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NPPF: Flood Risk Assessment & Outline Drainage Strategy

Henthorn Road, Clitheroe

Gladman Developments Ltd

SHF.1132.306.HY.R.001.A

'Experience and expertise working in union'

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Executive Summary

This report presents a Flood Risk Assessment in accordance with the National Planning Policy Framework and National Planning Practice Guidance: Flood Risk and Coastal Change ID: 7 guidance[1], for a proposed residential development located on land to the north and south of Henthorn Road, Clitheroe, Lancashire.

The report assesses the flood risk and how this could be managed to allow the Site to be developed in support of the outline planning application. The FRA also includes an assessment of the surface water and foul drainage requirements.

A summary of the baseline Site condition is included below:

- The 7.17ha Site is comprised of two agricultural (grazing) land parcels, located to the west (1.746ha) and east (5.425ha) of Henthorn Road.
- The Site is underlain by low permeability (clayey) soils and geology.
- Pendleton Brook conveys flows west along the southern boundary of eastern parcel. An unnamed watercourse (Watercourse 1) conveys flows south-west through the eastern extent of the eastern parcel, and is a tributary of Pendleton Brook.
- The western parcel falls south-east towards Watercourse 1. The eastern parcel falls south-west towards Watercourse 1 and Pendleton Brook.

The baseline risk of flooding to the Site is assessed as follows:

- The risk of fluvial flooding is assessed as negligible for most of the Site but medium to low along the reaches of onsite and bounding watercourses (Watercourse 1 and Pendleton Brook, respectively).
- The risk of groundwater flooding is assessed as negligible above ground, and low below ground.
- The risk of surface water flooding is assessed as negligible for most of the Site but low to high along the flow pathway through the southern extent of the eastern parcel.
- The risk of flooding from sewers is assessed as negligible. There is however a residual risk event for sewer leak or surcharge event.
- The risk of flooding from sewers and mains is assessed as negligible. There is however a residual (low risk) event for sewers or mains to leak or surcharge.
- Flood risk from all other sources is assessed as negligible.

The risk of flooding to the developable area and vehicle access is assessed as follows:

- Negligible to low and acceptable from all sources, subject to implementation of the below management measures.

Flood risk from identified sources can be reduced to a negligible or low and acceptable level through the following approach:

[1] https://www.gov.uk/guidance/flood-risk-assessment-local-planning-authorities

The strategy for developing the Site is as follows:

- Sequentially develop the Site, limiting the built development outside the mapped extent of fluvial flooding for the 1000-year event.
- Set the surface water outfall from the proposed development at an appropriate height, above the bed level of the receiving watercourse.
- Provide safe/dry access, with access roads set above the above the 1 in 100-year plus climate change or 1 in 1000-year event flood level (whichever is greatest).
    - The existing access to the western parcel (via the Miller Homes access from Henthorn Road) is set above the level of the extreme climate change (2070 to 2125) mapped level.
    - It is proposed that the developable area in the eastern parcel is accessed via a free-spanning bridge across Watercourse 1 and the associated floodplain, with soffit levels set 600mm above the level of the extreme climate change (2070 to 2125) mapped level. The proposed crossing will allow for the free conveyance of flood water, without increase flood risk to and from the development.
- Reprofile onsite channels (i.e. scrape the channel to remove overgrown vegetation and build-up of silt/soft bed) to increase the capacity and the conveyance of the channel.
- No below surface habitable buildings (i.e. basements).
- Lined attenuation to prevent groundwater ingress.
- Provide easements free from development along either side of onsite and bounding watercourses. These easements would provide access for inspection and maintenance purposes, including vehicle access.
- Provide a development free easement either side of onsite public foul and private surface water sewer assets in the western parcel.
- Provide a development free easement either side of onsite public mains assets, or re-direct through the Site boundary.
- Adoption of a surface water management strategy.
    - Runoff contributing to the overland flow originating within the south-east extent of the eastern parcel Site boundary will be intercepted by the proposed surface water drainage strategy, attenuated onsite, and discharged to watercourse at a controlled (QBAR) rate.
- Undertake maintenance activities to keep onsite and bounding watercourses clear from debris and overgrown vegetation to maintain the conveyance of the channels.
- Fit the outfall with backflow prevention and provide a high-level overflow.

The proposed residential use is classified as more vulnerable. More vulnerable uses are considered acceptable in terms of flood risk in Flood Zone 1 (low risk).

Source of Flooding	Risk of Flooding	Risk Without Measures	Recommended Measures	Risk to Development with Measures
Fluvial - Pendleton Brook, Watercourse 1, and Drain 1	Negligible for most of the Site, but Medium to High along the reaches of onsite and	Negligible for most of the Site, but Medium to High along the reaches of onsite and bounding watercourses	Avoid	Negligible to Low

Source of Flooding	Risk of Flooding	Risk Without Measures	Recommended Measures	Risk to Development with Measures
	bounding watercourses			
Tidal - None identified	Negligible	Negligible	N/A	Negligible
Groundwater - Secondary A and Undifferentiated Aquifers (Superficial designation), Secondary A Aquifer (Bedrock designation)	Negligible above ground, and low below ground	Negligible above ground, and low below ground	Avoid	Negligible
Surface Water - Poor permeability and Site topography	Negligible for most of the Site but Low to High along the flow pathway through the southern extent of the eastern parcel	Negligible for most of the Site but Low to High along the flow pathway through the southern extent of the eastern parcel	Avoid	Negligible to Low
Sewers and Mains - Public and private sewer assets, public mains	Negligible for most of the Site but Low (residual) along surcharge overland flows	Negligible for most of the Site but Low (residual) along surcharge overland flows	Avoid	Negligible
Infrastructure Failure - Reservoir and attenuation pond failure	Negligible	Negligible	N/A	Negligible

The FRA has considered the potential impact of the development on surface water runoff rates, given the increase in impermeable areas post-development. These rates have been calculated, and 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 (i.e. calculated greenfield [QBAR]) and appropriately sized attenuation basins, with an outfall to watercourse.

- A SuDS treatment train, including permeable paving and swales or rain gardens will improve water quality. Water butts could be utilised to encourage rainwater collection and reuse (the potential for more integrated rainwater harvesting solutions will be further explored at the reserved matters stage). A maintenance and management ensure the effectiveness of the drainage strategy during the operation phase.
- Implementation of a Construction Environmental Management Plan during the construction phase will manage surface water and foul drainage, thereby mitigating the potential for impacts on hydrology, flood risk, and water quality.

It is proposed that foul flow is discharged to the nearby public combined sewer via a gravity outfall for the western parcel, and a pumped solution for the eastern parcel.

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, as well as surface water and foul 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 an outline surface water and foul drainage strategy, in support of an outline application for a proposed residential development. The Site is located on land west and east of Henthorn Road, Clitheroe, Lancashire, BB7 2SN (the 'Site').

1.1.2 The proposal is for a residential development, with up to 115 dwellings as well as associated landscaping, open spaces, SuDS features, and vehicle access points on the 7.17-hectare (ha) Site.

1.1.3 A site-specific FRA assesses the current and future flood risk to and from a development site. It demonstrates how flood risk will be managed now and over the development's lifetime, taking climate change, drainage, and the vulnerability of its intended users into account.

1.1.4 The objectives of a site-specific FRA are to:

- Assess whether a proposed development is likely to be affected by current or future flooding from a range of sources. The Site will be sequentially developed, limiting the developable areas (including surface water attenuation) to areas outside the mapped extent of flooding.
- Assess whether the development will increase flood risk elsewhere.
- Decide on measures to deal with these effects and risks and assess their appropriateness.

1.1.5 In England, planning applications for development need an FRA[2] for most developments including:

- In Flood Zones 2 and 3 including minor development and change of use.
- Sites of 1ha or larger in Flood Zone 1.
- Sites of less than 1ha in Flood Zone 1, including change of use to a more vulnerable class (for example from commercial to residential), and where they could be affected by sources of flooding other than rivers and the sea.
- Land in Flood Zone 1 in a Critical Drainage Area (CDA) as notified by the Environment Agency (EA).
- Land in Flood Zone 1 identified in a Strategic Flood Risk Assessment (SFRA) as being at increased flood risk in future.

1.1.6 An FRA is required for this Site, as initial screening using EA online indicative flood mapping shows the Site is partially located in Flood Zones 2 and 3 (medium to high risk), partially at risk of surface water flooding, and is more than 1ha in area.

1.1.7 The purpose of this FRA is to assess the risk of flooding to the Site and where possible recommend measures to demonstrate that future users of the proposed development would remain safe throughout its lifetime, that the development would not increase flood risk on Site and elsewhere and, where practicable, would reduce flood risk overall.

[2] Department for Environment, Food & Rural Affairs and Environment Agency (published March 2014 and updated August 2025). Flood Risk Assessments if You're Applying for Planning Permission [https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications].

1.2 Scope

1.2.1 Government policy on development and flood risk is set out in the National Planning Policy Framework (NPPF) [3] and is supported by National Planning Practice Guidance: Flood Risk and Coastal Change (NPPG ID7) [4].

1.2.2 NPPF paragraphs 161-186 set out the need for an appropriate assessment of flood risk at all levels of the planning process and require the application of a sequential risk-based approach to assess the suitability of land for development in flood risk areas[5].

1.2.3 The FRA should also make allowances for climate change [6] to minimise vulnerability and provide resilience to flooding and coastal change in the future. The allowances are predictions of anticipated change in:

- Peak river flow by river basin district.
- Peak rainfall intensity.
- Sea level rise.
- Offshore wind speed and extreme wave height.

1.2.4 The allowances 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 are categorised according to level[7]. Simple Level 1 Screening studies give a general indication of the potential flood risk to a site and identify whether more detailed Level 2 assessment is required or not. 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 measures (see Section 5 - Avoid, Control, Mitigate, Manage). Level 3 assessments are more detailed quantitative studies, for example modelling to establish flood levels at a site in the absence of EA or other data or providing detailed outline drainage designs.

1.2.6 This report is a Level 2 qualitative FRA, which includes a Level 3 assessment of the surface water and foul drainage requirements for the proposed development.

1.3 Aims

1.3.1 This FRA aims to provide enough flood risk information to satisfy the requirements of the NPPF, PPG ID7 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 recommended measures that could be incorporated into the development to manage the identified risks.

[3] Ministry of Housing, Communities & Local Government (published March 2012 and updated February 2025). National Planning Policy Framework [https://www.gov.uk/government/publications/national-planning-policy-framework--2].
[4] Department for Levelling Up, Housing and Communities and Ministry of Housing, Communities & Local Government (published March 2014 and updated September 2025). Planning Practice Guidance ID7-020-20220825; Flood Risk & Coastal Change [https://www.gov.uk/guidance/flood-risk-and-coastal-change].
[5] https://www.gov.uk/guidance/national-planning-policy-framework/14-meeting-the-challenge-of-climate-change-flooding-and-coastal-change#footnote59
[6] Environment Agency (published February 2016 and updated May 2022). Flood Risk Assessments: Climate Change Allowances [https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances].
[7] CIRIA (October 2004) CIRIA C624 - Part C, Chapter 6, Section 6.1 to 6.3.

1.4 Planning Context

National Policy

1.4.1 The FRA was prepared in accordance with the NPPF and NPPG ID7.

Regional/Local Policy

1.4.2 The FRA considers the following policies within the Ribble Valley Borough Council Core Strategy (2008 to 2028)[8]:

- Key Statement EN3: Sustainable Development and Climate Change "*In adapting to the effects of climate change it is expected that proposals for development will demonstrate how sustainable development principles and sustainable construction methods, such as the use of sustainable drainage systems, will be incorporated… …All development should optimise energy efficiency by using new technologies and minimising the use of energy through appropriate design, layout, material and landscaping and address any potential issues relating to flood risk.*".
- Policy DME6: Water Management "*Development will not be permitted where the proposal would be at an unacceptable risk of flooding or exacerbate flooding elsewhere. Applications for development should include appropriate measures for the conservation, protection and management of water such that development contributes to: 1. Preventing pollution of surface and / or groundwater 2. Reducing water consumption 3. Reducing the risk of surface water flooding (for example the use of sustainable drainage systems (SuDS)) as a part of the consideration of water management issues, and in parallel with flood management objectives, the authority will also seek the protection of the borough's water courses for their biodiversity value. All applications for planning permission should include details for surface water drainage and means of disposal based on sustainable drainage principles. The use of the public sewerage system is the least sustainable form of surface water drainage and therefore development proposals will be expected to investigate and identify more sustainable alternatives to help reduce the risk of surface water flooding and environmental impact. It is important to ensure the water environment including the use of water, pollution and flood risk can be adequately controlled through the development management process to deliver the development strategy and its strategic framework as envisaged in the Core Strategy.*".

Strategic Flood Risk Assessment (SFRA)

1.4.3 The FRA has reviewed the guidance within the Ribble Valley Borough Council Level 1 Strategic Flood Risk Assessment (SFRA) report and associated mapping[9].

Guidance Documents / Best Practice

1.4.4 This FRA also considers the following flood risk and drainage guidance documents:

- Lancashire County Council Sustainable Drainage Systems (SuDS) Pro-forma and Guidance Notes for Sustainable Drainage Systems Pro-forma[10].
- North West River Basin District Flood Risk Management Plan 2021 to 2027 (2022)[11].

[8] https://www.ribblevalley.gov.uk/downloads/file/1700/adopted-core-strategy
[9] https://www.ribblevalley.gov.uk/downloads/file/2029/strategic-flood-risk-assessment-level-1-revised-2017-
[10] https://www.lancashire.gov.uk/business/business-services/pre-planning-application-advice-service/lead-local-flood-authority-planning-advice-service-for-surface-water-and-sustainable-drainage/
[11] https://assets.publishing.service.gov.uk/media/63809c7ee90e072345afbd65/North-West-FRMP-2021-2027.pdf

- Lancashire County Council Local Flood Risk Management Strategy for Lancashire 2021-2027[12].
- Ribble Valley District Flood Report (2017)[13].
- Ribble Catchment Flood Management Plan (2009)[14].

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 existing Site.
- Section 4 outlines the baseline flood risk from all sources.
- Section 5 details the recommended measures against identified flood risk sources.
- Section 6 assesses the surface water drainage requirements of the proposed development.
- Section 7 assesses the foul drainage requirements of the proposed development.
- Section 8 presents a summary and conclusions.

[12] https://www.lancashire.gov.uk/media/928565/lancashire-flood-risk-management-strategy-2021-2027-final-v2.pdf
[13] https://www.lancashire.gov.uk/media/901164/ribble-valley-final-report.pdf
[14] https://assets.publishing.service.gov.uk/media/5a7baedfed915d01ba1ca531/Ribble_Catchment_Flood_Management_Plan.pdf

2.0 Sources of Information

2.1 Sources of Information

2.1.1 The following information was consulted:

- Ordnance Survey mapping (Drawings 0001 and 0002).
- Detailed topographic survey (Appendix 1).
- EA online mapping (Flood Map for Planning[15], Long Term Flood Risk Assessment for Locations in England[16], Catchment Data Explorer[17] and Main River Map[18]).
- EA Reduction in Risk of Flooding from Rivers and Sea online mapping[19].
- Online mapping for Climate Change Allowances for Peak River Flow and Peak Rainfall in England online mapping[20].
- National Soils Resources Institute (NSRI): Soilscapes online mapping[21].
- British Geological Survey (BGS) Geology Viewer online mapping[22].
- British Geological Survey (BGS) Borehole Records online mapping[23].
- Landmark's Promap: Flood Data package (see Drawings).
- Geosmart 1 in 100-year groundwater flood risk map (see Drawings).
- DEFRA's Magic Map for identifying Designated Sites[24].
- River Levels UK for identifying Flood Alert and Flood Warning areas[25].

2.2 Consultation and Discussion with Regulators

2.2.1 Consultation and discussions were undertaken with the relevant water regulators.

Environment Agency

2.2.2 The Environment Agency (EA) 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 EA Standing Advice[26] and the NPPF/PPG ID: 7 was consulted and reviewed.

2.2.4 Correspondence with the EA is included in Appendix 2.

[15] https://flood-map-for-planning.service.gov.uk/
[16] https://check-long-term-flood-risk.service.gov.uk/postcode
[17] http://environment.data.gov.uk/catchment-planning/
[18] https://environment.maps.arcgis.com/apps/webappviewer/index.html?id=17cd53dfc524433980cc333726a56386
[19] ArcGIS - My Map
[20] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[21] https://www.landis.org.uk/soilscapes/
[22] https://www.bgs.ac.uk/map-viewers/bgs-geology-viewer/
[23] https://www.bgs.ac.uk/information-hub/borehole-records/
[24] https://magic.defra.gov.uk/MagicMap.html
[25] https://riverlevels.uk/flood-map#.XclKwPn7RPZ
[26] Environment Agency and Department for Environment, Food & Rural Affairs (published April 2012 and updated August 2025). Preparing a Flood Risk Assessment: Standing Advice [https://www.gov.uk/guidance/flood-risk-assessment-standing-advice].

Lead Local Flood Authority

2.2.5 Lancashire County Council as the Lead Local Flood Authority (LLFA) is responsible for local flood risk management in their area and for maintaining a register of flood risk assets. They also have lead responsibility for managing the risk of flooding from surface water, groundwater, and ordinary watercourses.

2.2.6 Correspondence with the LLFA is included in Appendix 3.

Water Utility

2.2.7 Drainage and sewerage services in the UK are provided by a number of water and sewerage companies. United Utilities is responsible for sewerage within the area of the Site.

2.2.8 All sewerage undertakers maintain the 'DG5 register' of properties and external areas (such as gardens, highways, open spaces) which have suffered flooding from public foul/combined sewers. It does not include flooding caused by blockages.

2.2.9 United Utilities asset plans and pre-development enquiry response are included in Appendix 4.

2.3 Site Walkover

2.3.1 Enzygo staff carried out a walkover of the Site during December 2024. Observations made were used to inform the Site description.

3.0 Site Location and Description

3.1 Location

3.1.1 The Site is located on land west and east of Henthorn Road, Clitheroe, BB7 2SN.

3.1.2 The Site is centred on National Grid Reference (NGR) 372882, 440627.

3.1.3 The 7.17ha Site location is shown in Drawing 0001 and in more detail in Drawing 0002.

3.2 Land Use

3.2.1 The land use is comprised of two agricultural (grazing) land parcels, located to the west (1.746ha) and east (5.425ha) of Henthorn Road (Figures 3.1 and 3.2).

Western Parcel

3.2.2 The western parcel is bounded by Henthorn Road to the east/south-east; a wooded area to the south-west; agricultural land to the west; a Siddows Hall to the west; a recently constructed (Miller Homes) residential development to the north/north-east.

3.2.3 Vehicle access is via a gated private road along the southern boundary. A public footpath is also located along the private road.

Eastern Parcel

3.2.4 The eastern parcel is bounded by Henthorn Road to the north-west; residential dwellings to the north; agricultural land to the east; Pendle Brook with agricultural land/solar farm to the south.

3.2.5 Vehicle access is via a gate along the north-western boundary from Henthorn Road. A public footpath is orientated west to east through the southern extent of this parcel.

Figure 3.1: Aerial Image of the Site

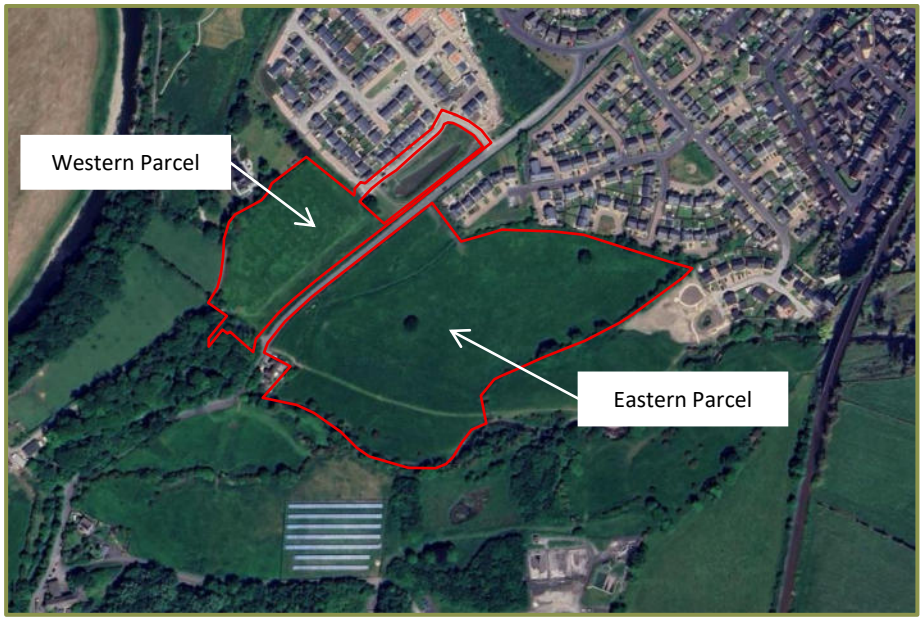


Image © 2025 Maxar Technologies

Figure 3.2: Photographs of the Site

Top: View south across the Western Parcel. Bottom: View north across the Eastern Parcel.

3.3 Topographic Information

3.3.1 A detailed topographic survey was carried out during June 2019 and October 2025. A copy is included in Appendix 1.

3.3.2 Flow pathway analysis was undertaken in KeyTERRA-FIRMA (KTF) software to understand watershed catchments (Drawing 0007). A summary of the Site topography is included in Figure 3.3 and described below.

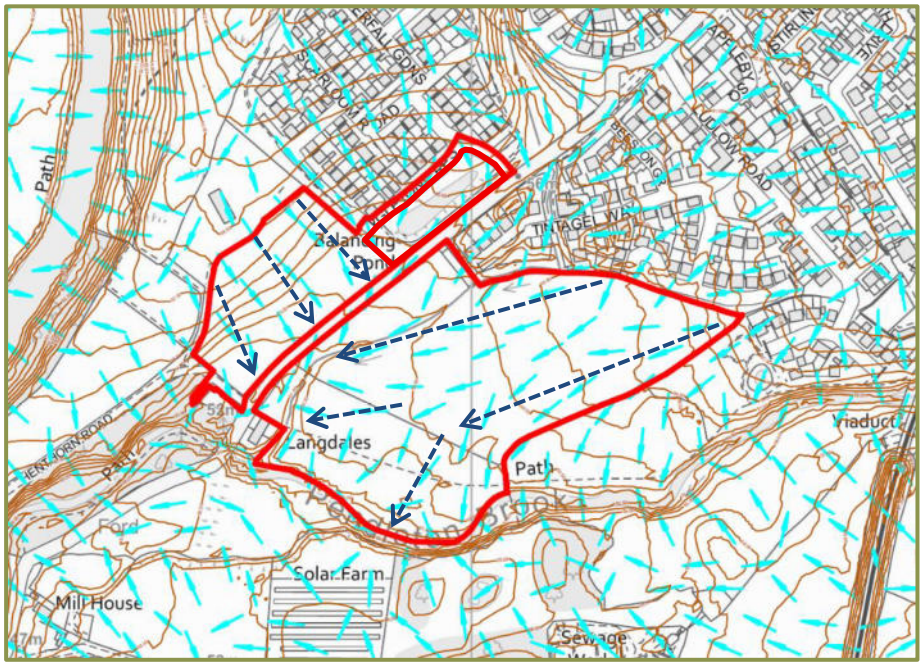
Western Parcel

3.3.3 The main area of the western parcel (excluding the existing access road) falls south-east, from 58.24 metres Above Ordnance Datum (m AOD) along the north-west boundary, to 50.72m AOD in the southern corner. The fall of 7.97m over 156m gives an average gradient of 1:20.

Eastern Parcel

3.3.4 The eastern parcel falls south-west from 60.10m AOD in the north-east corner, to 47.84m AOD in the south-west corner. The fall of 12.26m over 405m gives an average gradient of 1:33.

Figure 3.3: Summary of Site Topography



3.4 Soils and Geology

Soils Mapping

i. Western Parcel

3.4.1 The online NSRI Soilscapes mapping (Figure 3.4) shows most of the western parcel is underlain by slowly permeable, seasonally wet, loamy and clayey soils. The southern corner is underlain by loamy and clayey floodplain soils with naturally high groundwater.

ii. Eastern Parcel

3.4.2 The northern and central extent of the eastern parcel of the Site is underlain by slowly permeable, seasonally wet, loamy and clayey soils. The southern extent is underlain by loamy and clayey floodplain soils with naturally high groundwater.

Figure 3.4: Soils Mapping

Soils Data © Cranfield University (NSRI) and for the Controller of HMSO [2025].

Geology Mapping

i. Western Parcel

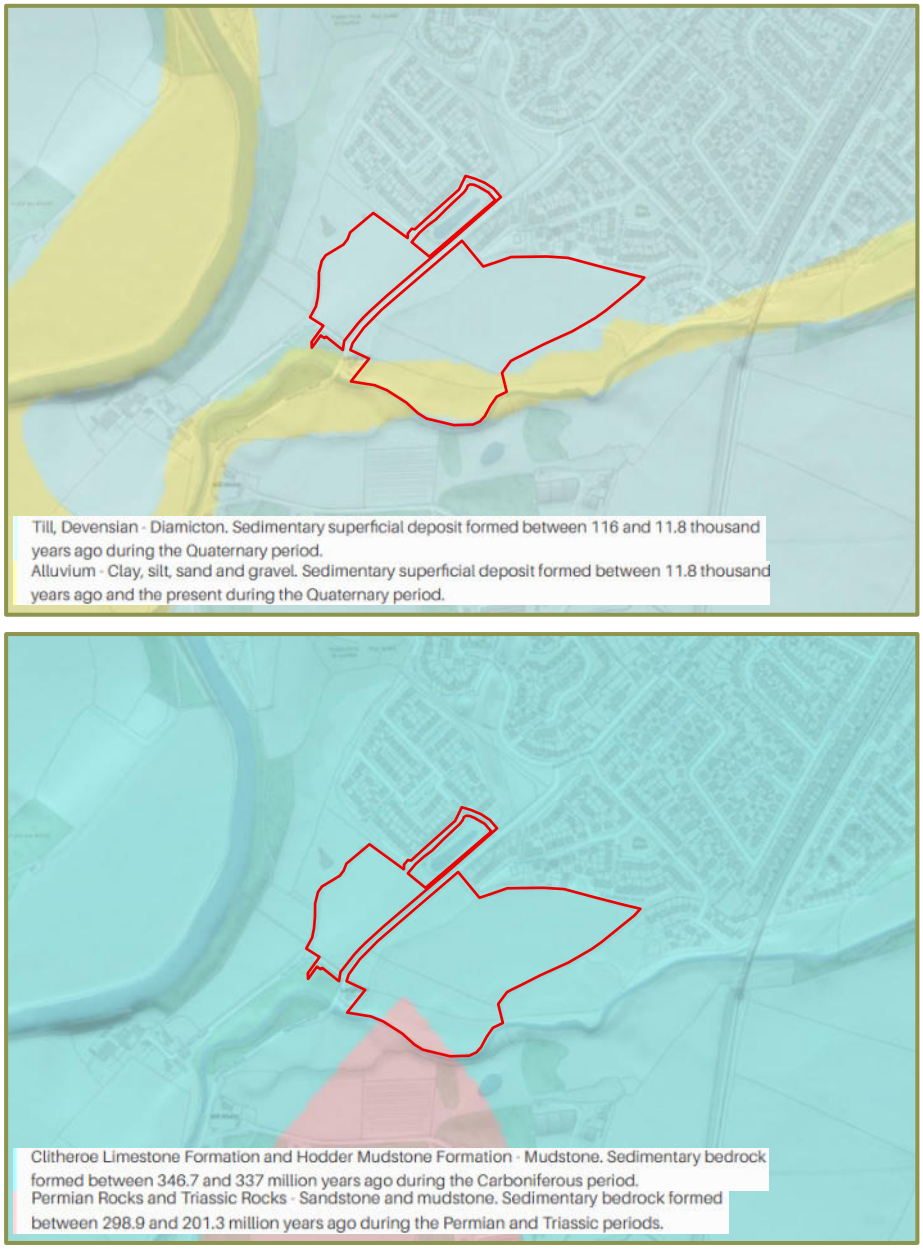
3.4.3 The online BGS Geology Viewer (Figure 3.5) shows the western parcel is underlain by Devensian Till - Diamicton superficial deposits, and Clitheroe Limestone Formation and Hodder Mudstone Formation - Mudstone.

ii. Eastern Parcel

3.4.4 The northern and central extent of the eastern parcel is underlain by Devensian Till - Diamicton superficial deposits, whereas the southern extent is underlain by Alluvium - Clay, silt, sand and gravel.

3.4.5 Most of the eastern parcel is underlain by Clitheroe Limestone Formation and Hodder Mudstone Formation - Mudstone, whereas the southernmost extent is underlain by Permian and Triassic Rocks - Sandstone and mudstone.

Figure 3.5: Geology Mapping



Top: Superficial deposits. Bottom: Bedrock geology. Contains British Geological Survey materials © NERC [2025].

BGS Borehole Records

3.4.6 The BGS Borehole Records online mapping shows there are no available borehole records located within the Site boundary or the immediate vicinity.

Soakaway Testing

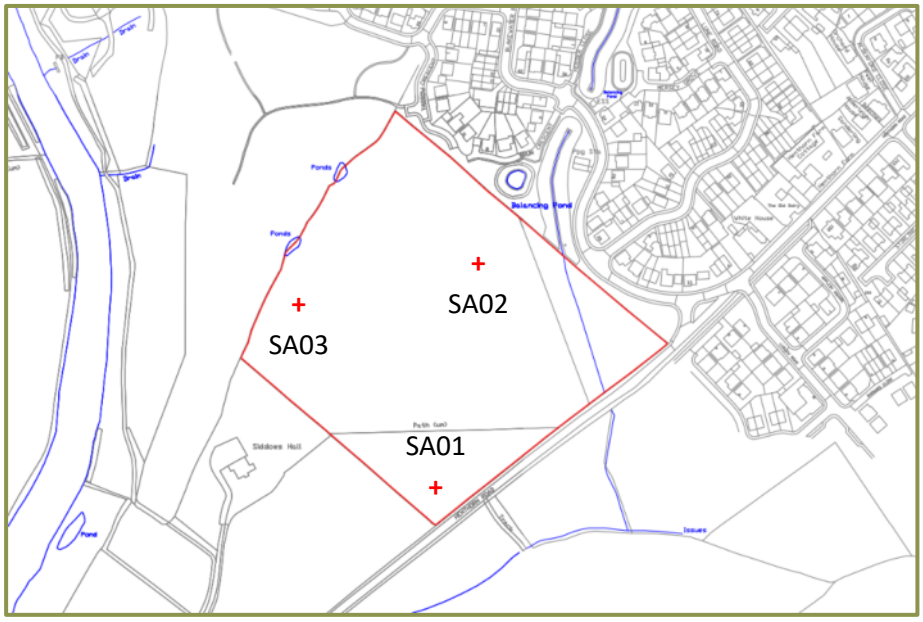
3.4.7 Soakaway testing was undertaken during July 2018, within land to the north of the western land parcel, which is now occupied by a recently constructed (Miller Homes) residential development.

3.4.8 Testing was in accordance with BRE 365 'Soakaway Design' methodology guidance. A copy of the Soakaway Testing Results is included in Appendix 5.

3.4.9 A total of three soakaway test pits were established (Figure 3.6) within the same geology as the western parcel, and northern/central extents of the eastern parcel.

3.4.10 Trial pits were excavated to a depth of between 2.00 and 2.20 metres below ground level (m bgl), a summary of the trial pit logs is included in Table 3.2, which confirm the soils and geology as depicted by the soils and geology mapping.

Figure 3.6: Trial Pit Location Plan



Note, the indicative redline boundary does not align with the current application boundary.

Table 3.2: Soakaway Data

Trial Pit	Depth (m bgl)	Soil Infiltration Rate (m/s)			Comments
		Test 1	Test 2	Test 3	
SA01	2.00	-	-	-	0.00 - 0.30m = Topsoil 0.30 - 2.00m = Grey/brownish slightly sandy clay **Insufficient uptake to calculate infiltration.**
SA02	2.00	-	-	-	0.00 - 0.28m = Topsoil 0.28 - 0.80m = Grey clay with sand 0.80 - 2.00m = Grey clay with gravel **Insufficient uptake to calculate infiltration.**
SA03	2.20	-	-	-	0.00 - 0.30m = Topsoil 0.30 - 2.20m = Grey/ brown clay with sand and gravel **Insufficient uptake to calculate infiltration.**

3.5 Hydrogeology

Infiltration Potential

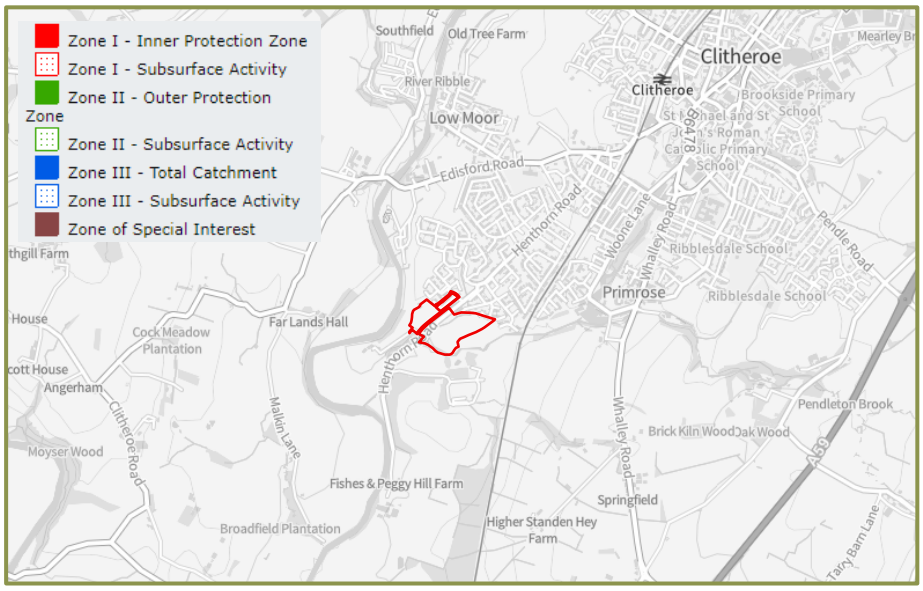
3.5.1 The SuDS Infiltration Potential Mapping (Drawing 0005) shows the Site is in the mapped extent indicative of moderate potential, which is likely to be associated with the underlying superficial deposits (Devensian Till - Diamicton / Alluvium - Clay, silt, sand and gravel).

3.5.2 Soakaway testing demonstrated low infiltration potential into the clayey soils and geology. Groundwater ingress was not encountered in any of the trial pits.

Defra Magic Map

3.5.3 The online Defra Magic Map mapping (Figure 3.7) shows the Site is not located in a groundwater Source Protection Zone (SPZ).

Figure 3.7: Source Protection Zone Map



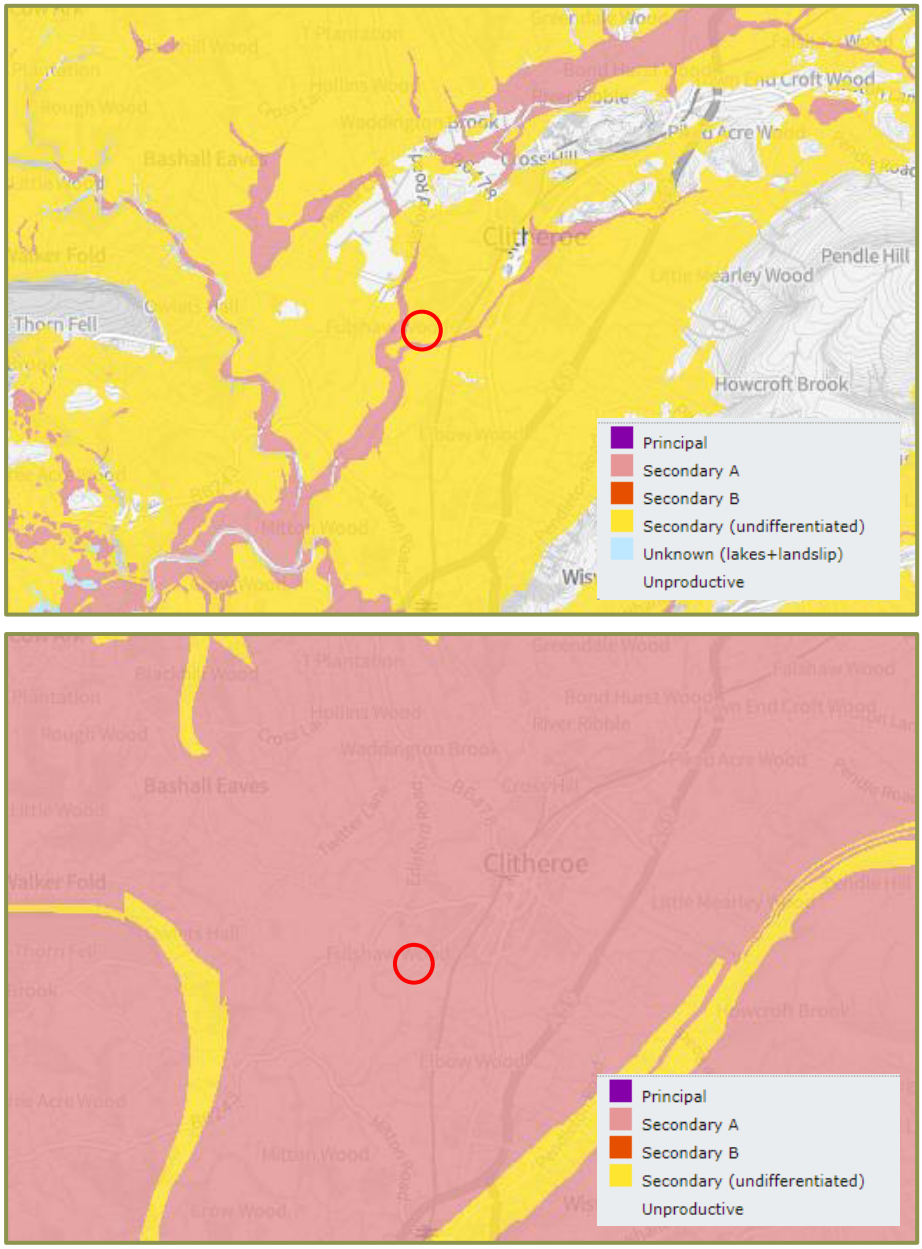
From Magic Map. Contains EA information © EA and database right [2025].

3.5.4 The BGS Aquifer Designation mapping (Figure 3.8) shows that the Site is not located above a Principal Aquifer. The Site is however located above a Secondary A aquifer (bedrock designation).

3.5.5 Most of the Site is located above a Secondary (undifferentiated) Aquifer (superficial deposits), where Devensian Till - Diamicton superficial deposits are present. The southern extent of the eastern parcel is located above a Secondary A Aquifer (superficial deposits) where Alluvium - Clay, silt, sand and gravel, where superficial deposits are present.

3.5.6 Indirect inputs of clean surface water to groundwater are permissible, for example where the base of the soakaway is above the water table and there is an unsaturated zone in the aquifer unit.

Figure 3.8: Aquifer Designation Map



Top: Aquifer Designation (superficial deposits). Bottom: Aquifer Designation (bedrock). From Magic Map. Contains EA information © EA and database right [2025].

3.6 Catchment Hydrology

OS Mapping

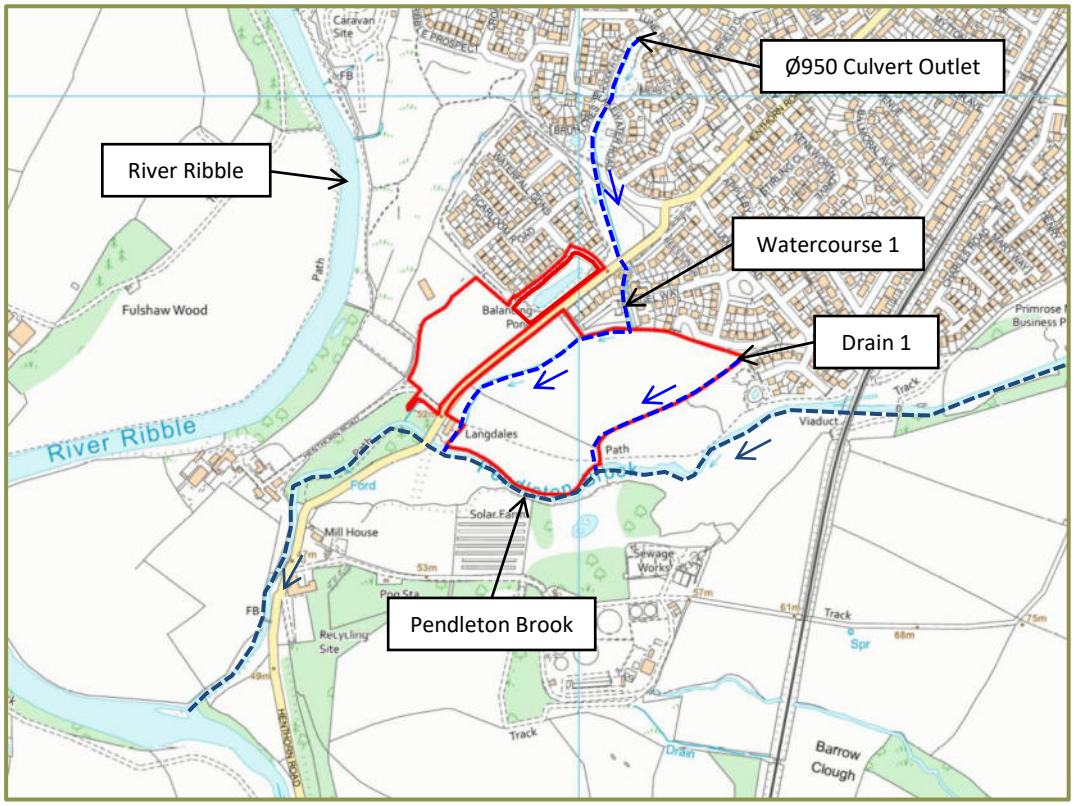
3.6.1 OS mapping (Figure 3.9) shows the River Ribble (a main river) conveys flows south, approximately 110m to the west of the western parcel.

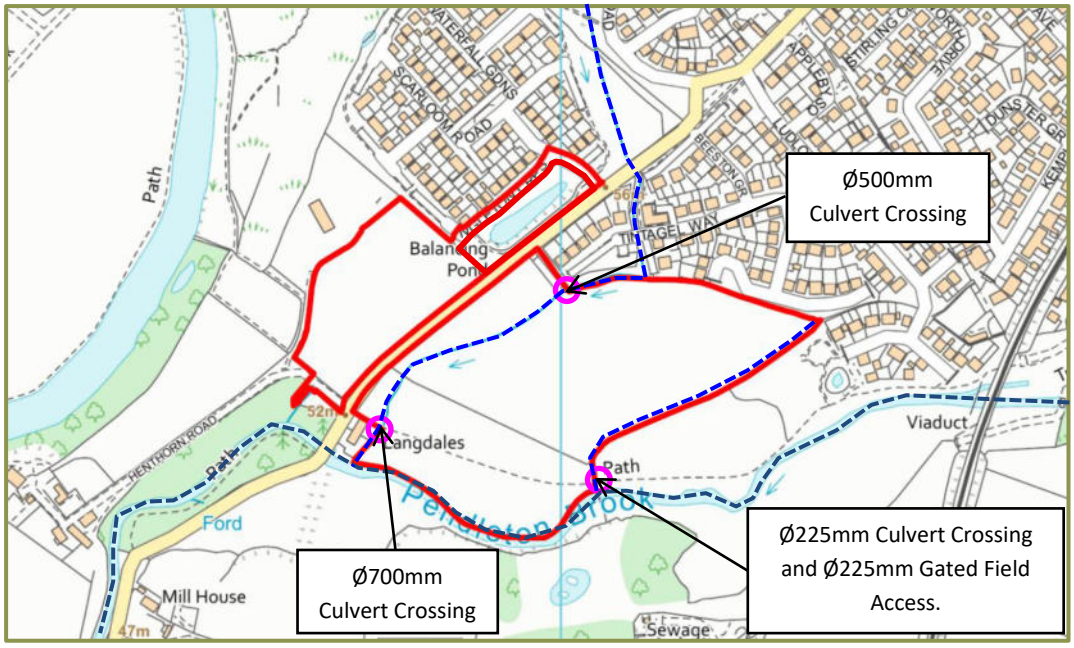
3.6.2 Pendleton Brook (a main river) conveys flows west along the southern boundary of the eastern parcel. Pendleton Brook is a tributary of the River Ribble, converging approximately 500m to the south of the Site.

3.6.3 An unnamed watercourse ('Watercourse 1' - an ordinary watercourse) conveys flows south-west, through the western extent of the eastern parcel. Watercourse 1 originates from a

Ø950mm culvert outlet, located approximately 400m to the north of the Site (to the south of Lune Road). Watercourse 1 is a tributary of Pendleton Brook, converging at the south-west corner of the eastern parcel.

Figure 3.9: Map of Watercourses and Associated Structures





Site Walkover Observations

Pendleton Brook

3.6.4 The Site walkover observed Pendleton Brook conveying flows west along the southern boundary of the eastern land parcel (Figure 3.10).

3.6.5 The channel was observed to have an approximate 5.00 - 7.00m bed width, 0.50 to 1.00 depth, and 1:3 side slope. The channel was free flowing, and free from overgrown vegetation and blockages. Some bank erosion was observed, which is assumed to be associated with livestock access to the watercourse.

Figure 3.10: Pendleton Brook

Left: View upstream (east) along Pendleton Brook, along the southern boundary of the eastern parcel. Right: View downstream (west) along Pendleton Brook, along the southern boundary of the eastern parcel.

Watercourse 1

3.6.6 The Site walkover observed Watercourse 1 conveying flows south-west through the western extent of the eastern parcel (Figure 3.11).

3.6.7 The channel was observed to have an approximate 0.50m bed width, 0.25 to 1.00 depth, and 1:2 to 1:3 side slope. The channel was free flowing, and free from overgrown vegetation and blockages. Some bank erosion was observed, which is assumed to be associated with livestock access to the watercourse.

3.6.8 Two onsite structures were observed along the reach of Watercourse 1 (Figure 3.11), including a Ø500mm culvert crossing under a private access road along the northern boundary of the eastern parcel, and a Ø700mm culvert crossing under the public footpath within the south-west extent of the eastern parcel.

Figure 3.11: Watercourse 1

Left: View upstream (north-east) along Watercourse 1. Right: View downstream (south-west) along Watercourse 1.

Left: Ø500mm culvert crossing. Right: Ø700mm culvert crossing.

Drain 1

3.6.9 The Site walkover observed a dry land drain ('Drain 1' - an ordinary watercourse) orientated south-west along the eastern boundary of the eastern parcel (Figure 3.12). The channel originates along the eastern boundary, and discharge Pendleton Brook along the southern boundary.

3.6.10 The channel was observed to have an approximate 0.50m bed width, 0.5m depth, and 1:3 side slope. The channel was free from overgrown vegetation and blockages. Some bank erosion was observed, which is assumed to be associated with livestock access to the watercourse.

3.6.11 Two onsite structures were observed along the reach of Drain 1 (Figure 3.12), including a Ø225mm culvert crossing under a public footpath within the south-east extent of the eastern parcel, and a Ø225mm culvert crossing under the gated field access in the same location.

Figure 3.12: Drain 1


Left: View upstream (north-east) along Drain 1. Right: View downstream stream (south-west) along Drain 1.

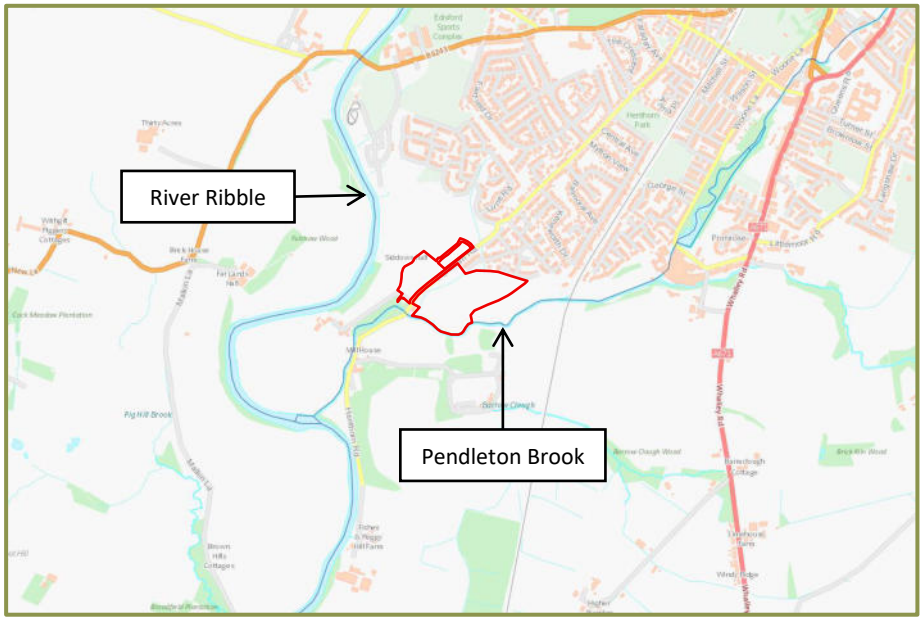

Left: Ø225mm culvert crossing under a public footpath. Right: Ø225mm Gated Field Access.

Main River Map

3.6.12 The EA online main river map (Figure 3.13) identifies both the River Ribble and Pendleton Brook as 'main rivers', which are watercourses where flood risk work is carried out by the EA.

3.6.13 Watercourse 1 and Drain 1 are classified as 'ordinary watercourses', where flood risk work is carried out by the local drainage authority/riparian landowner.

Figure 3.13: Main River Map

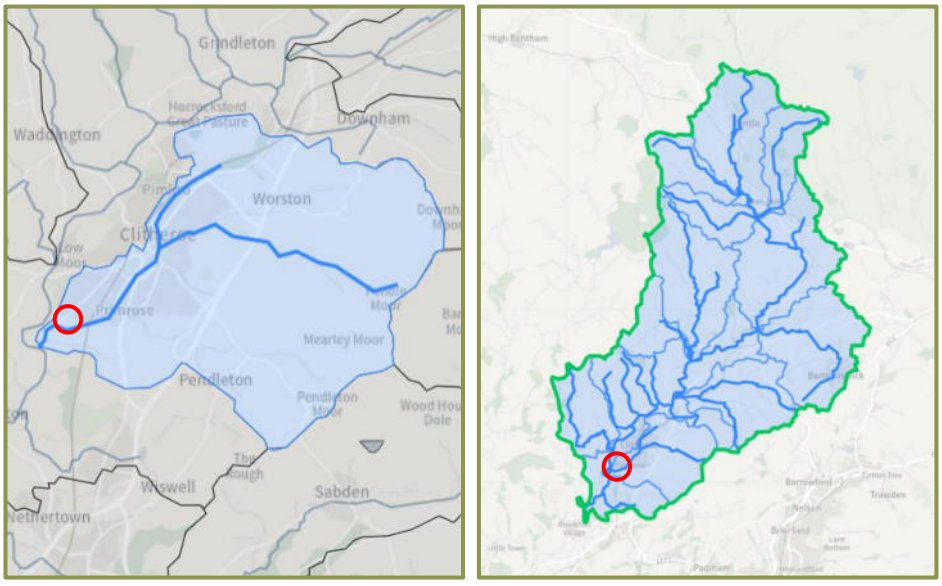


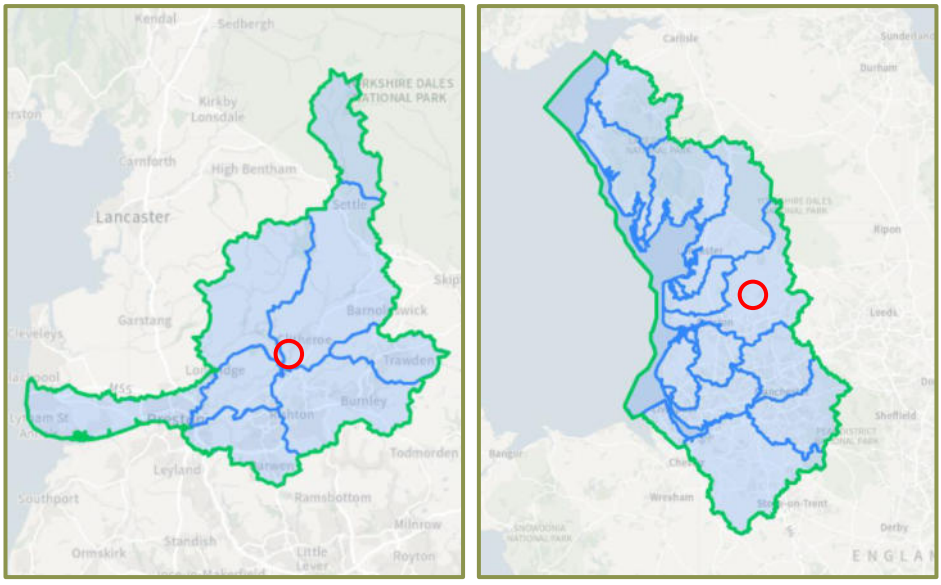
Contains EA information © EA and database right [2025].

EA Catchment Data Explorer Mapping

3.6.14 The Site resides within the Mearley Brook Water Body catchment (Figure 3.14), which is in the Ribble Middle - Settle to Calder Operational Catchment, Ribble Management Catchment, and North West River Basin District.

Figure 3.14: Catchment Data Explorer





Top Left: Mearley Brook Water Body catchment. Top Right: Ribble Middle - Settle to Calder Operational Catchment. Bottom Left: Ribble Management Catchment. Bottom Right: North West River Basin District. Contains EA information © EA and database right [2025].

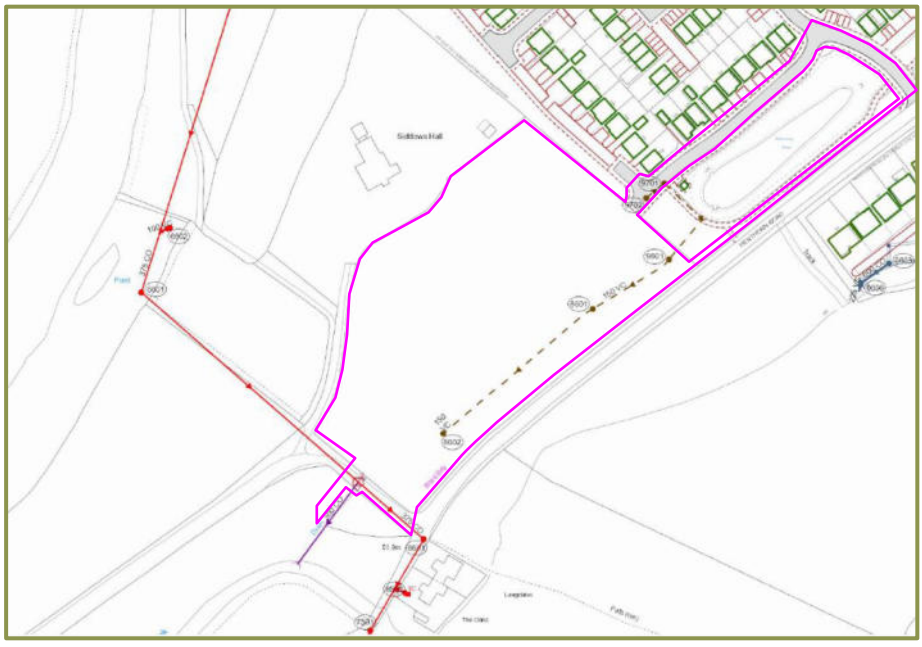
3.7 Sewer and Mains Assets

Sewer Assets

i. Western Parcel

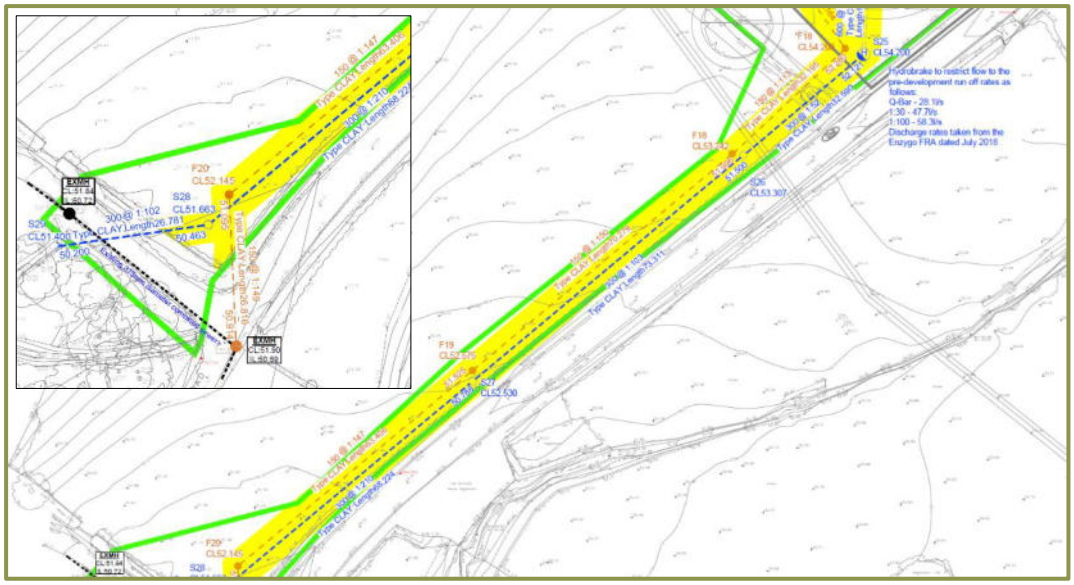
3.7.1 United Utilities sewer asset plans (Appendix 4 and extract in Figure 3.15) show a Ø150mm public foul sewer orientated south-west beneath (through) the eastern extents of the western parcel. It is assumed the foul sewer connects into the Ø375mm public combined sewer, orientated south-east beneath the private road within the southernmost extent, then south along Henthorn Road.

Figure 3.15: United Utilities Sewer Asset Plan Extract (Western Parcel)



3.7.2 The recently constructed (Miller Homes) development to the north/north-east of the western parcel is surface water drainage strategy (Figure 3.16), including an attenuation pond with a Ø300mm piped outfall (through/beneath the eastern boundary of the western parcel) to a land drainage located in woodland to the south, which has connectivity to Pendleton Brook.

Figure 3.16: Miller Homes Drainage Plan

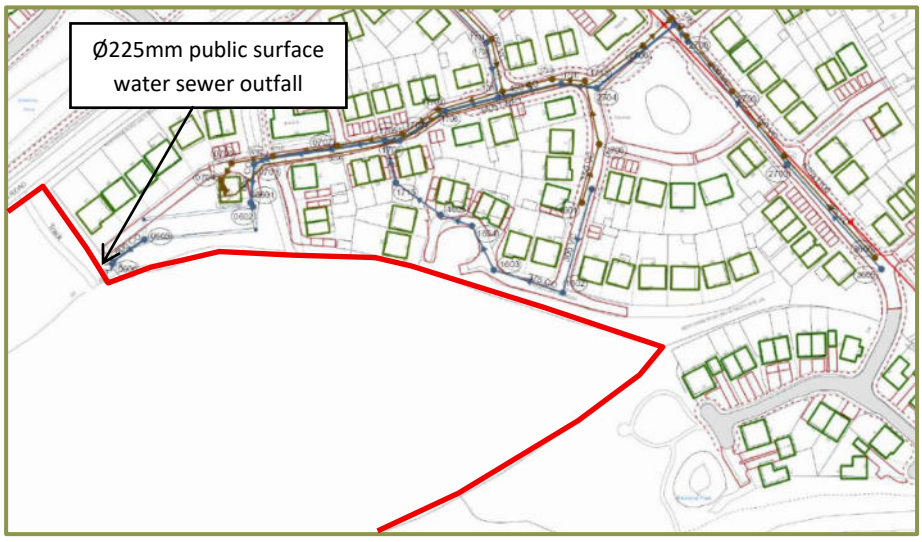


ii. Eastern Parcel

3.7.3 United Utilities sewer asset plans (Appendix 4 and extract in Figure 3.17) show there are no public sewers recorded within the boundary of the eastern parcel.

3.7.4 The residential dwellings to the north are served by a separate public surface water and foul network. The public surface water sewer network outfalls to Watercourse 1 via a Ø225mm piped outlet from an assumed attenuation (tank) feature, along the northern boundary.

Figure 3.17: United Utilities Sewer Asset Plan Extract (Eastern Parcel)

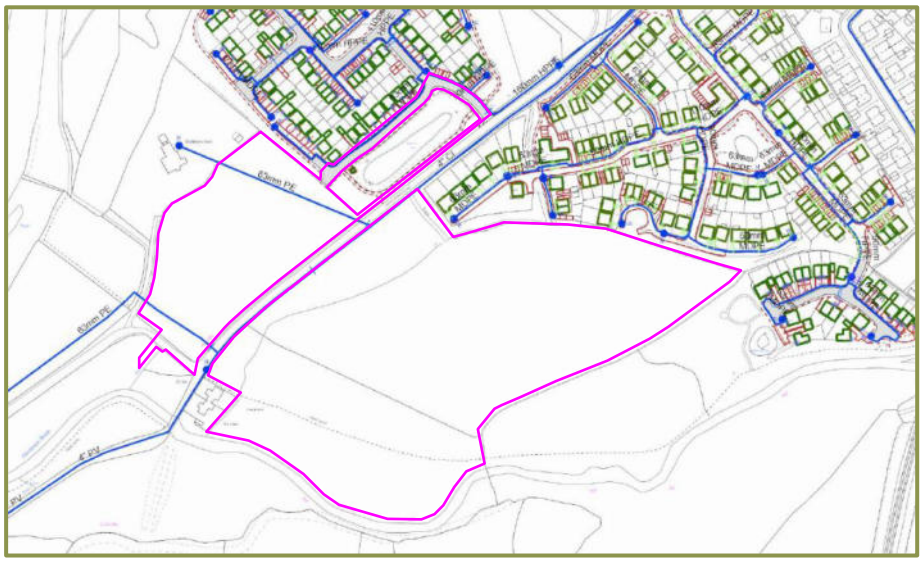


Main Assets

3.7.5 United Utilities mains asset plans (Appendix 4 and extract in Figure 3.18) show 63mm main orientated east to west through the northern and southern extent of the western parcel. A 63mm main is also located along the existing access.

3.7.6 A 4" main is orientated north to south through the north-west extent of the eastern parcel.

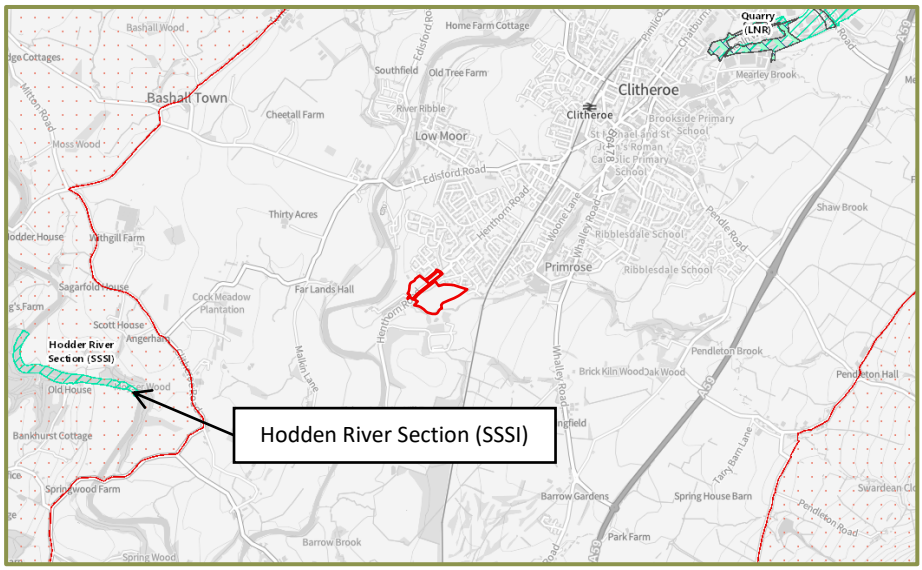
Figure 3.18: United Utilities Mains Asset Plan Extract



3.8 Designated Sites

3.8.1 The online Defra Magic Map mapping (Figure 3.19) shows the nearest designated site is Hodden River Section (Site of Special Scientific Interest [SSSI]), located approximately 2.25km to the south-west of the Site. The designated site is not hydrologically connected to the Site from a flood risk or drainage perspective.

Figure 3.19: Designated Sites



From Magic Map. Contains EA information © EA and database right [2025].

4.0 Assessment of Flood Risk Sources

4.1 Potential Sources of Flooding

4.1.1 A summary of the potential sources of flooding and source is summarised in Table 4.1. Each source of flooding and level of risk is then assessed in further detail below.

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	Pendleton Brook, Watercourse 1, and Drain 1	EA consultation response/data (Appendix 2), EA Flood Zone mapping (Drawing 0003), and EA online Flood Map for Planning.
Tidal	No	None identified	EA consultation response/data (Appendix 2) and EA Flood Zone mapping (Drawing 0003).
Groundwater	Yes	Secondary A and Undifferentiated Aquifers (Superficial designation), Secondary A Aquifer (Bedrock designation)	Geosmart Groundwater (Drawing 0004), and Soakaway Test Results (Appendix 5).
Surface Water	Yes	Poor permeability and Site topography	EA Risk of Flooding from Surface Water Mapping (Drawings 0006.1 to 0006.2) and EA online mapping: Long Term Flood Risk Assessment for Locations in England.
Sewers and Mains	Yes	Public and private sewers, public mains	United Utilities asset plans (Appendix 4), topographic survey (Appendix 1), and Miller Homes drainage drawing (Figure 3.16).
Infrastructure Failure	Yes	Reservoir and attenuation pond failure	OS mapping (Drawings 0001 to 0002), EA online mapping: Long Term Flood Risk Assessment for Locations in England, and Miller Homes drainage drawing (Figure 3.16).

4.2 Fluvial Flooding

EA Flood Zone Mapping

4.2.1 The EA 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.

i. Western Parcel

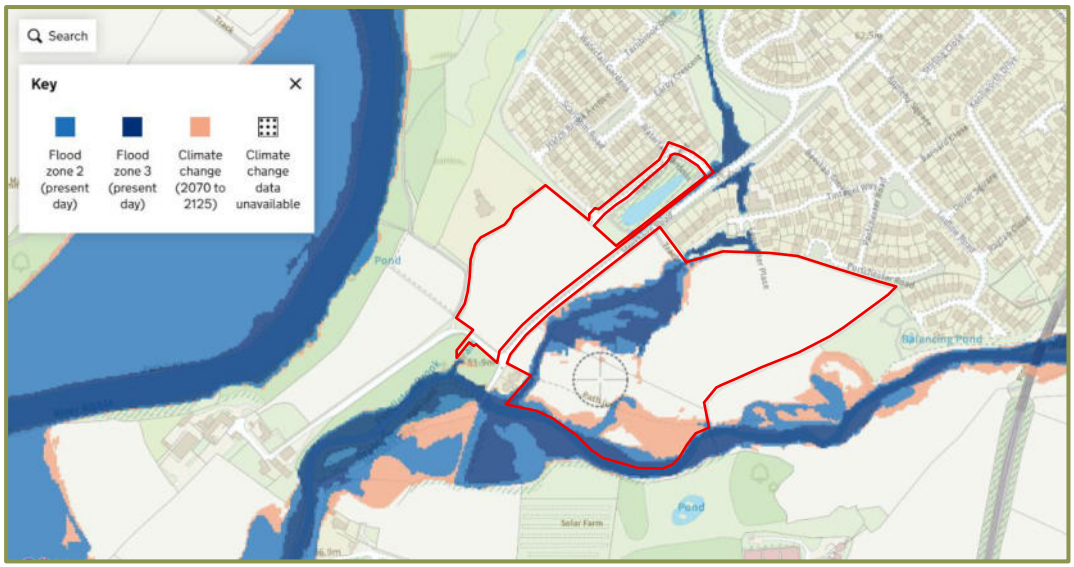
4.2.2 The EA Flood Zone mapping (Drawing 0003 and Figure 4.1) shows most of the western parcel is in Flood Zone 1, which is land outside the 1 in 1000-year (0.1% Annual Exceedance Probability [AEP]) extent of fluvial (river) flooding, at 'low' risk. There is however an area of

Flood Zone 2 and 3 along the reach of Watercourse 1, which affects the access at the Ingleton Crescent/Henthorn Road Junction. Flood Zone 2 is land between the 1 in 100-year (1% AEP) and 1 in 1000-year (0.1% AEP) probability of fluvial flooding, at 'medium' risk; whilst Flood Zone 3 is land within the 1 in 100-year (>1% AEP) risk of fluvial flooding, at 'high' risk.

ii. Eastern Parcel

4.2.3 The EA Flood Zone mapping (Drawing 0003 and Figure 4.1) shows most of the eastern parcel is in Flood Zone 1 (low risk), which is mostly limited to the central/eastern extent. There is an area of Flood Zone 2 and 3 (low to high risk) along the reach of Watercourse 1 and Pendleton Brook in the southern and western extents, respectively. The latest online mapping (Figure 4.1) shows part of the Site is in the mapped extent for climate change (2070 to 2125).

Figure 4.1: Environment Flood Map for Planning



Modelled Flood Levels and Flood Outline Mapping

i. River Ribble

4.2.4 The EA provided modelled flood levels for the River Ribble sourced from the Low Moor Model (June 2006) for an undefended scenario, for nodes along the River Ribble adjacent to the Site (Appendix 2).

4.2.5 Flood levels and flows were provided for a range of return periods, including the 1 in 5-year, 10-year, 25-year, 50-year, 75-year, and 100-year, as well as a 20% climate change uplift scenario for the 1 in 100-year (1% AEP) event.

4.2.6 Based on a review of the Flood Zone mapping, the Ribble does not affect the Site and no further analysis is required.

ii. Pendleton Brook

4.2.7 The EA also provided modelled flood levels for the Pendleton Brook, sourced from the Mearley Brook Model (December 2018) for both defended and undefended scenarios, for nodes along the Pendleton Brook adjacent to the Site (Appendix 2).

4.2.8 Flood levels and flows were provided for a range of return periods, including the 1 in 2-year, 5-year, 10-year, 20-year, 25-year, 30-year, 50-year, 75-year, 100-year, 200-year, and 1000-

year events. They additionally supplied +30/35/70% climate change uplifts for the defended 1 in 100-year (1% AEP) event and a +30% climate change uplift for the defended 1 in 1000-year (0.1% AEP) event (Appendix 2).

4.2.9 A summary of the modelled flood levels for the River Ribble is included in Table 4.2, and for the Pendleton Brook in Table 4.3. The node location plans are included in Figure 4.2.

Table 4.2: River Ribble Undefended Modelled Flood Levels (Low Moor Model, 2006)

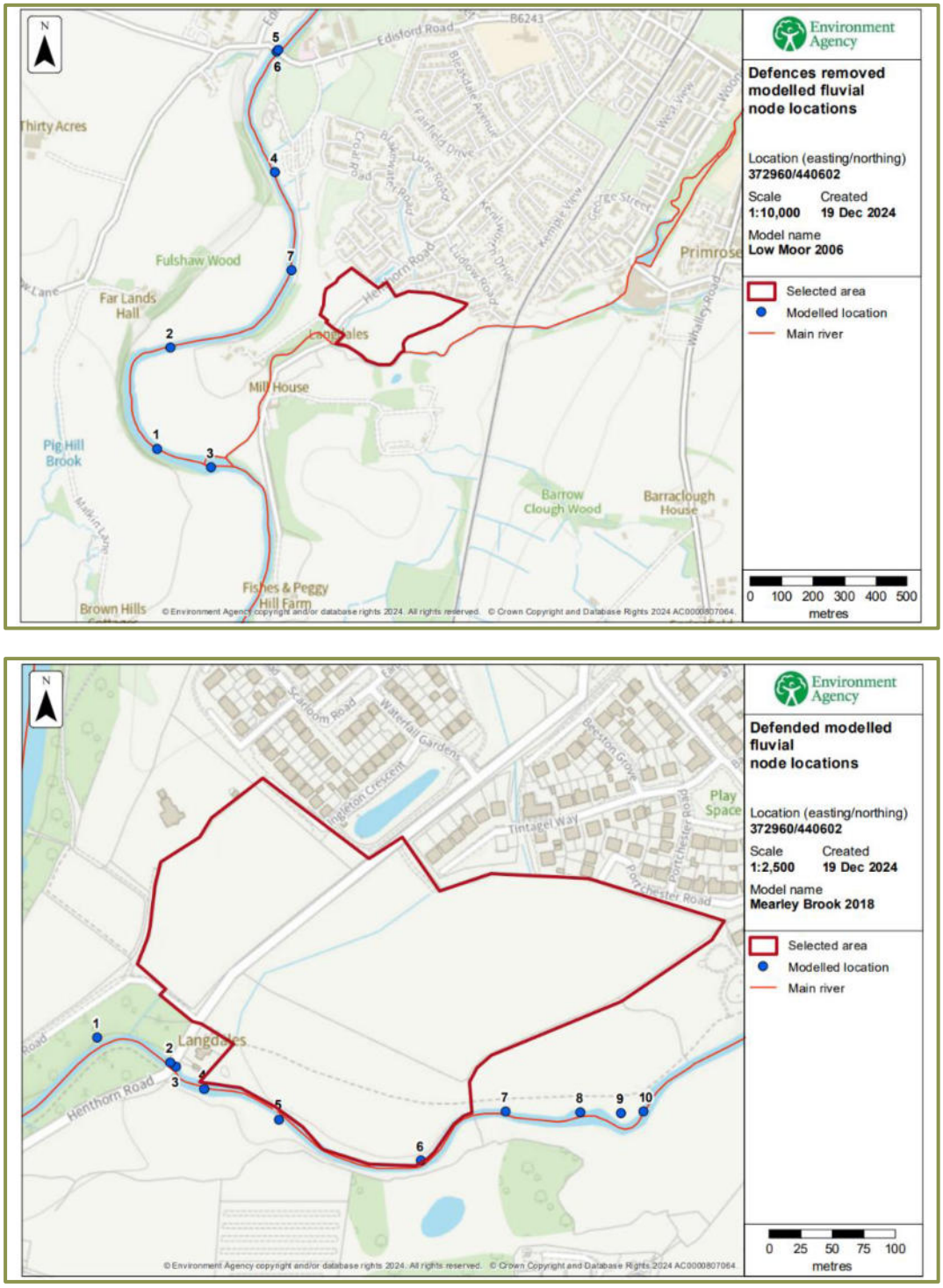
Node (ID)	Location (Easting, Northing)	Return Period / Flood Level (m AOD)			
		25yr (4% AEP)	75yr (1.33% AEP)	100yr (1% AEP)	100yr+CC (1%+CC AEP)
1 (1000863)	372246, 440178	45.40	45.62	45.67	45.89
2 (1000869)	372289, 440500	46.97	47.23	47.29	47.51
3 (1000867)	372418, 440119	44.72	44.29	44.98	45.20
4 (1000856)	372622, 441058	49.13	49.46	49.44	49.71
5 (1000846)	372627, 441441	50.18	50.48	50.53	50.83
6 (1000851)	372632, 441447	50.40	50.80	50.88	51.32
7 (1000839)	372675, 440747	48.28	48.58	48.65	48.90

Table 4.3: Pendleton Brook Defended Modelled Flood Levels (Mearley Brook Model, 2018)

Node (ID)	Location (Easting, Northing)	Return Period / Flood Level (m AOD)		
		30yr (3.33% AEP)	100yr (1% AEP)	1000yr (0.1% AEP)
1 (982257)	372732, 440548	48.67	48.90	49.42
2 (982193)	372790, 440529	49.01	49.23	49.62
3 (982403)	372795, 440525	49.48	49.98	50.92
4 (982188)	372817, 440507	49.50	50.01	50.99
5 (982354)	372877, 440483	49.84	50.23	51.06
6 (982247)	372990 , 440451	50.94	51.11	51.76
7 (982385)	373058, 440490	51.91	52.14	52.88
8 (982190)	373117, 440489	52.49	52.66	53.45
9 (982311)	373149, 440488	53.03	53.24	53.91
10 (982408)	373168, 440489	53.27	53.45	54.16

Node (ID)	Location (Easting, Northing)	Return Period / Flood Level (m AOD)		
		100yr +35%CC (1%+CC AEP)	100yr +70%CC (1%+CC AEP)	1000yr+30%CC (0.1%+CC AEP)
1 (982257)	372732, 440548	49.20	49.34	49.64
2 (982193)	372790, 440529	49.48	49.57	49.88
3 (982403)	372795, 440525	50.69	50.85	51.15
4 (982188)	372817, 440507	50.76	50.92	51.22
5 (982354)	372877, 440483	50.83	50.98	51.28
6 (982247)	372990 , 440451	51.50	51.66	52.18
7 (982385)	373058, 440490	52.53	52.75	52.99
8 (982190)	373117, 440489	53.01	53.27	53.70
9 (982311)	373149, 440488	53.63	53.85	54.11
10 (982408)	373168, 440489	53.79	54.08	54.38

Figure 4.2: Node Location Plans



Top: EA Low Moor Model Nodes. Bottom: EA Mearley Brook Model Nodes. Note, the indicative redline boundary does not align with the current application boundary.

4.2.1 The Higher (35%) and Upper (70%) climate change allowances are now superseded by latest climate change allowances (46% Higher and 71% Upper) for the Ribble Management Catchment.

4.2.2 It would be the responsibility of the applicant to obtain and re-run the existing model. When considering the worst-case scenario, the Upper (71%) climate change allowance is considered

the most appropriate modelled flood level to guide the proposed layout and management measures.

4.2.3 Node 6 along Pendleton Brook is considered the most relevant to the Site to assess modelled flood levels. The flood level for a climate change increase of +1%, representing the 'upper end' estimate was derived using the following linear interpolation calculation.

- 100-year +70% CC = 51.66mAOD) [-] 100-year (51.11mAOD) = 0.55m
- 0.55m/70% = 0.0078m per 1 percent increase
- 0.0078m x 1% = 0.0078m (increase due to +1% climate change increase)
- 100-year +70% (51.66m AOD) + 0.0078m = **51.67m AOD**

4.2.4 The 1 in 100-year (plus 71%CC) interpolated flood level (51.67m AOD) is less than the 1 in 1000-year event (51.76m AOD). The 1000-year modelled level is considered worst-case, and the current mapped outline should be used to guide the layout and management measures for Pendleton Brook and Watercourse 1.

Flood History

4.2.5 Correspondence with the EA (Appendix 2) and LLFA (Appendix 3) reported no historical fluvial flooding incidents within the Site boundary or immediate vicinity.

Flood Defences

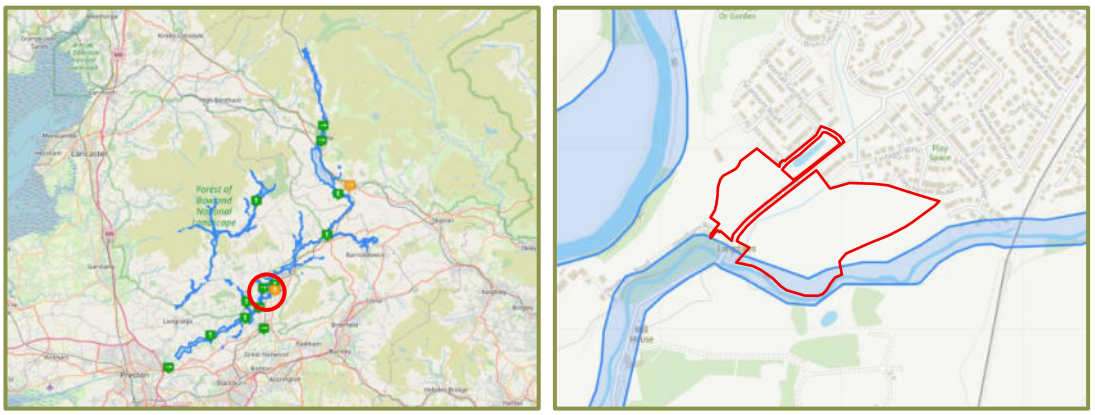
4.2.6 The EA Reduction in Risk of Flooding from Rivers and Sea online mapping shows the Site benefits from flood defences, consisting of 'Natural High Ground' along the bank of Pendleton Brook.

4.2.7 Correspondence with the EA (Appendix 2) reported one flood defence, consisting of an embankment, on the opposite side of Pendleton Brook from the Site, and therefore is not relevant to the Site.

Flood Warning Service

4.2.8 The River Levels UK website (Figure 4.3) shows the southern extent of the eastern parcel receives flood warnings for 'Upper River Ribble, Hodder'.

Figure 4.3: Flood Warning Areas



River Levels UK [2025].

Flood Risk Summary

4.2.9 The risk of fluvial flooding is assessed as negligible for most of the Site but medium to low along the reaches of onsite and bounding watercourses (Watercourse 1 and Pendleton Brook, respectively).

4.2.10 Measures required for fluvial flooding are discussed in Section 5.

4.3 Tidal Flooding

OS Mapping

4.3.1 OS mapping (Drawings 0001 to 0002) shows the Site is not located close to tidally affected flooding sources.

EA Flood Zone Mapping / Modelled Flood Levels

4.3.2 The EA mapped Flood Zones 2 and 3 (medium to high risk) are associated with fluvial flooding, and is not tidally influenced at this location.

Flood Risk Summary

4.3.3 The risk of tidal flooding 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.

Flood History

4.4.2 Consultation with the LLFA (Appendix 3) reported no historical groundwater flooding incidents within the Site boundary.

Geosmart Groundwater Flood Risk Map

4.4.3 The Geosmart 1 in 100-year groundwater flood risk map (Drawing 0004) shows the northern/north-west extents of the western parcel, and the central/northern extent of the eastern parcel are at negligible risk of groundwater flooding (Risk Class 4) (Table 4.2).

4.4.4 The eastern/southern extent of the western parcel, and the western/southern extents of the eastern parcel are in the mapped extent of low risk (Risk Class 3). There are limited areas along the reaches of Pendleton Brook and Watercourse 1 which are in the mapped extent of moderate risk (Risk Class 2).

4.4.5 The risk of groundwater flooding is likely to be associated with the Alluvium superficial deposits (where present), and proximity to onsite/bounding watercourses. Groundwater levels would be in hydrostatic continuity with fluvial flood levels along these watercourses. As such, fluvial flooding would be the dominant source of flooding in this location.

4.4.6 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 4.3).

Table 4.3: 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.

Soakaway Testing Results

4.4.7 The Site is underlain by clayey soils and superficial deposits. Soakaway testing did not encounter groundwater ingress in any of the nearby trial pits to depths of 2.20m bgl (Appendix 5). Based on the low infiltration rates, any groundwater present would not rise to the surface.

Flood Risk Summary

4.4.8 The risk of groundwater flooding is assessed as negligible above ground, and low below ground.

4.4.9 Measures required for 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 groundwater levels.

Flood History

4.5.2 Consultation with the LLFA (Appendix 3) reported no historical surface water flooding incidents within the Site boundary.

EA Risk of Flooding from Surface Water Mapping

4.5.3 The EA Risk of Flooding from Surface Water [RoFSW] (Drawings 0006.1 to 0006.2) shows most of the Site is located outside the mapped extent of surface water flooding.

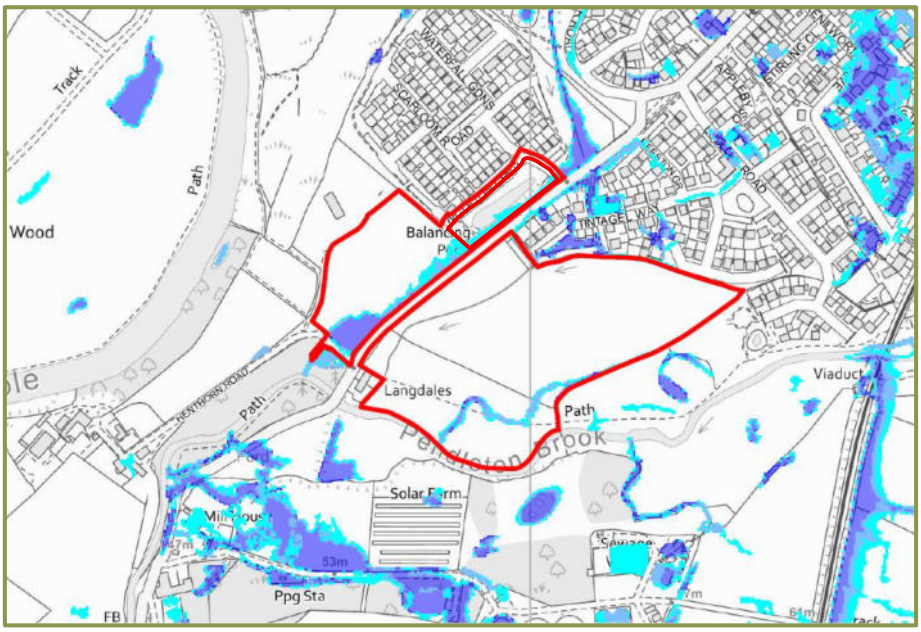
i. Western Parcel

4.5.4 A flow pathway (low to high risk) is orientated south-west along/through the eastern boundary of the western parcel, which ponds in the southern extent (Figure 4.4).

4.5.5 The flow pathway originates from a flow pathway located along the reach of Watercourse 1, to the north-east of the western parcels access from Henthorn Lane.

4.5.6 The flood outline is indicative of fluvial flooding, but does not account for the conveyance capacity of the watercourse channel and Henthorn Road culvert crossing. As such, the fluvial Flood Map for Planning (Figure 4.1) should supersede the surface water Flood Map in this location.

Figure 4.4: Surface Water [RoFSW] vs EA Flood Zone Mapping



ii. Eastern Parcel

4.5.7 A flow pathway (low to high risk) is orientated south-west through the southern extent of the eastern parcel. The flow pathway originated within the Site boundary and is indicative of overland flows generated by low permeable (clayey) soils/geology and localised topography.

EA Long Term Flood Risk Mapping

4.5.8 In January 2025, the EA released an update to their online Long Term Flood Risk mapping, including that of surface water. The new mapping still presents the likelihood of flood extents as 'Low', 'Medium' and 'High' chance, as well as now providing the likelihood of estimated flood depths (up to 0.20, 0.30, 0.60, 0.90 and 1.20m) as 'Very low', 'Low', 'Medium', and 'High' chance.

4.5.9 Additionally, the new mapping includes the same risk classes for extent and depth with a pre-applied 'Central Allowance' climate change uplift. This is based on the latest UK Climate Projections (UKCP18) from the Met Office, using the Representative Concentration Pathway (RCP) 8.5 to derive the new near-term '2040 to 2060' epoch. The mapping also now utilises a 2m grid as an improvement to the spatial resolution of the data.

4.5.10 The EA Long Term Flood Risk Mapping (Figure 4.5), considering the 2040 to 2060 epoch as a worst-case scenario, shows most of the Site is located outside the mapped extent of surface water flooding. There is however flow pathways associated with the western and eastern parcels, as described above. The flood extents for the flow pathways are Low' (0.1% to 1% AEP) to 'High' (>3.3% AEP) chance of flooding between 2040 and 2060; whilst the depths and their respective chance are detailed below:

i. Western Parcel

- Up to 20cm: 'Low' to 'Medium' along the flow pathway, and 'Low' to 'High' in the ponded area in the southern extent.
- Up to 30cm: 'Low' along the flow pathway, and 'Low' to 'High' in the ponded area in the southern extent.
- Up to 60cm: No depth along the flow pathway, and 'Low' to 'High' in the ponded area in the southern extent.
- Up to 90cm: No mapped outlines.

4.5.11 The flood outline is indicative of fluvial flooding, but does not account for the conveyance capacity of the watercourse channel and Henthorn Road culvert crossing. As such, the fluvial Flood Map for Planning (Figure 4.1) should supersede the surface water Flood Map in this location.

ii. Eastern Parcel

- Up to 20cm: 'Low' to 'High' along the flow pathway.
- Up to 30cm to up to 90cm: No mapped outlines.

4.5.12 The flow pathway is indicative of overland flows generated by low permeable (clayey) soils and geology, and localised topography. This area of flooding should be managed as surface water flooding.

Figure 4.5: EA Long Term Flood Risk Mapping

RoFSW Climate Change Extents. Contains EA information © EA and database right [2025].

RoFSW Climate Change <20cm Depth. Contains EA information © EA and database right [2025].

RoFSW Climate Change <30cm Depth. Contains EA information © EA and database right [2025].

RoFSW Climate Change <60cm Depth. Contains EA information © EA and database right [2025].

RoFSW Climate Change <90cm Depth. Contains EA information © EA and database right [2025].

Flood Risk Summary

4.5.13 The risk of surface water flooding is assessed as negligible for most of the Site but low to high along the flow pathway through the southern extent of the eastern parcel.

4.5.14 Measures required for surface water flooding are discussed in Section 5.

4.6 Sewer and Mains Flooding

Introduction

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 adoptable sewers are built to have a minimum design standard up to and including the 1 in 30-year rainfall event. Older sewers were not designed to any standard. Modern sewer systems will only surcharge during rainstorm events with a return period greater than 1 in 30-years (e.g. 1 in 100-years).

Asset Plans

4.6.3 United Utilities asset plans (Appendix 4) and Miller Homes drainage drawing (Figure 3.16) shows there are a number of public and private assets within the Site boundary and the immediate vicinity, including the following:

- Ø150mm public foul sewer orientated south-west beneath (through) the eastern extents of the western parcel.
- Ø375mm public combined sewer, orientated south-east beneath the private road within the southernmost extent.
- Ø300mm piped surface water outfall (orientated south-west beneath (through) the eastern extent of the western parcel, which serves the Miller Homes development to the north.

- United Utilities asset plans (Appendix 4 and extract in Figure 3.17) show there are no public sewers recorded within the boundary of the eastern parcel.
- Separate public surface water and foul network serving the residential dwellings to the north of the eastern parcel - the public surface water sewer network outfalls to Watercourse 1 via a Ø225mm piped outlet from an assumed attenuation (tank) feature, along the northern boundary.
- A 63mm main orientated east to west through the northern and southern extent of the western parcel. A 63mm main is also located along the existing access.
- A 4" main is orientated north to south through the north-west extent of the eastern parcel.

4.6.4 There is a residual (low) risk of surcharging or leaking of the above assets, which would result in shallow overland flows (<150mm), which would shed overland (following the localised topography of the Site) as per existing conditions (Drawing 007).

Flood Risk Summary

4.6.5 The risk of flooding from sewers and mains is assessed as negligible. There is however a residual (low risk) event for sewers or mains to leak or surcharge.

4.6.6 Measures required for residual flooding are discussed in Section 5.

4.7 Flooding from Infrastructure Failure

Reservoir Failure

4.7.1 The EA online flood mapping shows the Site is outside the extent of flooding sourced from reservoirs.

Attenuation Pond Failure

4.7.2 The attenuation pond serving the Miller Homes residential development to the north/north-east has been designed in line with national guidance, and will be incorporate into a maintenance and management plan, which will ensure its effectiveness for the lifetime of the development.

4.7.3 A storm event in excess of this design standard would be extreme and would cause the attenuation pond to overtop (with no sudden deluge), and would then shed overland following the topography (south) through the Site/Henthorn Road.

Flood Risk Summary

4.7.4 The risk of flooding from infrastructure failure is assessed as negligible.

5.0 Planning and Flood Risk

5.1 Introduction

5.1.1 The main steps to be followed in addressing flood risk are set out below:

5.2 Assess

5.2.1 As per Paragraph: 003 Reference ID: 7-003-20220825 (Revision date: 25 08 2022) of NPPG ID7, we have prepared a site-specific FRA to assess flood risk from all sources to the Development.

Baseline Flood Risk to the Site

- The risk of fluvial flooding is assessed as negligible for most of the Site but medium to low along the reaches of onsite and bounding watercourses (Watercourse 1 and Pendleton Brook, respectively).
- The risk of groundwater flooding is assessed as negligible above ground, and low below ground.
- The risk of surface water flooding is assessed as negligible for most of the Site but low to high along the flow pathway through the southern extent of the eastern parcel.
- The risk of flooding from sewers and mains is assessed as negligible. There is however a residual (low risk) event for sewers or mains to leak or surcharge.
- Flood risk from all other sources is assessed as negligible.

Flood Risk to the Developable Area and Vehicle Access

- The risk of flooding to the developable area and vehicle access is assessed as negligible to low and acceptable from all sources, subject to implementation of the below management measures.

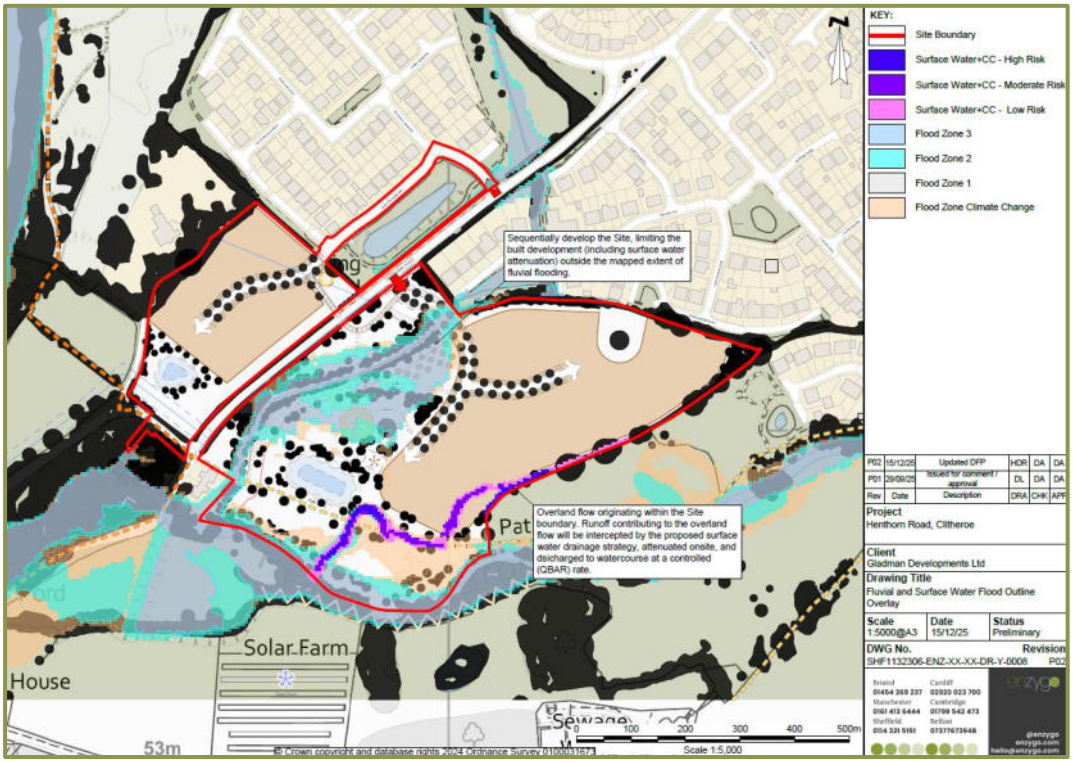
5.3 Decision Making Process

Avoid

5.3.1 We recommend the following avoidance measures to manage the risk of flooding to and from the development:

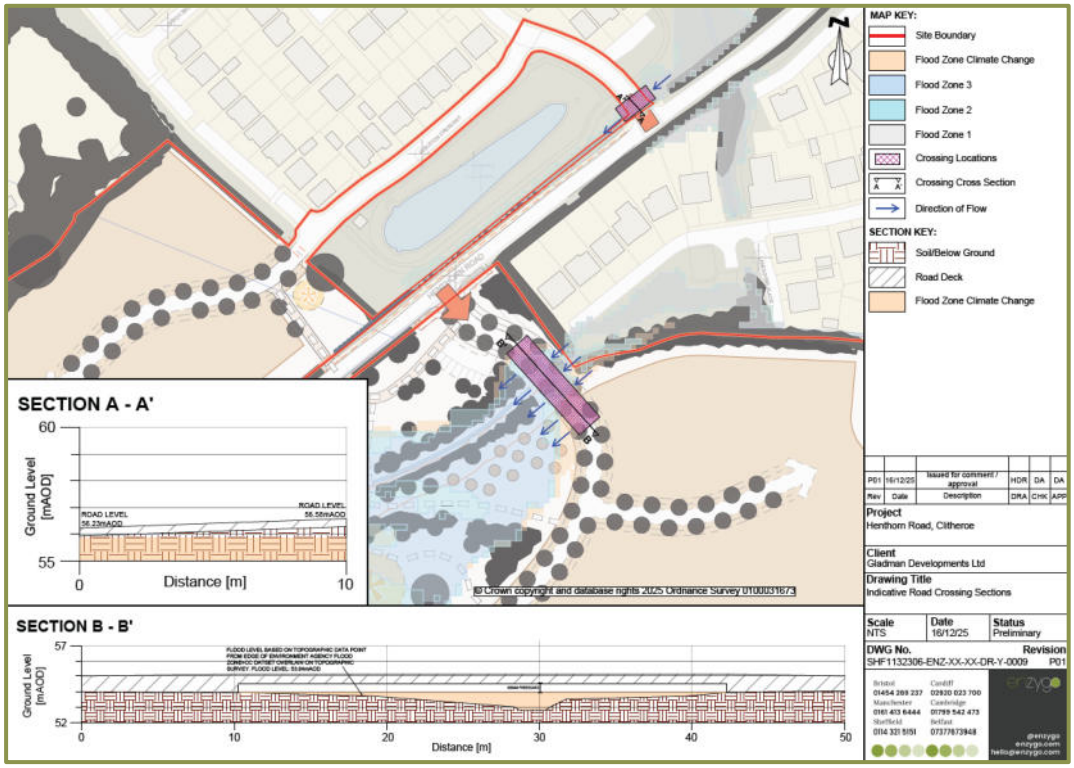
- Sequentially develop the Site, limiting the built development outside the mapped extent of fluvial flooding for the 1000-year event (as per Drawing 0008 - extract included in Figure 5.1).

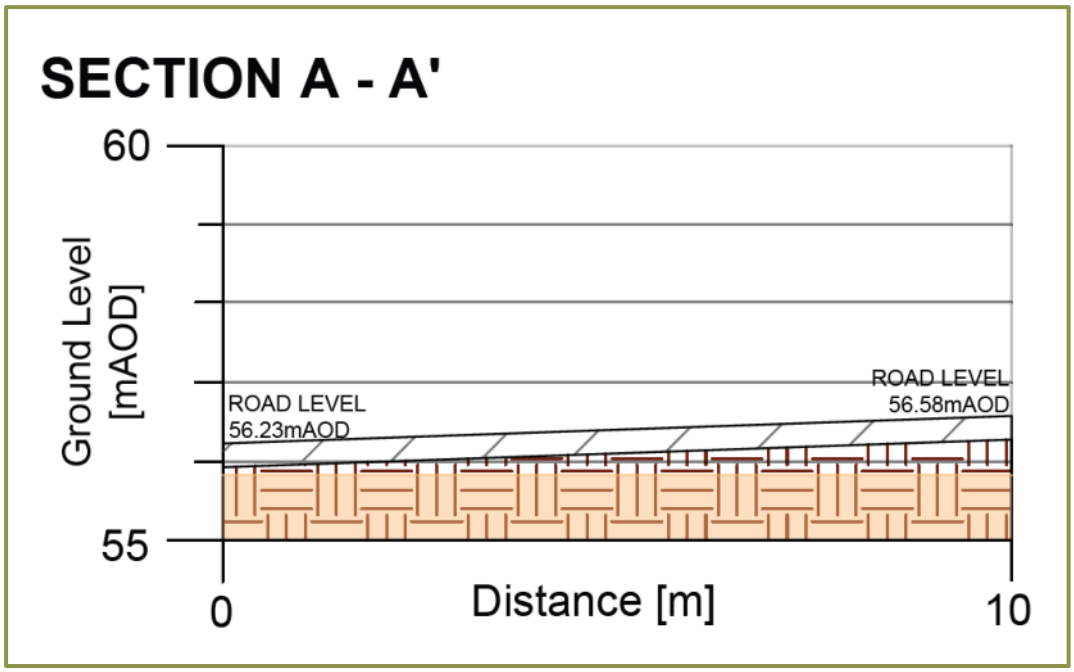
Figure 5.1: Fluvial and Surface Water Flood Outline Overlay



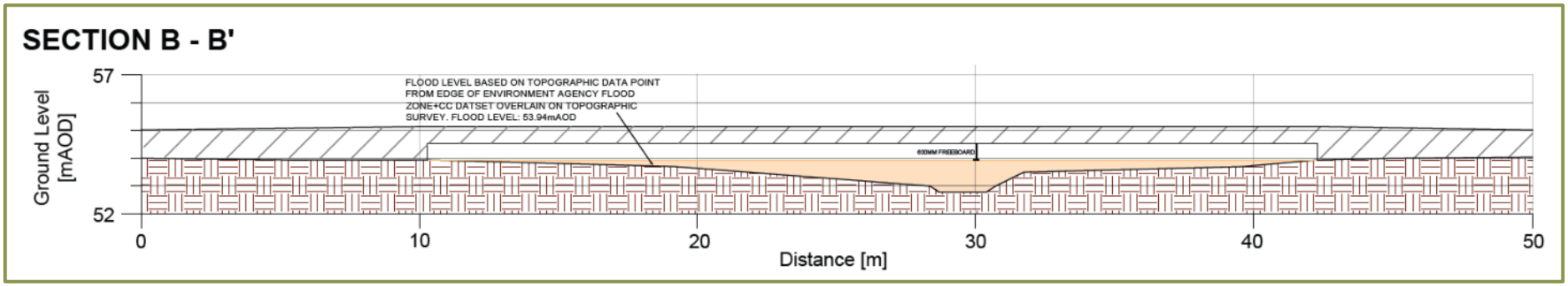
- Set the surface water outfall from the proposed development at an appropriate height, above the bed level of the receiving watercourse.
- Set building floor levels +300mm above external levels for dwellings closest to the mapped flood outline, grading back to +150mm for dwellings located further away.
- Provide safe/dry access, with access roads set above the above the 1 in 100-year plus climate change or 1 in 1000-year event flood level (whichever is greatest).
    - The existing access to the western parcel (via the Miller Homes access from Henthorn Road) is set above the level of the extreme climate change (2070 to 2125) mapped level (see Drawing 0009 / Figure 5.2 Section A-A).
    - It is proposed that the developable area in the eastern parcel is accessed via a free-spanning bridge across Watercourse 1 and the associated floodplain, with soffit levels set 600mm above the level of the extreme climate change (2070 to 2125) mapped level (see Drawing 0009 / Figure 5.2 Section B-B). The proposed crossing will allow for the free conveyance of flood water, without increase flood risk to and from the development.

Figure 5.2: Indicative Road Crossing Sections





Western parcel's existing highway access from Henthorn Road.



Eastern parcels free spanning bridge over Watercourse 1 and associated floodplain.

- Reprofile onsite channels (i.e. scrape the channel to remove overgrown vegetation and build-up of silt/soft bed) to increase the capacity and the conveyance of the channel (in line with Environment Agency's online guidance 'Owning a watercourse: Your responsibilities and rules to follow for watercourses on or near your property, and permissions you need to do work around them'[27].
- No below surface habitable buildings (i.e. basements).
- Lined attenuation to prevent groundwater ingress.

5.3.2 Further to the above, the following measures are recommended in line with statutory requirements / following best practice:

- Provide a 4m easement free from development along either side of Watercourse 1 and Drain 1 (ordinary watercourses), and an 8m easement free along the reach of Pendleton Brook (main river). These easements would provide access for inspection and maintenance purposes, including vehicle access.
- Provide a development free easement (3m either side) of onsite public foul and private surface water sewer assets in the western parcel.
- Provide a development free easement (3m either side) of onsite public mains assets, or re-direct through the Site boundary.

Control

5.3.3 We recommend the following control measures to manage the risk of flooding to and from the development:

- Adoption of a surface water management strategy (see Section 6).
  - Runoff contributing to the overland flow originating within the south-east extent of the eastern parcel Site boundary will be intercepted by the proposed surface water drainage strategy, attenuated onsite, and discharged to watercourse at a controlled (QBAR) rate.
- Undertake maintenance activities to keep onsite and bounding watercourses clear from debris and overgrown vegetation to maintain the conveyance of the channels.
- Fit the outfall with backflow prevention and provide a high-level overflow.

Mitigate

5.3.4 Based on the above avoidance measures, no mitigation measures are proposed.

Manage Residual Risk

5.3.5 Based on the above measures, no residual risk management measures are proposed.

5.4 Summary

5.4.1 Table 5.1 summarises the risk of flooding, both without and with recommended measures.

[27] https://www.gov.uk/guidance/owning-a-watercourse

Table 5.1: Risk of Flooding and Recommended Measures

Source of Flooding	Risk of Flooding	Risk Without Measures	Recommended Measures	Risk to Development with Measures
Fluvial - Pendleton Brook, Watercourse 1, and Drain 1	Negligible for most of the Site, but Medium to High along the reaches of onsite and bounding watercourses	Negligible for most of the Site, but Medium to High along the reaches of onsite and bounding watercourses	Avoid	Negligible to Low
Tidal - None identified	Negligible	Negligible	N/A	Negligible
Groundwater - Secondary A and Undifferentiated Aquifers (Superficial designation), Secondary A Aquifer (Bedrock designation)	Negligible above ground, and low below ground	Negligible above ground, and low below ground	Avoid	Negligible
Surface Water - Poor permeability and Site topography	Negligible for most of the Site but Low to High along the flow pathway through the southern extent of the eastern parcel	Negligible for most of the Site but Low to High along the flow pathway through the southern extent of the eastern parcel	Avoid	Negligible to Low
Sewers and Mains - Public and private sewer assets, public mains	Negligible for most of the Site but Low (residual) along surcharge overland flows	Negligible for most of the Site but Low (residual) along surcharge overland flows	Avoid	Negligible
Infrastructure Failure - Reservoir and attenuation pond failure	Negligible	Negligible	N/A	Negligible

Key: Green - Negligible, Yellow - Low, Orange - Medium and Red - High; based on risk with without/with recommended measures from each flooding source.

6.0 Surface Water Drainage

6.1 Introduction

6.1.1 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 management should build in enough capacity for the entire Site.

6.1.2 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.

6.1.3 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 7.17ha Site is comprised of two agricultural (grazing) land parcels, located to the west (1.746ha) and east (5.425ha) of Henthorn Road.

6.2.2 The Site is underlain by low permeability (clayey) soils and geology. Drainage is predominantly via overland flow, following the topography of the Site (south) towards onsite and bounding watercourses, with a small amount of infiltration to bedrock, and throughflow to watercourse.

6.3 Developable and Impermeable Areas

6.3.1 An allowance of 55% impermeable area (inclusive of 10% for urban creep) was applied to the 0.972ha developable area in the western parcel (excluding existing access road), and 2.266ha developable area in the eastern parcel. The existing and proposed impermeable areas are summarised in Tables 6.1 and 6.2.

6.3.2 The proposed development will increase the impermeable surfaces and so increase the amount of runoff.

Table 6.1: Impermeable Area - Western Parcel

Area	Existing Buildings and Hardstanding	Proposed Buildings and Hardstanding	Difference
Area (ha)	0.00	0.53	+0.53
Percentage of Total Site Area (%)	0.0	32.2	+32.2

Table 6.2: Impermeable Area - Eastern Parcel

Area	Existing Buildings and Hardstanding	Proposed Buildings and Hardstanding	Difference
Area (ha)	0.00	1.246	+1.246
Percentage of Total Site Area (%)	0.0	23.2	+23.2

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 the HRWallingford UKSuDS online tool, with FEH method inputs (descriptors obtained from the FEH webservice[28]). This is a recommended methodology for Sites up to 50ha in area and the approach is in line with the current 'industry best practice' guidelines as outlined in the Interim Code of Practice for SuDS[29], and EA Report SC030219 - Rainfall runoff management for developments.

6.4.3 The following parameters were used in the runoff calculations:

- Developable Area:
  - Western Parcel: 0.972ha
  - Eastern Parcel: 2.66ha
- Average Annual Rainfall (SAAR): 1178mm/year
- Region No.: 10
- BFIHOST19: 0.417

6.4.4 BFIHOST was updated to BFIHOST19 (November 2019) since a number of issues were identified with BFIHOST, which including a tendency to underestimate BFI in clay-dominated catchments.

6.4.5 BFIHOST19 is the baseflow index developed using the Hydrology of Soil Types (HOST) classification and is the baseflow proportion of the flow on average. It is estimated based on the daily mean flow data. Baseflow comprises water entering the watercourse through shallow subsurface flow and groundwater flow (mechanisms other than direct surface runoff); hence permeable soils and geology tend to yield a higher baseflow.

6.4.6 The Soilscapes online soils map viewer and Geology of Britain online map viewer identified the following, which were confirmed by soakaway trial pit logs (Appendix 5):

- Soils: Slowly permeable, seasonally wet, loamy and clayey soils / loamy and clayey floodplain soils with naturally high groundwater.
- Superficial Deposits: Devensian Till – Diamicton / Alluvium - Clay, silt, sand and gravel.
- Bedrock: Clitheroe Limestone Formation and Hodder Mudstone Formation – Mudstone / Permian and Triassic Rocks - Sandstone and mudstone.

6.4.7 BFIHOST19 value assigned by the FEH webservice is considered to replicate on-site conditions.

6.4.8 Table 6.3 shows the calculated greenfield runoff rates. Runoff calculations are included in Appendix 6.

6.4.9 A climate change allowance of 50% was applied to the 1 in 100-year rainfall event, in line with the Ribble Management Catchment Peak Rainfall Allowances (Figure 6.1).

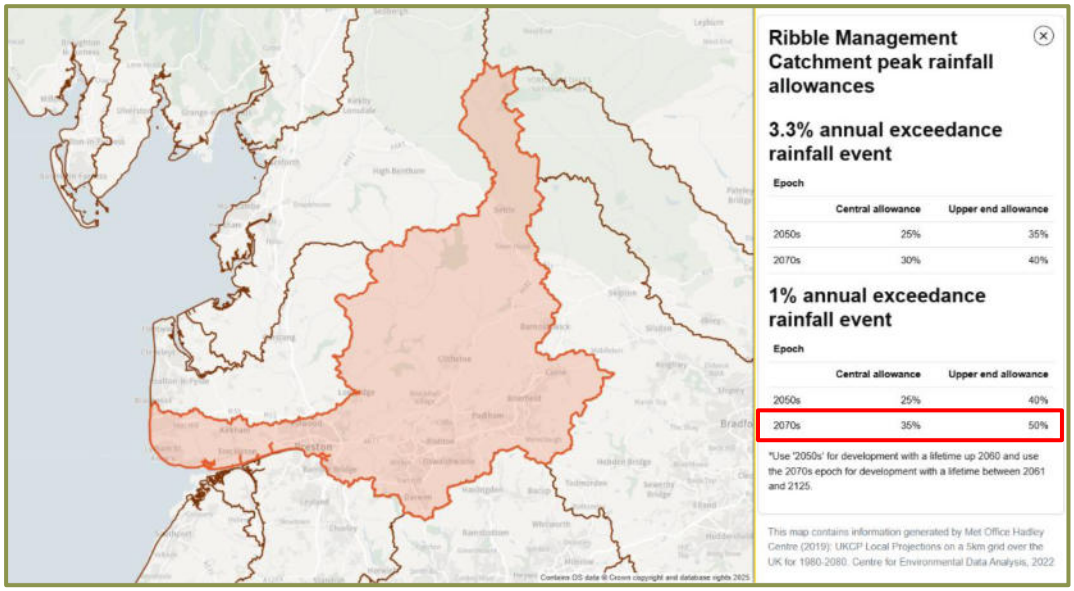
[28] Centre for Ecology and Hydrology, Flood Estimation Handbook Web Service [https://fehweb.ceh.ac.uk/].
[29] Office of the Deputy Prime Minister, National SuDS Working Group (July 2004) Interim Code of Practice for Sustainable Drainage Systems [https://www.susdrain.org/files/resources/other-guidance/nswg_icop_for_suds_0704.pdf].

Table 6.3: Greenfield Runoff Rates

Annual Probability (Return Period, Years)	Greenfield Runoff (l/s) - Western Parcel	Greenfield Runoff (l/s) - Eastern Parcel	Total (l/s)
QBAR	6.38	14.72	21.10
100% (1)	5.60	12.80	18.40
3.33% (30)	10.80	25.00	35.80
1% (100)	13.30	30.60	43.90
1% Plus Climate Change	19.95	45.90	65.85

Note: 50% climate change added. The 1 in 1-year, 30-year and 100-year annual probability events are of importance to the Water Companies and the EA when looking at sewage discharge and flood risk.

Figure 6.1: Ribble Management Catchment Peak Rainfall Allowances



6.5 Surface Water Management Strategy

Hierarchy of Discharge

6.5.1 In accordance with requirement H3 of the Building Regulations 2010[30] rainwater runoff must discharge to one of the following, listed in order of priority:

1. ***An adequate soakaway or some other adequate infiltration system:*** The use of infiltration-based SuDS is not feasible due to low infiltration potential into the clayey soils and geology, demonstrated through soakaway test results undertaken on an adjacent development (Appendix 5).
2. ***A watercourse:*** Pendleton Brook conveys flows west along the southern boundary of the eastern parcel.

   Watercourse 1 conveys flows south-west, through the western extent of the eastern parcel, and is a tributary of Pendleton Brook.

[30] Office of the Deputy Prime Minister, The Building Regulations 2010, amended 2021 [https://www.gov.uk/government/publications/drainage-and-waste-disposal-approved-document-h]

Drain 1 is orientated south-west along the eastern boundary of the eastern parcel, and is a tributary of Pendleton Brook

3. ***A sewer:*** There are no public surface water sewers located within the immediate vicinity of the Site.

i. Western Parcel

6.5.2 The potential route for discharging surface water from the western parcel involves directing it to Pendleton Brook through a land drain to the south. The exact route to the watercourse (tbc at the detailed design stage) could be either:

- A connection to the existing Miller Homes outfall.
- Through the ancient woodland to the south.

6.5.3 A secondary option would be to the public combined sewer to the south.

ii. Eastern Parcel

6.5.4 The potential route to discharge surface water from the eastern parcel will be to Watercourse 1.

6.6 Sustainable Drainage Options (SuDS)

Choice of SuDS Options

6.6.1 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.

6.6.2 Current guidance promotes sustainable water management using SuDS. Options applicable to this Site are identified in Table 6.4.

Table 6.4: SuDS Options

Green roofs	Infiltration basins
Water butts	Attenuation 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.

6.6.3 A hierarchy of SuDS techniques is identified[31]:

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).

[31] CIRIA (2004) Report C609, Sustainable Drainage Systems - Hydraulic, Structural and Water Quality advice.

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.

6.6.4 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.
- Replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

SuDS Maintenance

6.6.5 Detention basins will form the main attenuation features within the development Site, with permeable paving, rain gardens or swales integrated as part of the treatment train. Water butts could be utilised to encourage rainwater collection and reuse.

6.6.6 Maintenance of the SuDS features would be in line with the SuDS Manual (CIRIA C753, 2015), as detailed in Figures 6.2 to 6.5. It is standard for SuDS features within a new development to be maintained by a private maintenance company unless the council adopt it. If the maintenance company goes into administration, the Site will be contracted to a new maintenance company. Residents will pay a surcharge to the maintenance company and a number of them would be appointed to its board. This will ensure maintenance throughout the lifetime of the development.

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

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

Figure 6.3: Pervious Pavements Operation and Maintenance Requirements (Table 20.15 of the SuDS Manual)

TABLE 20.15 Operation and maintenance requirements for pervious pavements

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface)	Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations – pay particular attention to areas where water runs onto pervious surface from adjacent impermeable areas as this area is most likely to collect the most sediment
Occasional maintenance	Stabilise and mow contributing and adjacent areas	As required
	Removal of weeds or management using glyphosate applied directly into the weeds by an applicator rather than spraying	As required – once per year on less frequently used pavements
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, and replace lost jointing material	As required
	Rehabilitation of surface and upper substructure by remedial sweeping	Every 10 to 15 years or as required (if infiltration performance is reduced due to 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	Three-monthly, 48 h after large storms in first six months
	Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually
	Monitor inspection chambers	Annually

Figure 6.4: Swale Operation and Maintenance Requirements (Table 17.1 of the SuDS Manual)

TABLE 17.1 Operation and maintenance requirements for swales

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly, or as required
	Cut grass – to retain grass height within specified design range	Monthly (during growing season), or as required
	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 infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48 hours	Monthly, or when required
	Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Half yearly
Occasional maintenance	Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required	As required or if bare soil is exposed over 10% or more of the swale treatment area
Remedial actions	Repair erosion or other damage by re-turfing or reseeding	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required
	Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip	As required
	Remove and dispose of oils or petrol residues using safe standard practices	As required

Figure 6.5: Bioretention Systems Operation and Maintenance Requirements (Table 18.3 of the SuDS Manual)

TABLE 18.3 Operation and maintenance requirements for bioretention systems

Maintenance schedule	Required action	Typical frequency
Regular inspections	Inspect infiltration surfaces for silting and ponding, record de-watering time of the facility and assess standing water levels in underdrain (if appropriate) to determine if maintenance is necessary	Quarterly
	Check operation of underdrains by inspection of flows after rain	Annually
	Assess plants for disease infection, poor growth, invasive species etc and replace as necessary	Quarterly
	Inspect inlets and outlets for blockage	Quarterly
Regular maintenance	Remove litter and surface debris and weeds	Quarterly (or more frequently for tidiness or aesthetic reasons)
	Replace any plants, to maintain planting density	As required
	Remove sediment, litter and debris build-up from around inlets or from forebays	Quarterly to biannually
Occasional maintenance	Infill any holes or scour in the filter medium, improve erosion protection if required	As required
	Repair minor accumulations of silt by raking away surface mulch, scarifying surface of medium and replacing mulch	As required
Remedial actions	Remove and replace filter medium and vegetation above	As required but likely to be > 20 years

Drainage Design Summary

6.6.8 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.

6.6.9 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.

6.6.10 Surface water will be directed to onsite detention basins, positioned to achieve gravity fed connections to watercourse.

6.6.11 A SuDS treatment train, including permeable paving, rain gardens or swales will improve water quality. Water butts could be utilised to encourage rainwater collection and reuse.

6.6.12 At this stage, the drainage strategy proposes the use of basic rainwater harvesting measures such as water butts to support non-potable use (e.g. garden irrigation), which aligns with the revised SuDS hierarchy. The potential for more integrated rainwater harvesting solutions (e.g. for WC flushing) will be further explored at the reserved matters stage, subject to detailed layout and viability.

6.6.13 An outline surface water drainage layout is in Drawing 0010.

Attenuation Requirements

6.6.14 Attenuation storage is required to reduce the post-application surface water runoff from the Site to calculated greenfield runoff rates, up to and including the 1 in 100-year (+50%CC) rainfall event, assuming no infiltration losses.

6.6.15 The following input parameters were assumed in the calculations:

- Impermeable Areas:
  - Western Parcel: 0.54ha
  - Eastern Parcel: 1.26ha
- Cv (proportion of rainfall forming surface water runoff): 100% summer, 100% winter;
- Infiltration losses: 0.00m/hour;
- With outfall: (Table 6.2):
  - Western Parcel: 6.38l/s
  - Eastern Parcel: 14.72l/s

6.6.16 The attenuation volumes for the 1 in 100-year event (plus climate change) are:

- Western Parcel: 444m^3
- Eastern Parcel: 1045m^3

6.6.17 Attenuation calculations are included in Appendix 6. The calculated runoff rates and attenuation volumes will be reviewed at detailed design stage.

6.7 Exceedance Routes

6.7.1 Detention basins will be designed with a capacity up to a 1 in 100-year (plus 50% climate change) event, with a +300mm freeboard allowance, based on the QBAR restricted discharge rate for each basin. This provides a betterment (reduction) in runoff when compared to existing undeveloped conditions, where runoff is uncontrolled across all return periods.

6.7.2 A storm event in excess of this design standard would be extreme and would cause the detention basins to overtop (with no sudden deluge) and would then shed overland following the topography towards onsite/bounding watercourses, as per existing conditions (Drawing 0007).

6.7.3 Finished floor levels of new dwellings will be set above external levels, which will manage the residual risk of overtopping.

6.8 Offsite Runoff

6.8.1 Land to the north of both the western and eastern parcels is currently developed, and served by an existing surface water drainage arrangement. As such, there is a negligible risk of offsite runoff entering the Site.

6.8.2 There is a small undeveloped area to the north-west of the western parcel, which falls towards the Site. Any residual risk of offsite runoff will be intercepted by an interception ditch, incorporation check dams. Any intercepted flows will infiltrate over time.

6.9 Greenspace Runoff

6.9.1 The layout of the development incorporates the majority of greenspace to the south/south-east of the western parcel, and south/south-west/west of the eastern parcel. These areas are located topographically lower than the proposed development areas. As such, runoff from these areas will shed overland, away from the developable areas (as per existing conditions). As such, there is no risk of runoff from these large greenspace areas getting into the proposed surface water drainage network.

6.9.2 Smaller greenspace areas located in and around the developable areas are mitigated against in the drainage calculations, whereby a Cv (proportion of rainfall forming surface water runoff) value of 1 (i.e. 100% impermeable) has been used. Furthermore, we have made an allowance in the drainage calculations for 5% additional area, which would account for additional areas contributing to the drainage network.

6.9.3 The above should be sufficient at outline stage, and will be refined at detailed design stage. Note, the proposed attenuation basins are in large areas of greenspace, and there should not be any restrictions to accommodate any future amendments.

6.10 Water Quality

Operations Phase

6.10.1 Water quality improvements are achieved by decreasing flow rates, which in turn traps silt, sediment, and pollutants before discharging to the sewer.

6.10.2 A SuDS treatment train, including permeable paving, rain gardens or swales will improve water quality. Water butts could be utilised to encourage rainwater collection and reuse.

6.10.3 The online Simple Index Approach [SIA] Tool[32] has been used to demonstrate the effectiveness of the proposed strategy to manage surface water quality. A copy of the calculations is included in Appendix 7, and a summary of the results are included in Tables 6.5 and 6.6.

6.10.4 A maintenance and management ensure the effectiveness of the drainage strategy during the operation phase.

[32] https://www.susdrain.org/resources/SuDS_Manual.html

Table 6.5: Simple Index Approach Results Summary - Swales or Rain Garden

	Total Suspended Solids	Metals	Hydrocarbons
Pollution Hazard Score	0.7	0.6	0.7
Pollution Mitigation Score	0.75	0.85	>0.90
Sufficiency of SuDS	Sufficient	Sufficient	Sufficient

Table 6.6: Simple Index Approach Results Summary - Permeable Paving

	Total Suspended Solids	Metals	Hydrocarbons
Pollution Hazard Score	0.5	0.4	0.4
Pollution Mitigation Score	0.95	0.85	>0.95
Sufficiency of SuDS	Sufficient	Sufficient	Sufficient

Construction Phase

6.10.5 Implementation of a Construction Environmental Management Plan during the construction phase will manage surface water and foul drainage, thereby mitigating the potential for impacts on hydrology, flood risk, and water quality.

SuDS Proforma

6.10.6 A copy of the Lancashire County Council SuDS Proforma is included in Appendix 8.

7.0 Foul Drainage Strategy

7.1 Proposed Strategy

7.1.1 It is proposed that foul flow is discharged to the nearby public combined sewer beneath Henthorn Road. The topography of the western parcel would allow for a gravity fed connection. The eastern parcel would require a pumped solution, which would also need to pass beneath Watercourse 1.

7.1.2 An outline foul drainage layout is in Drawing 0011.

7.1.3 In accordance with the Design and Construction Guidance[33] document, peak foul water discharge from a residential development is 4,000 litres per property per day. Using this method, peak foul flows are estimated to be 5.32l/s from the 115-unit residential development. The calculated foul flow rate will be reviewed at detailed design stage.

7.1.4 All foul sewerage should be designed in accordance with Building Regulations Part H34. In areas where sewers are to be adopted by United Utilities, sewerage should be designed in accordance with Design and Construction Guidance document and supplemented with additional standards provided by United Utilities. An application to enter into a Section 104 agreement for sewer adoption must be made in writing to United Utilities prior to any works commencing on Site. A connection point should be agreed with United Utilities.

[33] Water UK (published October 2019 and update May 2021). Design and Construction Guidance for foul and surface water sewers offered for adoption under the Code for adoption agreements for water and sewerage companies operating wholly or mainly in England ("the Code") [SSG-App-C-Des-Con-Guide.pdf (water.org.uk)]

[34] HM Government (published 2002 and updated October 2015) The Buildings Regulations 2010 - Drainage and Waste Disposal: Part H [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/442889/BR_PDF_AD_H_2015.pdf].

8.0 Summary and Conclusions

8.1 Introduction

8.1.1 A site-specific Flood Risk Assessment (FRA) has been undertaken for a proposed residential development, located on a 7.17ha Site on land to the north and south of Henthorn Road, Clitheroe, Lancashire.

8.2 Flood Risk

Baseline Flood Risk to the Site

- The risk of fluvial flooding is assessed as negligible for most of the Site but medium to low along the reaches of onsite and bounding watercourses (Watercourse 1 and Pendleton Brook, respectively).
- The risk of groundwater flooding is assessed as negligible above ground, and low below ground.
- The risk of surface water flooding is assessed as negligible for most of the Site but low to high along the flow pathway through the southern extent of the eastern parcel.
- The risk of flooding from sewers is assessed as negligible. There is however a residual risk event for sewer leak or surcharge event.
- Flood risk from all other sources is assessed as negligible.

Flood Risk to the Developable Area and Vehicle Access

- The risk of flooding to the developable area and vehicle access is assessed as negligible to low and acceptable from all sources, subject to implementation of the below management measures.

8.3 Management Measures

8.3.1 Flood risk from identified sources can be reduced to a negligible or low and acceptable level through the following approach:

8.3.2 The strategy for developing the Site is as follows:

- Sequentially develop the Site, limiting the built development outside the mapped extent of fluvial flooding for the 1000-year event.
- Set the surface water outfall from the proposed development at an appropriate height, above the bed level of the receiving watercourse.
- Set building floor levels above external levels.
- Provide safe/dry access, with access roads set above the above the 1 in 100-year plus climate change or 1 in 1000-year event flood level (whichever is greatest).
    - The existing access to the western parcel (via the Miller Homes access from Henthorn Road) is set above the level of the extreme climate change (2070 to 2125) mapped level.

- It is proposed that the developable area in the eastern parcel is accessed via a free-spanning bridge across Watercourse 1 and the associated floodplain, with soffit levels set 600mm above the level of the extreme climate change (2070 to 2125) mapped level. The proposed crossing will allow for the free conveyance of flood water, without increase flood risk to and from the development.

- Reprofile onsite channels (i.e. scrape the channel to remove overgrown vegetation and build-up of silt/soft bed) to increase the capacity and the conveyance of the channel.
- No below surface habitable buildings (i.e. basements).
- Lined attenuation to prevent groundwater ingress.
- Provide easements free from development along either side of onsite and bounding watercourses. These easements would provide access for inspection and maintenance purposes, including vehicle access.
- Provide a development free easement either side of onsite public foul and private surface water sewer assets in the western parcel.
- Provide a development free easement either side of onsite public mains assets, or re-direct through the Site boundary.
- Adoption of a surface water management strategy.
  - Runoff contributing to the overland flow originating within the south-east extent of the eastern parcel Site boundary will be intercepted by the proposed surface water drainage strategy, attenuated onsite, and discharged to watercourse at a controlled (QBAR) rate.
- Undertake maintenance activities to keep onsite and bounding watercourses clear from debris and overgrown vegetation to maintain the conveyance of the channels.
- Fit the outfall with backflow prevention and provide a high-level overflow.

8.4 Flood Guidance

8.4.1 The proposed residential use is classified as more vulnerable. More vulnerable uses are considered acceptable in terms of flood risk in Flood Zone 1 (low risk).

8.5 Site Drainage

Surface Water

8.5.1 The proposed development will increase the area of impermeable surfaces and therefore increase the amount of runoff without appropriate management.

8.5.2 Surface water runoff from the Site will be restricted to greenfield rate (QBAR), which offers a betterment to existing conditions with uncontrolled runoff across all return periods.

8.5.3 Surface water runoff from the proposed development would be attenuated on-site up to and including the 1 in 100-year event, plus 50% climate change.

8.5.4 A SuDS treatment train, including permeable paving and swales or rain gardens will improve water quality. Water butts could be utilised to encourage rainwater collection and reuse (the potential for more integrated rainwater harvesting solutions will be further explored at the reserved matters stage). A maintenance and management ensure the effectiveness of the drainage strategy during the operation phase.

8.5.5 A SuDS treatment train, including permeable paving, rain gardens pits or swales will improve water quality. A maintenance and management ensure the effectiveness of the drainage strategy during the operation phase.

8.5.6 Implementation of a Construction Environmental Management Plan during the construction phase will manage surface water and foul drainage, thereby mitigating the potential for impacts on hydrology, flood risk, and water quality.

Foul Water

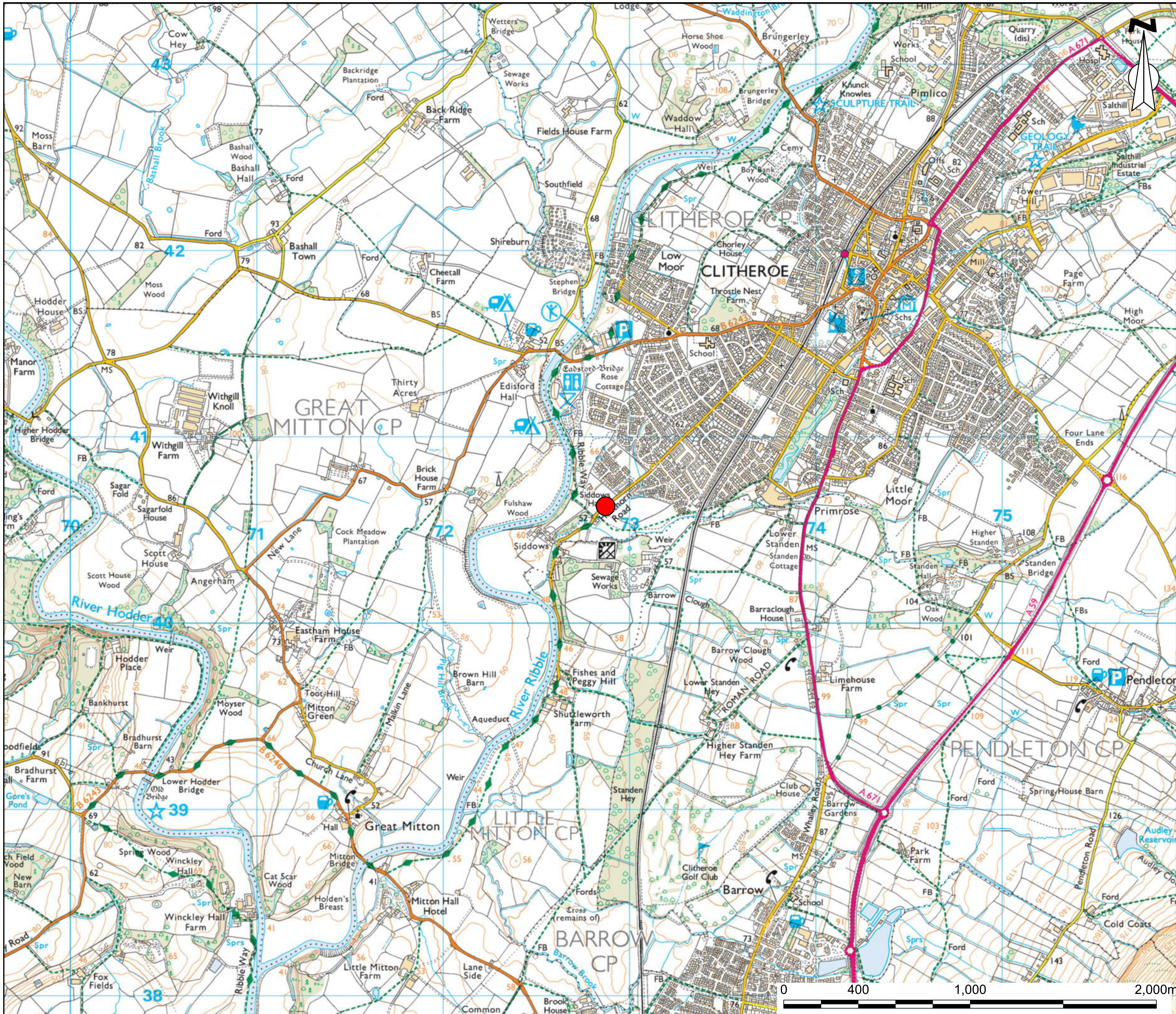
8.5.7 It is proposed that foul flow is discharged to the nearby public combined sewer via a gravity outfall for the western parcel, and a pumped solution for the eastern parcel.

8.6 Conclusion

8.6.1 This FRA demonstrates 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.

8.6.2 The development should therefore not be precluded on the grounds of flood risk, as well as surface water and foul drainage.

DRAWINGS



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KEY:

Site Location

Rev	Date	Description	DRA	CHK	APP
P01	26/11/24	Issued for comment / approval	SD	DA	DA

Project
Henthorn Road, Clitheroe

Client
Gladman Developments Ltd

Drawing Title
Site Location Plan

Scale	Date	Status
1:20,000@A3	26/11/24	Preliminary

DWG No. SHF1132306-ENZ-XX-XX-DR-Y-0001 **Revision** P01

Bristol 01454 269 237
Cardiff 02920 023 700
Manchester 0161 413 6444
Cambridge 01799 542 473
Sheffield 0114 321 5151
Belfast 07377673948

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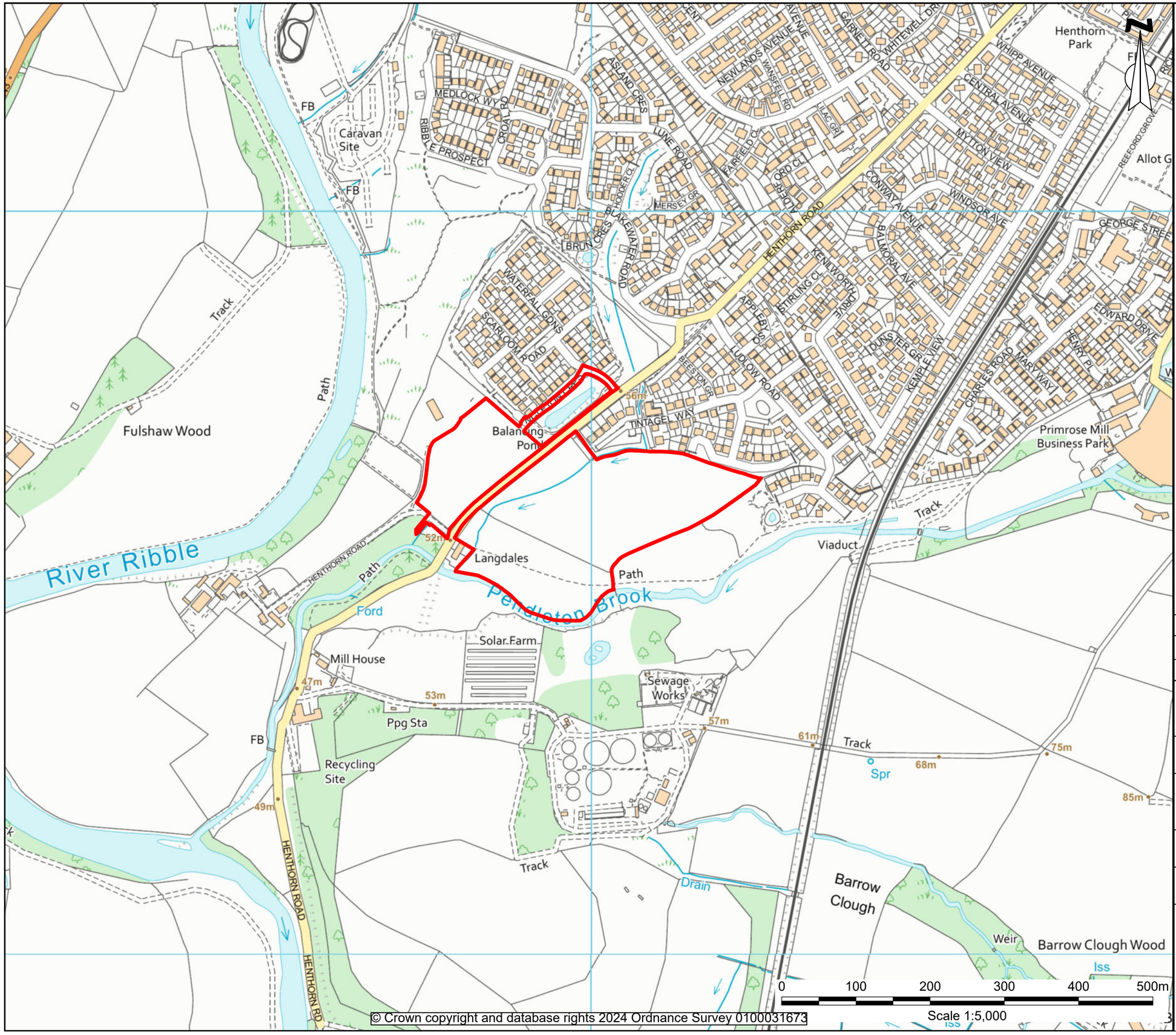

Rev	Date	Description	DRA	CHK	APP
P02	15/12/25	RLB updated	DL	DA	DA
P01	26/11/24	Issued for comment / approval	SD	DA	DA

Project
Henthorn Road, Clitheroe

Client
Gladman Developments Ltd

Drawing Title
Surface Water Features

Scale	Date	Status
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DWG No. SHF1132306-ENZ-XX-XX-DR-Y-0002 **Revision** P02

Bristol 01454 269 237
Cardiff 02920 023 700
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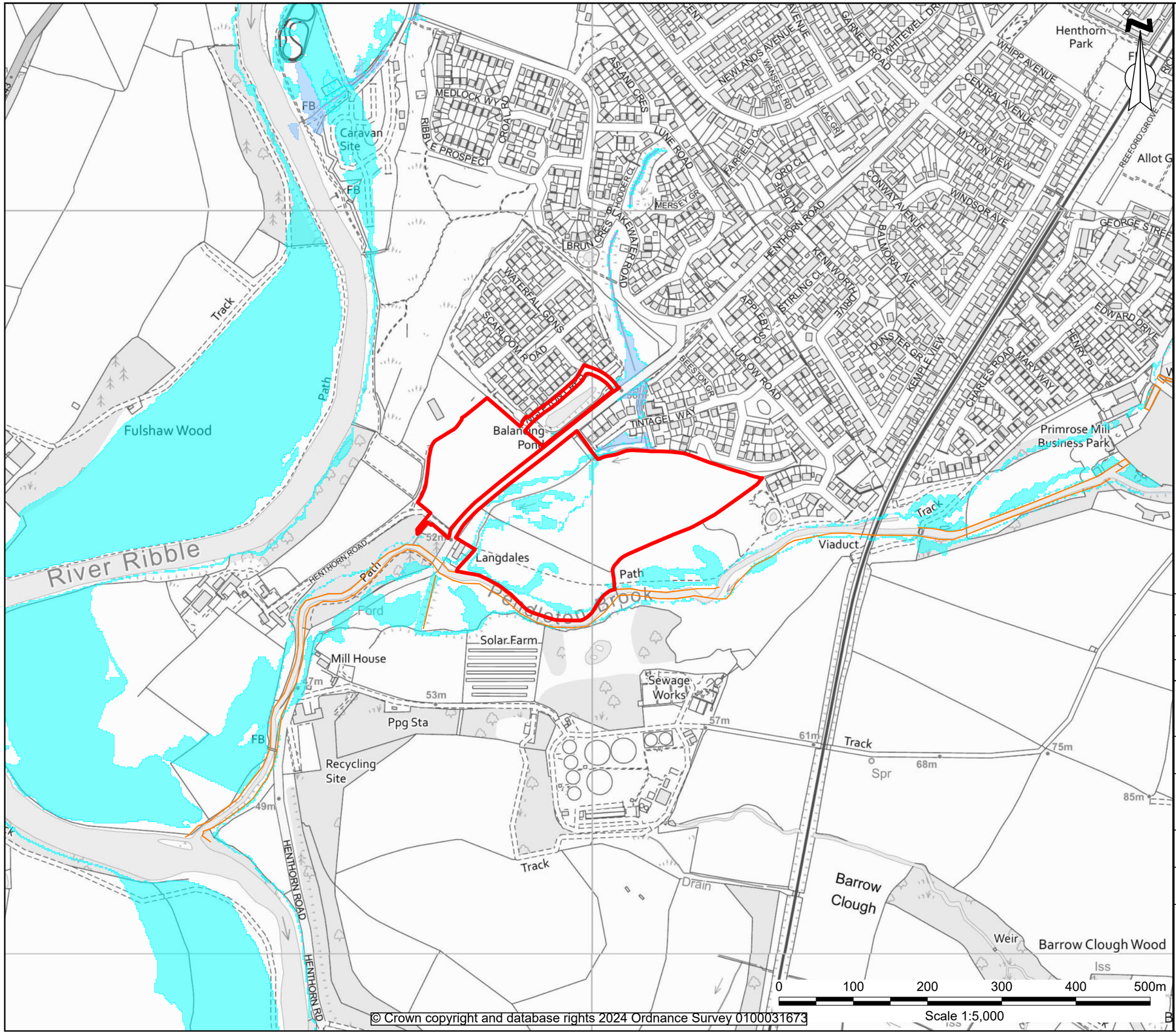

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Rev	Date	Description	DRA	CHK	APP
P03	15/12/25	RLB updated	DL	DA	DA
P02	03/07/25	Data Updated	SD	DA	DA
P01	26/11/24	Issued for comment / approval	SD	DA	DA

Project
Henthorn Road, Clitheroe

Client
Gladman Developments Ltd

Drawing Title
EA Flood Zones

Scale	Date	Status
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DWG No. SHF1132306-ENZ-XX-XX-DR-Y-0003 **Revision** P03

Bristol 01454 269 237
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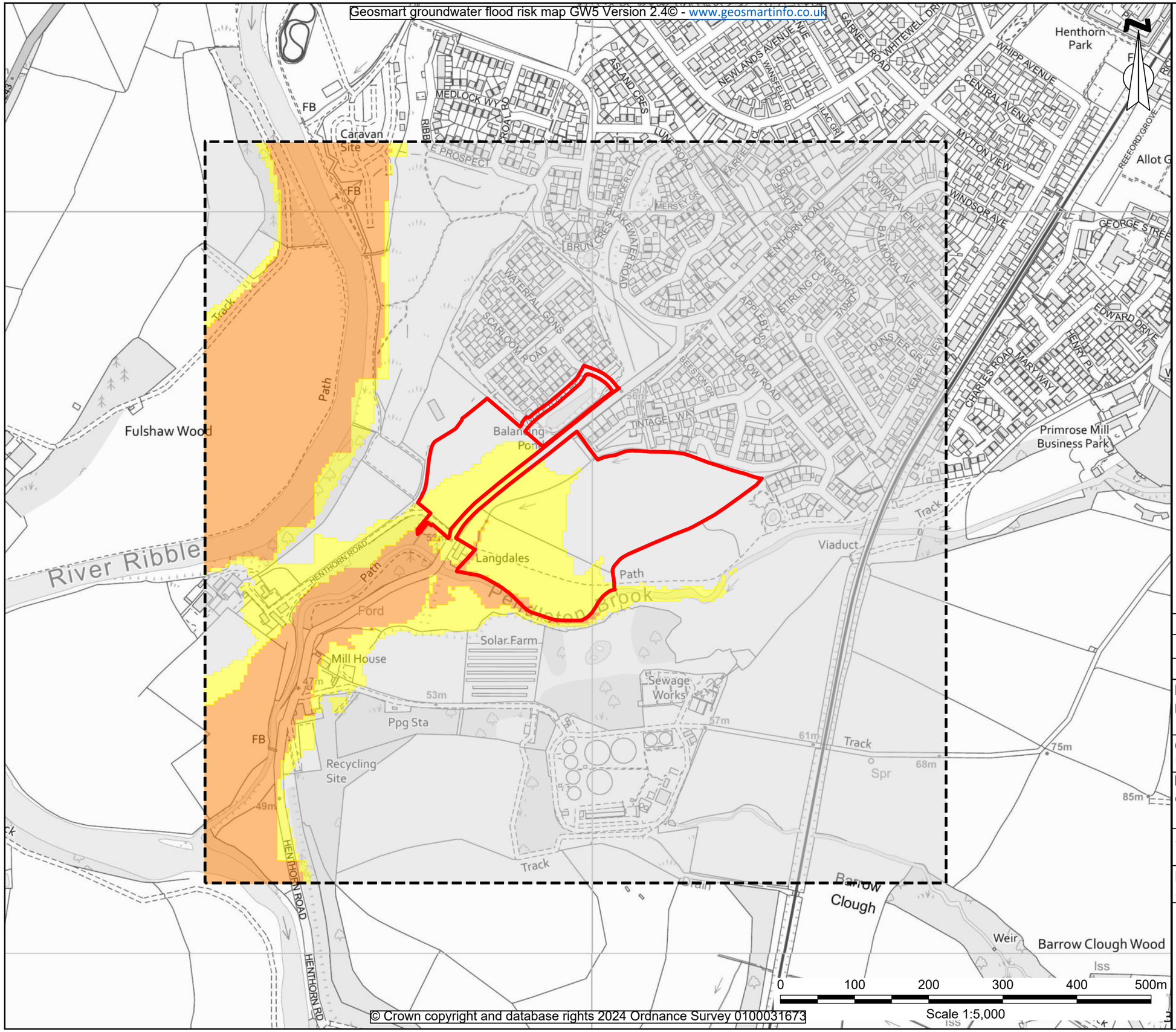
Geosmart groundwater flood risk map GW5 Version 2.4© - www.geosmartinfo.co.uk



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Scale 1:5,000

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KEY:

- Site Boundary
- Class 1 - High Risk
- Class 2 - Moderate Risk
- Class 3 - Low Risk
- Class 4 - Negligible Risk
- Search Extent

Rev	Date	Description	DRA	CHK	APP
P02	15/12/25	RLB updated	DL	DA	DA
P01	26/11/24	Issued for comment / approval	SD	DA	DA

Project
Henthorn Road, Clitheroe

Client
Gladman Developments Ltd

Drawing Title
Groundwater Flood Risk

Scale	Date	Status
1:5000@A3	26/11/24	Preliminary

DWG No. SHF1132306-ENZ-XX-XX-DR-Y-0004 **Revision** P02

Bristol 01454 269 237
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Geosmart SUDS infiltration suitability map Version 1.0© - www.geosmartinfo.co.uk

KEY:

- Site Boundary
- High Potential
- Moderate Potential
- Low Potential
- Search Extent

Rev	Date	Description	DRA	CHK	APP
P02	15/12/25	RLB updated	DL	DA	DA
P01	26/11/24	Issued for comment / approval	SD	DA	DA

Project
Henthorn Road, Clitheroe

Client
Gladman Developments Ltd

Drawing Title
SuDS Infiltration Potential

Scale	Date	Status
1:5000@A3	26/11/24	Preliminary

DWG No. SHF1132306-ENZ-XX-XX-DR-Y-0005 **Revision** P02

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