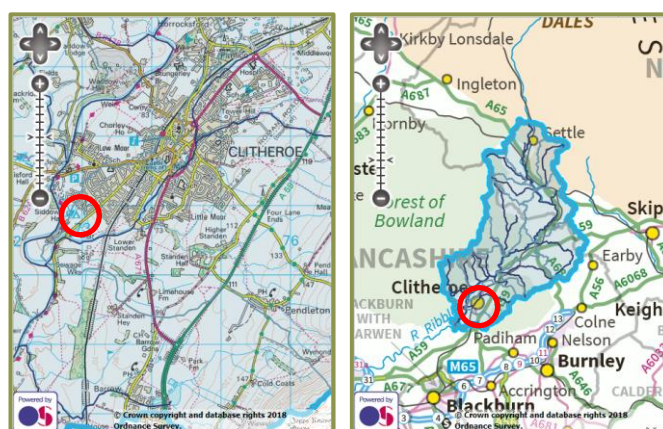
3.5.1 The borehole log shows groundwater was struck at 3m below ground level (bgl) rising to 1.8mbgl following removal of the temporary casing (Appendix 6).

3.5.2 The Environment Agency online groundwater mapping shows the Site is located above a Secondary undifferentiated superficial deposit aquifer and a Secondary A bedrock aquifer.

3.6 Catchment Hydrology

i. Environment Agency Catchment Data Explorer Mapping

3.6.1 The Environment Agency Catchment Data Explorer mapping (Figure 3.4) shows the Site is within the catchment of Mearley Brook, a tributary of the River Ribble which lies in the Ribble Middle (Settle to Calder) catchment. The River Ribble is within the Ribble Management Catchment and North West River Basin District.

Figure 3.4: Environment Agency Catchment Explorer Mapping



Top Left: Mearley Brook, zoomed to Site level. **Top Right:** Ribble Middle (Settle and Calder) full catchment.

Bottom Left: Ribble Management Catchment. **Bottom Right:** North West River Basin District. Contains Environment Agency information © Environment Agency and database right

ii. OS Mapping and Topographic Survey

- 3.6.2 OS mapping (Figure 3.5 and Drawings 001/002) identifies an unnamed watercourse (an 'ordinary watercourse' where flood risk work is carried out by the local drainage authority/riparian landowner hereafter referred to as Drain 1), conveying flows south, through the eastern corner of the Site. Drain 1 is conveyed beneath Blakewater Road via a 1270mm x 1020mm rectangular culvert 80m north-east of the Site and beneath Henthorn Road via a 1100mm wide by 1130mm high rectangular culvert immediately south-east of the Site (Figure 3.6). Drain 1 then turns south-west to join Pendleton Brook (a 'main river' where flood risk work is carried out by the Environment Agency) 200m south-west of the Site. The topographic survey identifies a ø225mm outfall discharging to Drain 1 approximately 10m north of the Site.
- 3.6.3 Pendleton Brook conveys flow west and south-west to join the River Ribble (also a main river) 700m south-west of the Site.
- 3.6.4 Two ponds are shown on the north-west boundary of the Site. The ponds are not impounded. The topographic survey identifies a dry ditch along the north-western boundary of the Site.

Figure 3.5: Watercourse Map

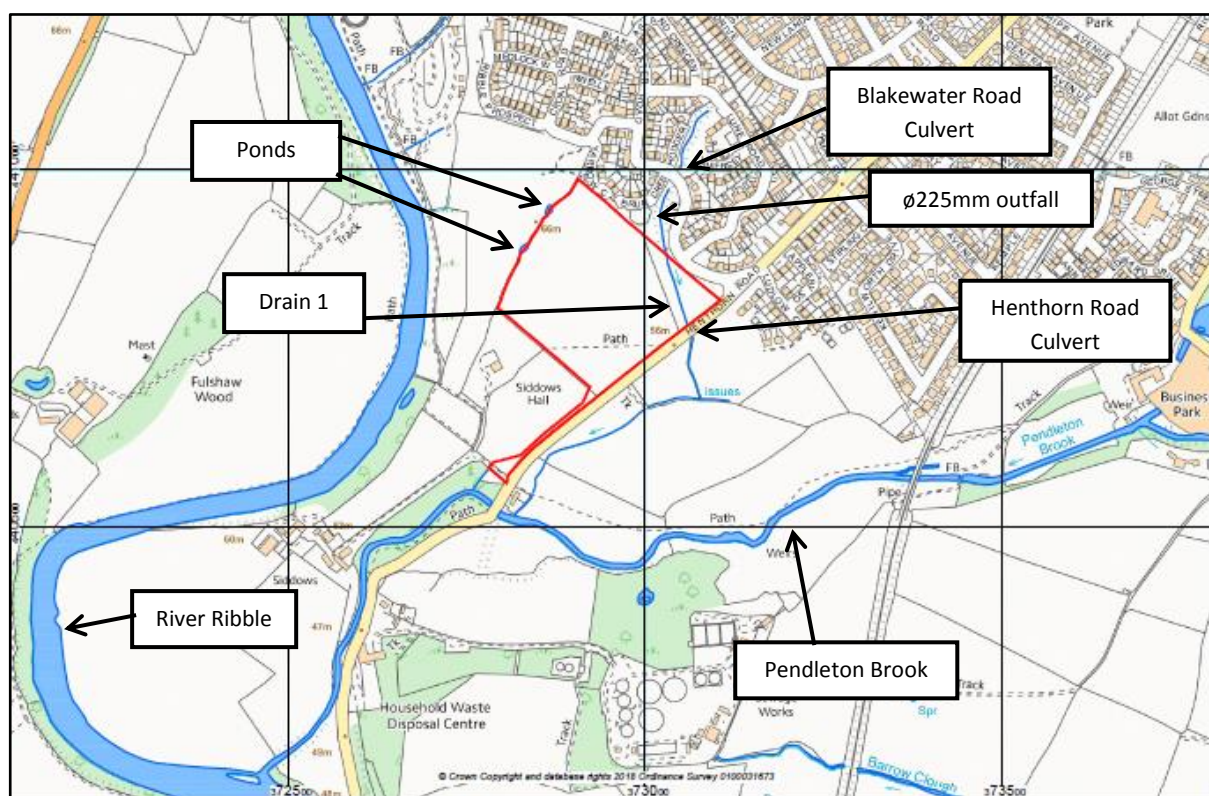


Figure 3.6: Watercourse Photographs



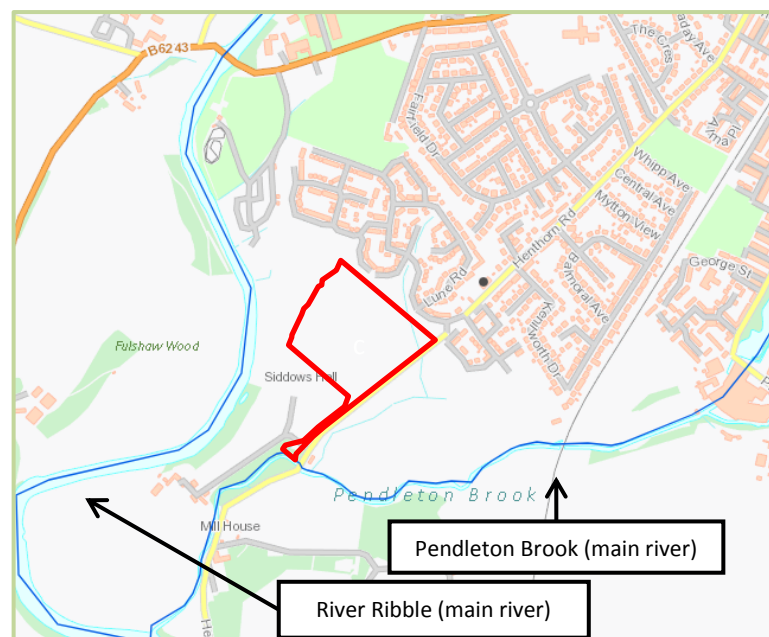


Top: Henthorn Road culvert. **Bottom Left:** Drain 1, looking south. **Bottom Right:** Pendleton Brook, south of the Site

iii. *Environment Agency online Main River Consultation Mapping*

- 3.6.5 The Main River Map (Figure 3.7) shows Pendleton Brook conveys flow west and south-west approximately 220m south of the Site to join the River Ribble which conveys flow south approximately 110m west of the Site. Main rivers are watercourses where flood risk work is undertaken by the Environment Agency.

Figure 3.7: Environment Agency Main River Consultation Map

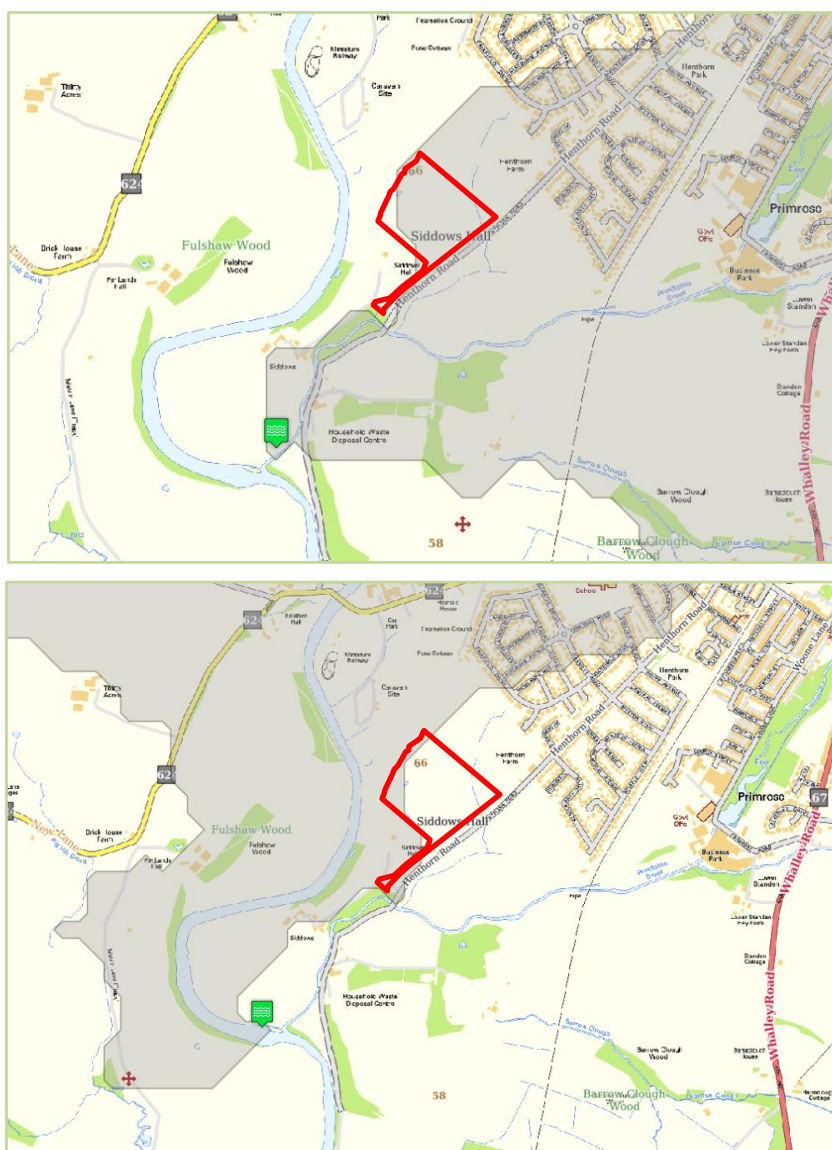


Contains Environment Agency information © Environment Agency and database right.

iv. FEH Web Service Mapping

- 3.6.6 A review of the FEH Web Service mapping (Figure 3.8) shows most of the Site is located within the catchment of Pendleton Brook. The western edge of the Site is shown to be located within the catchment of the River Ribble. Due to the course resolution of the Digital Terrain Model (DTM) used within the FEH Web Service Mapping, the western edge is expected to also fall within the Pendleton Brook catchment. This is confirmed by the ground levels shown on the topographic survey (Appendix 1) which shows the whole Site slopes from north to south towards Pendleton Brook.

Figure 3.8: Catchment Boundaries (continued overleaf)



Contains OS data © Crown copyright and database right.

Top: Pendleton Brook catchment. **Bottom:** River Ribble catchment

3.7 Sewerage Assets

- 3.7.1 United Utilities Water asset plans (Appendix 3) show no public sewers within the Site. Public foul and surface water sewer networks serve the newly built residential properties on Ludlow

Road and Beeston Grove immediately south-east of the Site beyond Henthorn Road. Public combined sewers are shown to serve the residential properties immediately east of the Site along Henthorn Road as well as west of the Site beyond Siddows Hall. Both combined networks route south to the sewage treatment works 350m south of the Site.

3.8 Designated Sites

- 3.8.1 The DEFRA Magic Map (England and Wales)¹⁹ shows the nearest designated site is the Hodder River Section Site of Special Scientific Interest (SSSI) located approximately 2.5km south-west of the Site. The Site is within the SSSI Impact Risk Zone of the Hodder River Section SSSI. However, the SSSI is in the River Hodder catchment which is a tributary of the River Ribble and although the confluence is downstream of the Site the SSSI is far enough upstream on the River Hodder that there is no pathway from the Site to the SSSI and no impact on the designated site.

¹⁹ <http://www.natureonthemap.naturalengland.org.uk/MagicMap.aspx>

4.0 Flood Risk Assessment

4.1 Potential Sources of Flooding

- 4.1.1 A summary of the potential sources of flooding and the potential risk posed by each source at the Site is presented in Table 4.1. Each source of flooding and level of risk is then assessed in further detail.

Table 4.1: Potential Risk Posed by Flooding Sources

Flooding Source	Potential Flood Risk at Application Site (Yes/No)	Potential Source	Data Sources
Fluvial	Yes	River Ribble, Pendleton Brook, Drain 1	Surface Water Features (Drawing 002), JBA Flooding from Rivers (Drawing 004.2), Environment Agency flood mapping (Drawing 005), OS mapping, and SFRA mapping (Appendix 2).
Tidal	No	None identified	Site location (Drawing 001) and Environment Agency flood mapping (Drawing 005).
Groundwater	Yes	Secondary Aquifers	BGS mapping (Drawing 003 and 007) and Geosmart Groundwater (Drawing 006).
Surface Water	Yes	Poor permeability	Environment Agency online flood mapping, JBA Surface Water Flooding (Drawing 004.1) and Environment Agency Complex mapping (Drawing 008.1-008.4).
Sewer	Yes	Public sewers	United Utilities Water Asset plans (Appendix 3) and Topographic survey (Appendix 1).
Infrastructure Failure	Yes	Reservoir or pond failure	Environment Agency online flood mapping and Surface Water Features (Drawing 002).

4.2 Fluvial Flooding

Environment Agency Flood Map

- 4.2.1 The Environment Agency Flood Zones are the current best information on the extent of the extremes of flooding from rivers or the sea that would occur without the presence of flood defences, since these can be breached, overtopped and may not be in existence for the lifetime of a development.
- 4.2.2 The Environment Agency online flood map (Drawing 005) shows the Site is located within Flood Zone 1; outside the 1 in 1000-year probability of fluvial (river) flooding (0.1% Annual Exceedance Probability [AEP]), at 'low' risk.

Flood History

- 4.2.3 Environment Agency correspondence (Appendix 4) states they hold no record of flooding for the Site or surrounding area.
- 4.2.4 SFRA mapping (Appendix 2) shows no records of historical fluvial flooding within the Site boundary. The closest recorded flooding is shown approximately 500m north-west of the Site associated with the River Ribble. An historic flooding event is also shown on Pendleton Brook approximately 1.1km north-east of the Site.

Flood Defences

- 4.2.5 Environment Agency online flood mapping and SFRA mapping show that the Site does not benefit from flood defences.

Flood Warning

- 4.2.6 Environment Agency online flood mapping shows the Site is not located within an area which receives flood warnings.

Summary Flood Risk

- 4.2.7 The risk of fluvial flooding is assessed as negligible.
- 4.2.8 Mitigation measures to account for the residual flood risk from Drain 1/culvert surcharging are discussed in Section 5.

4.3 Tidal Flooding

- 4.3.1 The Site is not located close to tidally affected flooding sources and so the flood risk from this source is assessed as negligible.

4.4 Groundwater Flooding

Introduction

- 4.4.1 Groundwater flooding occurs when subsurface water emerges either at surface or in made ground or in subsurface structures such as basements and services ducts. It occurs as diffuse seepage, emergence from new point source springs or an increase in flow from existing springs. It results from aquifer recharge from infiltrating rainfall, from sinking streams entering aquifers from adjacent non-aquifers, or from high river levels or tides driving water through near surface deposits. It tends to occur with a delay following rainfall and can last for several weeks or months. Groundwater flooding or shallow water tables also prevent or reduce infiltration and so can worsen surface water flooding.

BGS Groundwater Flooding Susceptibility Map

- 4.4.2 The BGS Groundwater Flooding Susceptibility Map (Drawing 003) shows that most of the Site (north-western parts) is within the mapped extent of limited potential for groundwater flooding to occur. The central part of the Site is within the mapped extent of susceptibility to groundwater flooding, with potential for groundwater flooding of property situated below ground level. The southern and eastern parts of the Site are within the mapped extent of

susceptibility to groundwater flooding, with potential for groundwater flooding to occur at surface.

- 4.4.3 The Site is underlain by loamy and clayey soils, superficial till deposits, and mudstone geology with low infiltration potential. Based on the BGS Groundwater Flooding Susceptibility Mapping, the risk of groundwater flooding is considered to be negligible to high.

Geosmart 1 in 100-year Groundwater Flood Risk Map

- 4.4.4 The Geosmart 1 in 100-year groundwater flood risk map (Drawing 006) shows that the majority of the Site is at negligible risk of groundwater flooding. The southern corner is shown to be low risk of groundwater flooding (Table 4.2). This data source is of a higher resolution and accuracy level than the BGS mapping.
- 4.4.5 Mapped classes combine understanding of likelihood, model and data uncertainty, and possible severity. Likelihood is ranked according to whether we expect groundwater flooding at a site due to extreme elevated groundwater levels with an annual probability of occurrence greater than 1%, considering model and data uncertainty. Severity relates to expectations of the amount of property damage or other harm that groundwater flooding at that location might cause (Table 4.2).

Table 4.2: Groundwater flood risk classification

Risk Class	Probability of Groundwater Flooding	Effect
4: Negligible	Annual probability less than 1%.	Negligible unless unusually sensitive use.
3: Low	Annual probability greater than 1%.	Remote possibility of damage to property or harm to sensitive receptors. Flooding likely to be limited to seepages and waterlogged ground, damage to basements and subsurface infrastructure, and should pose no significant risk to life. Surface water flooding may be worsened.
2: Moderate	Annual probability greater than 1%.	Significant possibility of damage to property or harm to other sensitive receptors at or near this location. Flooding is likely to be in the form of shallow pools or streams. Surface water flooding and failure of drainage systems may be worsened when groundwater levels are high.
1: High	Annual probability greater than 1%.	Groundwater flooding will occur which could lead to damage to property or harm to other sensitive receptors at or near this location. Flooding may result in damage to property, road or rail closures and, in exceptional cases, may pose a risk to life. Surface water flooding and failure of drainage systems may be worsened when groundwater levels are high.

Flood Risk

- 4.4.6 The risk of groundwater flooding is assessed as mostly negligible with the southern part of the Site at low risk.
- 4.4.7 Mitigation measures against the risk of groundwater flooding are discussed in Section 5.

4.5 Surface Water Flooding

Introduction

- 4.5.1 Surface water flooding occurs following rainfall on ground where infiltration rates are less than the rainfall precipitation rate. This can occur when either:
- Soils or ground materials are naturally of low permeability or have been compacted (infiltration excess runoff);
 - Soils or ground materials are saturated from previous rainfall either directly or from upslope (saturation excess runoff and return flow) or from high or perched groundwater.

JBA Surface Water Flood Map

- 4.5.2 The JBA Surface Water Flood Map (Drawing 004.1) shows that most of the Site is located outside the mapped extent of surface water flooding. A small area of surface water flooding is shown on the south-eastern boundary. The area of surface water flooding is associated with the 1 in 75-year event. The risk of surface water flooding is likely to be associated with the Drain 1 culvert under Henthorn Road which is not represented by the JBA mapping.

Environment Agency Complex Surface Water Flood Mapping

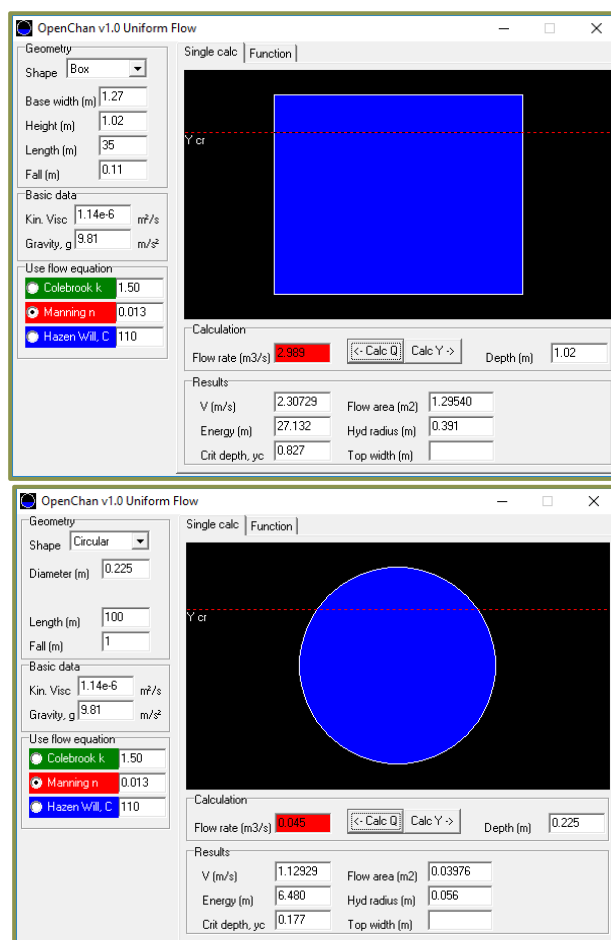
- 4.5.3 The Environment Agency Complex Surface Water Flood Mapping (Drawings 008.1 to 008.4) shows a surface water flow pathway originating north of the Site around Fairfield Drive and Newlands Avenue before conveying flow south along the course of Drain 1 and into the Site. The flow pathway splits on the south-eastern boundary with the majority continuing south along the course of Drain 1 and a proportion flowing south-west along the boundary of the Site and Henthorn Road. The flood depth is between 0.15 and 1.2m during the extreme 1000-year event. The flood velocity is up to 2.0m/s or greater. The flood hazard is between 'low' (0.50-0.75) and 'extreme' (>2.0).
- 4.5.4 A small area of surface water ponding is shown on the north-western boundary associated with the southern onsite pond. The flood depth is up to 0.6m during the extreme 1000-year event.

Flow Pathway Analysis

- 3.8.2 Flow conveyance calculations, using Open Channel flow software, were undertaken for:
- the Blakewater Road Drain 1 culvert (Figure 4.1); and
 - the ø225mm outfall into Drain 1 (Figure 4.2).
- 3.8.3 The calculations were based on the following parameters:
- Size (based on topo survey):

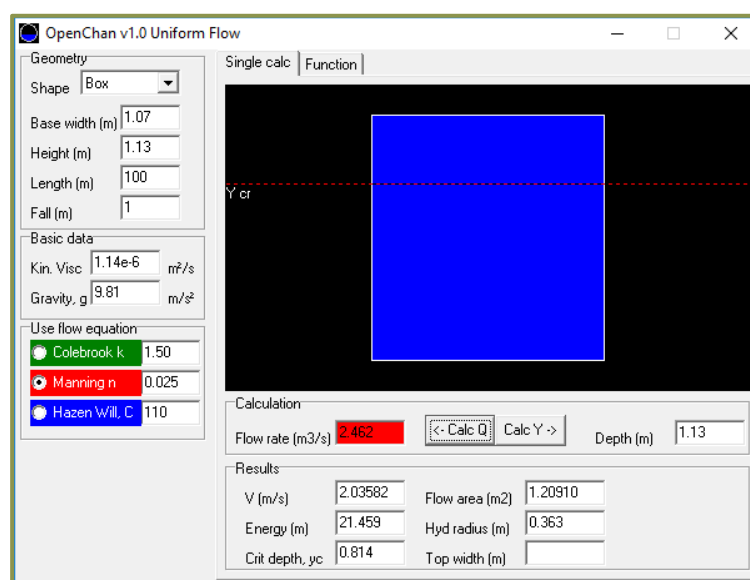
- Blakewater Road culvert: Rectangular 1.27m x 1.02m
 - ø225mm outfall: Circular ø225mm diameter
 - Manning's 'n': 0.013 (assumed concrete pipes)
 - Gradients:
 - Blakewater Road: Fall of 0.11m over 35m (from topo survey)
 - ø225mm outfall: assumed 1:100 (conservative estimate)
 - Depths:
 - Blakewater Road: 1.02m (full bore)
 - Depth: ø225mm outfall: 0.225m (full bore)
- 3.8.4 The full-bore flow for the Blakewater Road culvert is 2989 l/s (Figure 4.1) and for the ø225mm outfall is 45 l/s (Figure 4.2). Extracts showing the Open Channel calculations are included in Figure 4.1. The maximum flow entering the Site via Drain 1 based on the Open Channel calculations is 3034 l/s.

Figure 4.1: Upstream Culverts Open Channel Calculation Extracts



- 3.8.5 A flow conveyance calculation has been undertaken for the Henthorn Road culvert on the southern boundary of the Site based on:
- Size: Rectangular 1.07m x 1.13m (based on topo survey)
 - Manning's 'n': 0.025 (cemented masonry based on walkover observations)
 - Gradient: assumed 1:100 (conservative estimate)
 - Depth: 1.13m (full bore)
- 3.8.6 The calculations show that the full-bore flow capacity of the Henthorn Road culvert is 2462 l/s (Figure 4.2). The full-bore flow entering the Site would exceed the capacity of the Henthorn Road culvert by 572 l/s. The exceedance flows would cause flood water to back-up at the culvert and shed overland following the topographic fall of the Site. The calculations show that flow pathway along the south-eastern boundary of the Site shown on the Environment Agency Complex Surface Water Flood Mapping (Drawings 008.1 to 008.4) is likely to be representative of fluvial flooding associated with Drain 1 and the Henthorn Road culvert.

Figure 4.2: Henthorn Road Culvert Open Channel Calculation Extract



Flood Risk

- 4.5.5 The risk of surface water flooding is assessed as mostly negligible with areas at high risk within the eastern part and along the south-eastern boundary of the Site.
- 4.5.6 Mitigation measures against surface water flooding are discussed in Section 5.

4.6 Sewer Flooding

- 4.6.1 Sewer flooding occurs when urban drainage networks become overwhelmed after heavy or prolonged rainfall due to restrictions or blockage in the sewer network or if the volume of water draining into the system exceeds the sewer design capacity.
- 4.6.2 New sewers are built to the guidelines within Sewers for Adoption²⁰ and have a design standard to the 1 in 30-year flood event. Older sewers were not designed to any particular

²⁰ WRC (2012) Sewers for Adoption 7th Edition.

standard. Modern sewer systems will only surcharge during rainstorm events with a return period greater than 30-years (e.g. 100-years).

- 4.6.3 There are no public sewers located within the Site boundary.
- 4.6.4 From a review of COMMERCIALDW Drainage and Water Enquiry (Appendix 3), there are no recorded sewer flooding incidents located within, or within close proximity to, the Site.
- 4.6.5 The SFRA states there are no known property flooding incidents from sewers in the vicinity of the Site.
- 4.6.6 The risk of flooding from sewers is assessed as negligible.

4.7 Flooding from Infrastructure Failure

Reservoir Failure

- 4.7.1 The Environment Agency online flood mapping shows the Site is located outside the extent of flooding sourced from reservoirs. The risk of flooding from reservoirs is assessed as negligible.

Pond Failure

- 4.7.2 As identified in Section 3.7, two ponds are located on the north-western boundary of the Site. Both are not impounded. The ponds would therefore pose no flood risk to the Site.
- 4.7.3 Based on the above, the risk of flooding from pond failure is deemed to be negligible and will not be discussed further within this FRA report.

5.0 Flood Risk Mitigation Measures

5.1 Introduction

5.1.1 The following sources of flooding were identified:

- Surface water flooding;
- Groundwater flooding; and
- Residual flooding from Drain 1/culvert surcharging.

5.2 Mitigation Measures

Surface Water Flooding

- Set finished floor levels a minimum of +150mm above external levels.
- Sequentially develop the Site, limiting the built development (including surface water attenuation) outside the mapped extent of surface water flow pathways (Drawing 008.1).
- Adoption of a surface water management strategy.

Groundwater Flooding

- No below surface building (i.e. basements).
- Adoption of a surface water management strategy.
- Set finished floor levels as per above.

Residual Flooding from Drain 1/Culvert Surcharging

- Provide a 4m easement free from development along either side of Drain 1. This easement would provide access for inspection and maintenance purposes, including vehicle access.
- Limit all built development to outside the surface water flow pathway outlines.
- A bund feature is recommended to be located along the right bank of Drain 1 immediately upstream of the Henthorn Road culvert. This will prevent any floodwater that backs-up around the Henthorn Road culvert from causing flooding to the Site and will ensure that flows are contained within the Drain 1 channel.
- Undertake monthly maintenance activities to keep Drain 1 and the Henthorn Road culvert clear from debris and overgrown vegetation to maintain the conveyance of the channel and culvert.

5.3 Summary of Flood Risk

5.3.1 Table 5.1 summarises the probability and level of risk, both with and without mitigation measures.

Table 5.1: Probability and consequences of all sources of flooding

Flooding Source	Potential Source	Probability	Consequence & Impact Without Mitigation	Consequence & Impact with Mitigation
Fluvial	River Ribble, Pendleton Brook, Drain 1	Negligible	Negligible	Negligible
Tidal	None identified	Negligible	Negligible	Negligible
Groundwater	Secondary Aquifers	Negligible to Low	Negligible to Low	Negligible
Surface Water	Poor permeability	Negligible to High	Negligible to High	Negligible
Sewer	Public sewers	Negligible	Negligible	Negligible
Infrastructure Failure	Reservoir or Pond failure	Negligible	Negligible	Negligible

Key: Green - Negligible, Yellow - Low, Orange - Medium and Red - High; based on consequence and impact with mitigation from each flooding source.

5.4 Flood Guidance and Sequential Test

5.4.1 The proposal is for a residential development. Table 2 of NPPG ID: 7 (not included in this report) classifies the proposed use as 'more vulnerable'.

5.4.2 The Environment Agency Flood Zones and acceptable development types are listed in Table 5.2. All development types (including more vulnerable uses) are acceptable in Flood Zone 1 (low risk). As such, the Sequential Test would be passed, and the Exception Test would not be required as indicated in Table 5.3.

Table 5.2: Environment Agency Flood Zones and Appropriate Land Use

Flood Zone	Probability	Explanation	Appropriate Land use
Zone 1	Low	Less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).	All development types generally acceptable.
Zone 2	Medium	Between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1%) in any year.	Most development type are generally acceptable.

Flood Zone	Probability	Explanation	Appropriate Land use
Zone 3a	High	A 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.	Some development types not acceptable.
Zone 3b	'Functional Floodplain'	Land where water must flow or be stored in times of flood. SFRAs should identify this zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1% flood, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes).	Some development types not acceptable.

Note: The Flood Zones are the current best information on the extent of the extreme flood from rivers or the sea that would occur without the presence of flood defences, because these can be breached, overtopped and may not be in existence for the lifetime of the development. The identified risk of fluvial flooding is highlighted green.

Table 5.3: Vulnerability and Flood Zone 'Compatibility' as identified in Table 3 of PPG ID: 7

Flood Risk Vulnerability classification (see Table 1 of PPG ID: 7)	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	Yes	Yes	Yes	Yes	Yes
Zone 2	Yes	Yes	Exception test required	Yes	Yes
Zone 3a	Exception test required	Yes	No	Exception test required	Yes
Zone 3b 'Functional Floodplain'	Exception test required	Yes	No	No	No

Key: Yes: Development is appropriate, No: Development should not be permitted.
The identified risk of fluvial flooding is highlighted green.

6.0 Site Drainage

6.1 Surface Water Drainage

- 6.1.1 Consideration of flood issues is not confined to the floodplain. This is recognised in the NPPF and associated guidance where all proposed development of 1ha or more in Flood Zone 1 and so outside the floodplain nevertheless requires an FRA. The alteration of natural surface water flow patterns through developments can lead to problems elsewhere in a catchment, particularly flooding downstream; and replacing permeable vegetated areas with low permeability roofs, roads and other paved areas will increase the speed, volume and peak flow of surface water runoff.
- 6.1.2 A surface water management strategy for the development is proposed to manage and reduce the flood risk posed by surface water runoff from the Site. The developer will be required to ensure that any scheme for surface water should build in sufficient capacity for the entire Site.
- 6.1.3 The surface water drainage arrangements for any development Site should be such that the volume and peak flow rates of surface water leaving a developed Site are no greater than the rates prior to the proposed development unless specific off-Site arrangements are made and result in the same net effect.
- 6.1.4 An assessment of the surface water runoff rates was undertaken to determine the surface water options and attenuation requirements for the Site.

6.2 Existing Drainage System

- 6.2.1 The Site is 5.20ha in area and current land use comprises an agricultural field.
- 6.2.2 The Site is underlain by loamy and clayey soils, superficial till deposits, and mudstone bedrock with indicative moderate to low infiltration potential. It is likely that drainage is predominantly via overland flow, following the topography of the Site to the topographic low points, with a small amount of infiltration to bedrock.
- 6.2.3 There is currently no foul water discharging from the undeveloped Site. Please note that foul drainage is not considered within this FRA but is dealt with in a separate standalone report.

6.3 Proposed Development

- 6.3.1 The proposal is for a residential development.
- 6.3.2 A developable area of 3.16ha is proposed for the 5.20ha Site boundary. A figure of 55% impermeable area (which includes 10% for urban creep) was applied to the residential developable area. The existing and proposed impermeable areas are shown in Table 6.1.

Table 6.1: Impermeable Area

Area	Existing Buildings and Hardstanding	Proposed Buildings and Hardstanding	Difference
Area (ha)	0.0	1.74	+1.74
Percentage of Total Site Area (%)	0	33.5	+33.5

- 6.3.3 The proposed development will increase the impermeable surfaces and therefore increase the amount of runoff.

6.4 Greenfield Runoff Rates

- 6.4.1 An assessment of greenfield runoff rates was undertaken to determine the attenuation requirements for the proposed development.
- 6.4.2 The runoff rates were calculated using HR Wallingford UKSuDS design software using the current 'industry best practice' guidelines as outlined in the Interim Code of Practice for SuDS21, and the Environment Agency Report SC030219 – Rainfall runoff management for developments.
- 6.4.3 The following parameters were used in the runoff calculations:
- Developable Area: 3.16ha
 - Average Annual Rainfall (SAAR): 1183 mm/year;
 - Soil: 0.47;
 - Impermeable Areas: 0% (0.0ha);
 - Region No.: 10
- 6.4.4 The soil type assigned on the HR Wallingford website was 4 giving an SPR value of 0.47, indicating impermeable soils (Figure 6.1). These parameters are deemed appropriate given the indicative low to mixed permeability of the loamy and clayey soils, superficial till deposits, and mudstone bedrock.

Figure 6.1: Soil Index (Sourced from Microdrainage)

Soil Index	General Description	Soil Type
0.150	i) Well drained permeable sandy or loamy soils and shallower analogues over highly permeable limestone, chalk, sandstone or related drifts. ii) Earthy peat soil drained by dikes and pumps. iii) Less permeable soils in valleys.	1
0.300	i) Very permeable soils with shallow ground-water. ii) Permeable soils over rock or frangipani, commonly on slopes in western Britain associated with smaller areas of less permeable wet soils. iii) Moderately permeable soils, some with slowly permeable subsoils.	2
0.400	i) Relatively impermeable soils in boulder and sedimentary clays and in alluvium, especially in eastern England. ii) Permeable soils with shallow ground-water in low lying areas. iii) Mixed areas of permeable and impermeable soils in approximately equal proportions.	3
0.450	i) Clayey, or loamy over clayey soils with an impermeable layer at shallow depth.	4
0.500	Soils of the wet upland i) With peaty or humose surface horizons and impermeable layers at shallow depth. ii) Deep raw peat associated with gentle upland slopes or basin sites. iii) Bare rock cliffs and screes. iv) Shallow, permeable rocky soil on steep slopes.	5

- 6.4.5 Table 6.2 shows the calculated greenfield runoff rates. Extracts from the HR Wallingford UKSuDS calculations are included in Appendix 7.

²¹ Office of the Deputy Prime Minister, National SuDS Working Group, July 2004, Interim Code of Practice for sustainable drainage systems.

Table 6.2: Greenfield Runoff Rates

Annual Probability (Return Period, years)	Greenfield Runoff (l/s)
QBAR	28.1
100% (1)	24.4
3.33% (30)	47.7
1% (100)	58.3
1% + Climate Change	81.6

Note: 40% added to the data to account for long-term climate change as stated in 'Flood Risk Assessment: Climate Change Allowance'. The 1-year, 30-year and 100-year annual probability events are of importance to the Water Companies and the Environment Agency when looking at sewage discharge and flood risk.

6.5 Sustainable Drainage Options (SuDS)

Feasibility of SuDS

- 6.5.1 Soakaway testing was undertaken onsite during July 2018. A copy of the Infiltration Test Report is included in Appendix 8. Findings show that infiltration-based SuDS would not be feasible due to the low permeability of the loamy and clayey soils, superficial till deposits, and mudstone bedrock.

Choice of SuDS Options

- 6.5.2 Sustainable water management measures should be used to control the surface water runoff from the proposed development Site, thereby managing the flood risk to the Site and surrounding areas from surface water runoff. These measures will also improve the quality of water discharged from the Site.
- 6.5.3 Current guidance promotes sustainable water management using SuDS. Options applicable to this Site are identified in Table 6.3.

Table 6.3: SuDS Options

Green roofs	Infiltration basins
Water butts	Detention basins
Permeable paving	Oversized pipes
Rainwater harvesting	Brown roofs
Filter strips	Swales
Wetland Areas	Cellular Storage

Note: SuDS appropriate to the development are highlighted green.

6.5.4 A hierarchy of SuDS techniques is identified²²:

1. **Prevention** – the use of good Site design and housekeeping measures on individual Sites to prevent runoff and pollution (e.g. minimise areas of hard standing).
2. **Source Control** – control of runoff at or very near its source (such as the use of rainwater harvesting).
3. **Site Control** – management of water from several sub-catchments (including routing water from roofs and car parks to one/several large soakaways for the whole Site).
4. **Regional Control** – management of runoff from several Sites, typically in a detention pond or wetland.

6.5.5 Using SuDS as opposed to conventional drainage systems provides several benefits by:

- reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed Sites;
- improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- reducing potable water demand through rainwater harvesting;
- improving amenity through the provision of public open spaces and wildlife habitat; and
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

SuDS Maintenance

6.5.6 A detention basin will form the main attenuation feature within the development Site.

6.5.7 Maintenance of the SuDS features would be in line with the SuDS Manual (CIRIA C753, 2015), as detailed in Figure 6.2. The maintenance would be undertaken by a private maintenance company.

6.5.8 The specifics of other SuDS features and maintenance would be considered further at detailed design, when a more comprehensive layout has been produced. The level of detail provided within this FRA should be sufficient at outline stage to demonstrate that SuDS would be deliverable.

²² CIRIA (2004) Report C609, Sustainable Drainage Systems – Hydraulic, Structural and Water Quality advice.

Figure 6.2: Detention Basin Operation and Maintenance Requirements (Table 22.1 of the SuDS Manual)

TABLE 22.1 Operation and maintenance requirements for detention basins		
Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly
	Cut grass – for spillways and access routes	Monthly (during growing season), or as required
	Cut grass – meadow grass in and around basin	Half yearly (spring – before nesting season, and autumn)
	Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)
	Inspect inlets, outlets and overflows for blockages, and clear if required.	Monthly
	Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly
	Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies.	Monthly (for first year), then annually or as required
	Check any penstocks and other mechanical devices	Annually
	Tidy all dead growth before start of growing season	Annually
	Remove sediment from inlets, outlet and forebay	Annually (or as required)
	Manage wetland plants in outlet pool – where provided	Annually (as set out in Chapter 23)
Occasional maintenance	Reseed areas of poor vegetation growth	As required
	Prune and trim any trees and remove cuttings	Every 2 years, or as required
	Remove sediment from inlets, outlets, forebay and main basin when required	Every 5 years, or as required (likely to be minimal requirements where effective upstream source control is provided)
Remedial actions	Repair erosion or other damage by reseeding or re-turfing	As required
	Realignment of rip-rap	As required
	Repair/rehabilitation of inlets, outlets and overflows	As required
	Relevel uneven surfaces and reinstate design levels	As required

6.6 Surface Water Management Strategy

Hierarchy of Discharge

6.6.1 In accordance with requirement H3 of the Building Regulations 2000²³ rainwater runoff must discharge to one of the following, listed in order of priority:

- 1. An adequate soakaway or some other adequate infiltration system; or, where that is not reasonably practicable:** The use of infiltration-based SuDS is deemed to be unfeasible due to the low permeability of the soils, superficial deposits, and bedrock onsite.
- 2. A watercourse; or where that is not reasonably practicable:** Pendleton Brook conveys flow west and south-west approximately 220m south-west of the Site to join the River Ribble.
- 3. A sewer:** There are no public surface water sewers located within the Site.

6.6.2 The proposed drainage route will be via a new surface water sewer from the Site which will outfall to Pendleton Brook 220m south-east of the Site.

²³ Office of the Deputy Prime Minister, The Building Regulations 2000.

Drainage Design

- 6.6.3 Surface water runoff would be directed to the drainage system through drainage gullies located around the perimeter of the buildings and through contouring of the hardstanding areas.
- 6.6.4 Landscaped areas should be incorporated into the layout where possible, and the associated gardens of each unit will allow a proportion of the rainfall to infiltrate into the soil substrate.
- 6.6.5 Surface water will be directed to an onsite detention basin, positioned to achieve a gravity fed connection to the new surface water sewer connection to Pendleton Brook.
- 6.6.6 An indicative drainage layout is in Drawing 009.

Attenuation Requirements

- 6.6.7 Attenuation storage is required to reduce the post-application surface water runoff from the Site to the calculated greenfield runoff rates up to and including the 100-year (+40%CC) rainfall event, assuming no infiltration losses.
- 6.6.8 The following input parameters were assumed in the calculations:
 - Impermeable Area: 1.74ha (33.5%);
 - Cv (proportion of rainfall forming surface water runoff): 75% summer, 84% winter;
 - Infiltration losses: 0.00m/hour;
 - With outfall, using complex controls: Table 6.2.
- 6.6.9 The attenuation volume for the 1 in 100-year event (plus climate change) is 775m³.
- 6.6.10 Extracts from the PDS Flow calculations are included in Appendix 9.
- 6.6.11 The attenuation volumes will be reviewed at detailed design stage.

7.0 Summary and Conclusions

7.1 Introduction

- 7.1.1 A site-specific Flood Risk Assessment (FRA) has been undertaken for the proposed residential development, located on land off Henthorn Road, Clitheroe.

7.2 Flood Risk

- 7.2.1 The risk of fluvial flooding is assessed as negligible.
- 7.2.2 The risk of surface water flooding is assessed as mostly negligible with areas at high risk within the eastern part and along the south-eastern boundary of the Site.
- 7.2.3 The risk of groundwater flooding is assessed as mostly negligible with the southern part of the Site at low risk.
- 7.2.4 The risk of flooding from all other sources is negligible.

7.3 Mitigation Measures

- 7.3.1 Surface water, groundwater, and residual flood risk from Drain 1/culvert surcharging can be mitigated to a negligible level through the following approach:
- Sequentially develop the Site, limiting the built development outside the mapped extent of surface water flow pathways.
 - Set finished floor levels above external.
 - Adoption of a surface water management strategy.
 - No below surface buildings (i.e. basements)
 - Provide an easement free from development either side of Drain 1.
 - Introduction of a bund feature on the right bank of Drain 1 at the Henthorn Road culvert to prevent floodwater that backs-up at the culvert from flooding the Site.
 - Undertake maintenance to keep Drain 1 and the Henthorn Road culvert free from debris and overgrown vegetation.

7.4 Flood Guidance

- 7.4.1 The proposed residential use is classified as 'more vulnerable'.
- 7.4.2 All development is acceptable within Flood Zone 1. As such, the Sequential Test will be passed, and the Exception Test would not be required.

7.5 Site Drainage

- 7.5.1 The proposed development will increase the impermeable surfaces and therefore increase the amount of runoff.
- 7.5.2 A SuDS drainage scheme is proposed to manage excess runoff from the development, comprising a detention basin designed to maintain runoff at pre-development rates.
- 7.5.3 Surface water runoff from the proposed development would be attenuated onsite up to and including the 1 in 100-year event, plus 40% climate change.

- 7.5.4 Surface water runoff from the Site will be restricted to the greenfield rates using complex controls which would ensure no increase in flood risk downstream from the Site.

7.6 Conclusion

- 7.6.1 This FRA demonstrates that the proposed development would be operated with minimal risk from flooding, would not increase flood risk elsewhere and is compliant with the requirements of national policy and guidance.
- 7.6.2 The development should not therefore be precluded on the grounds of flood risk and surface water drainage.