



NPPF: Flood Risk Assessment

Henthorn Road, Clitheroe

Gladman Developments Ltd.

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Contact Details:

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

tel: 0114 321 5151
www: enzygo.com

Henthorn Road, Clitheroe

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Author:	Scott Dawson BSc, MSc, MCIWEM - Senior Hydrologist
Reviewer / Approver:	Paul Hardwick, PhD, FGS, FRSA – Technical Director

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

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Executive Summary

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

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

The FRA has demonstrated the following:

- The 6.96-hectare (ha) Site is comprised two land parcels of agricultural (arable and grassed) land.
- The Northern Land Parcel slopes southward and the Southern Land Parcel slopes southwest. The Site is underlain by loamy and clayey soils and clayey bedrock with low infiltration potential.
- Pendleton Brook conveys flows west along the southern boundary of the Southern Land Parcel.
- The risk of flooding is assessed as followed:
 - The risk of fluvial flooding is assessed as negligible for most of the Site, with an area of high risk within the southern extent of the Southern Land Parcel. A residual risk is associated with an onsite watercourse.
 - The risk of groundwater flooding is assessed as negligible for most of the Site, with a low risk in the south-east of the Northern Land Parcel, and in the west and along the southern boundary of the Southern Land Parcel.
 - The risk of surface water flooding is assessed as negligible for most of the Site, with an area of low to high risk associated with surface water flow pathways.
 - The risk of flooding from all other sources is assessed as negligible.
- Flood risk from identified sources can be mitigated to a negligible or low and acceptable level through the following approach:
 - Sequentially develop the Site, limiting the built development (inclusive of SuDS features) outside the mapped extent of fluvial and surface water flooding.
 - Set the surface water outfall from the proposed development at an appropriate height, i.e. above the 1 in 1000-year modelled flood level (51.76m AOD as the most conservative level).
 - No below surface habitable buildings (i.e. basements).
 - Adoption of a surface water management strategy.
 - Set finished floor levels within the vicinity of the onsite watercourse to a minimum of +300mm above external levels. All other floor levels should be a minimum of +150mm above external levels.
 - Lined pond to prevent groundwater ingress.
 - Adoption of a surface water management strategy.
 - Set finished floor levels as per above.

- The proposed residential use is classified as more vulnerable. More vulnerable uses are considered acceptable in terms of flood risk in Flood Zones 1 and 2. More vulnerable development in Flood Zone 3 requires the Exception Test.

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 and three appropriately sized detention basins with an outfall to Watercourse 1 and Pendleton Brook.

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

1.0 Introduction

1.1 Background

- 1.1.1 Enzygo Ltd was commissioned by Gladman Developments Ltd to carry out a site-specific flood risk assessment (FRA) including a surface water drainage strategy in support of an outline planning application for a proposed residential development, located on land to the north and south of Henthorn Road, Clitheroe (the 'Site').
- 1.1.2 The proposal is for up to 160 residential dwellings on a 6.96-hectare (ha) Site, with associated landscaping, open spaces and vehicle access from Henthorn Road.
- 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;
 - assess whether the development will increase flood risk elsewhere;
 - decide on measures to deal with these effects and risks and assess their appropriateness;
 - provide enough evidence for the local planning authority to apply (if necessary) the Sequential Test, and;
 - decide whether the development will be safe and will pass the Exception Test if applicable.
- 1.1.5 In England, planning applications for development need an FRA¹ 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;
 - Land in flood zone 1 identified in a strategic flood risk assessment as being at increased flood risk in future.
- 1.1.6 An FRA is required for this development, as initial site screening using Environment Agency online indicative flood mapping shows that the Site is located partially within Flood Zones 2 and 3 (medium to high risk), is more than 1ha, and is at risk of groundwater and surface water flooding.
- 1.1.7 The purpose of this FRA is to assess the risk of flooding to the proposed development and where possible provide sufficient mitigation to demonstrate that future users of the

¹ <https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications> 2014 (as updated February 2017)
<https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications>

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.

1.2 Scope

- 1.2.1 Government policy on development and flood risk is set out in the National Planning Policy Framework (NPPF)² and is supported by National Planning Practice Guidance: Flood Risk and Coastal Change [NPPG ID7]³.
- 1.2.2 NPPF paragraphs 148-169 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.
- 1.2.3 The FRA should also make allowances for climate change⁴ 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; and
 - offshore wind speed and extreme wave height.
- 1.2.4 They are based on climate change projections and different scenarios of carbon dioxide emissions to the atmosphere. There are different allowances for different periods of time over the next century.
- 1.2.5 Site-specific FRAs are categorised according to level. 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 mitigation measures. Level 3 assessments are more detailed quantitative studies, for example modelling to establish flood levels at a site in the absence of Environment Agency or other data or providing detailed outline drainage designs.
- 1.2.6 This report is a Level 2 qualitative FRA but includes a Level 3 assessment of the surface water drainage requirements for the proposed development.

1.3 Aims

- 1.3.1 This FRA aims to provide 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 proposed measures that could be incorporated into the development to mitigate the identified risks.

² Department for Communities and Local Government (2018) Revised National Planning Policy Framework (as updated February 2019).

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

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

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 also considers the following policy within the Ribble Valley Council Core Strategy (2008 to 2028):

Policy DME6 - Water Management: Flood risk to the site and surrounding area, SuDS, conservation, protection and management.

1.5 Report Structure

1.5.1 This report is structured as follows:

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

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2.0 Sources of Information

2.1 Sources of Information

2.1.1 The following information was consulted:

- Ordnance Survey 1:25,000 mapping (Explorer OL41: Forest of Bowland & Ribblesdale).
- Detailed topographic survey (Appendix 1).
- Environment Agency online mapping (Flood Map for Planning⁵, Long Term Flood Risk Assessment for Locations in England⁶, Catchment Data Explorer⁷ and Main River Map⁸).
- River Basin District (RBD) Maps⁹ (North West RBD) together with guidance on climate change allowances¹⁰.
- National River Flow Archive¹¹.
- Ribble Valley Strategic Flood Risk Assessment (SFRA) and associated mapping¹² (Appendix 2).
- British Hydrological Society Chronology of British Hydrological Events¹³.
- National Soils Resources Institute (NSRI): Soilscape online mapping¹⁴.
- British Geological Survey [BGS] online mapping: Geology of Britain Viewer¹⁵.
- Landmark's Promap: Flood Data package: Additional flood mapping.
- Geosmart 1 in 100-year groundwater flood risk map.
- United Utilities sewer asset plans (Appendix 3).
- DEFRA's Magic Map¹⁶ for identifying Designated Sites.

⁵ <https://flood-map-for-planning.service.gov.uk/>

⁶ <https://flood-warning-information.service.gov.uk/long-term-flood-risk/>

⁷ <http://environment.data.gov.uk/catchment-planning/>

⁸ <https://environment.maps.arcgis.com/apps/webappviewer/index.html?id=17cd53dfc524433980cc333726a56386>

⁹ <https://www.gov.uk/government/publications/flood-risk-assessments-river-basin-district-maps>

¹⁰ <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

¹¹ <http://nrfa.ceh.ac.uk>

¹² https://www.ribblevalley.gov.uk/downloads/download/6181/strategic_flood_risk_assessment

¹³ <http://www.cbhe.hydrology.org.uk/search.php>

¹⁴ <http://www.landis.org.uk/soilscape/>

¹⁵ <http://mapapps.bgs.ac.uk/geologyofbritain/home.html>

¹⁶ <http://www.natureonthemap.naturalengland.org.uk/>

2.2 Consultation and Discussion with Regulators

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

Environment Agency

2.2.2 The Environment Agency is a statutory consultee on flood risk and planning and is directly responsible for the prevention, mitigation and remediation of flood damage for main rivers and coastal areas; and it has a strategic overview for all forms of flooding.

2.2.3 Environment Agency Standing Advice¹⁷ and the NPPF/PPG ID: 7 was consulted and reviewed.

2.2.4 Correspondence with the Environment Agency is included in Appendix 4.

Lancashire County Council (LLFA)

2.2.5 LLFAs (unitary authorities or county councils) are Lancashire County Council as the Lead Local Flood Authority (LLFA) is responsible for local flood risk management in their areas 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.

United Utilities

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

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

2.3 Site Walkover

2.3.1 A site walkover was undertaken in September 2019. Information gathered has been used to inform the site descriptions in the following sections.

¹⁷ <https://www.gov.uk/guidance/flood-risk-assessment-standing-advice>

3.0 Site Location and Description

3.1 Location

- 3.1.1 The Site is located on land to the north and south of Henthorn Road, Clitheroe, BB7 2PL.
- 3.1.2 The Site is centred on National Grid Reference (NGR) 372882, 440627.
- 3.1.3 The Site location is shown in Drawing 001 and in more detail in Drawing 002, which shows the red line boundary enclosing an area of 6.96ha.

3.2 Land Use

- 3.2.1 The land use is comprised two land parcels; the Northern Land Parcel and the Southern Land Parcel (Figure 3.1).
- 3.2.2 The Northern Land Parcel is 1.59ha in area and comprises an agricultural field.
- 3.2.3 It is bounded by mature trees and hedgerow along all boundaries. To the northeast is agricultural (arable) land, to the southeast is Henthorn Road, to the south west lies woodland and access tracks, and to the northwest lies an access track to Siddows Hall.
- 3.2.4 The Southern Land Parcel is 5.37ha in area and comprises agricultural land.
- 3.2.5 The Southern Land Parcel is also bounded by mature trees and hedgerow along all boundaries. Henthorn Road is located to the northwest, residential dwellings to the northeast and agricultural (grassed and arable) land to the southeast and southwest. Pendleton Brook also conveys flows west along the southern boundary of the Southern Land Parcel. Furthermore, 'The Oaks' and 'Langdales' residential dwellings are located to the southwest of the land parcel.
- 3.2.6 The Northern Land Parcel is currently accessed from Henthorn Road via the gated access of the neighbouring field to the north east.
- 3.2.7 The Southern Land Parcel has gated vehicular access at the northern end of its north-western boundary from Henthorn Road. Public right of way access is located on the northwest boundary from Henthorn Road, adjacent the residential properties beyond the south-western corner.

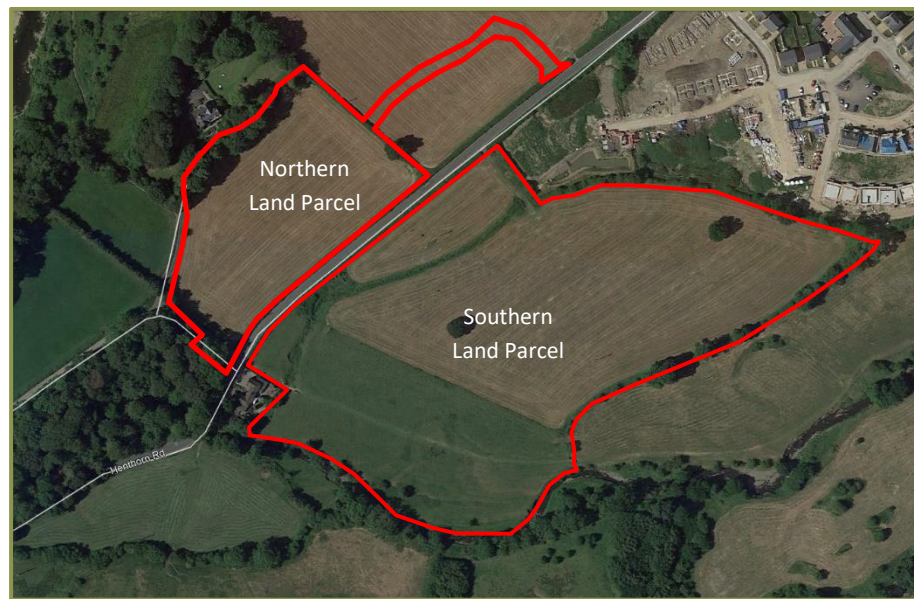
Figure 3.1: Aerial Photograph of the Site

Image © 2019 Digital Globe.

3.3 Topographic Information

- 3.3.1 A detailed topographic survey was carried out during May 2018 and a copy is included as (Appendix 1). The Site is divided into two land parcels and three catchments as described below.

Northern Land Parcel

- 3.3.2 The Northern Land Parcel falls south from 58.24 metres Above Ordnance Datum (m AOD) (located along the north-western boundary) to 50.89m AOD (located along the south-western boundary). The fall of 7.35m over 156.77m gives a gradient of 1:21.

Southern Land Parcel

- 3.3.3 The Southern Land Parcel is divided by a watercourse ('Watercourse 1') which flows south-west through the land parcel.
- 3.3.4 Land to the west of Watercourse 1 falls southwest from 54.47m AOD (located in the north-east corner) to 48.45m AOD (located in the south-west corner). The fall of ~6m over ~252m is a gradient of 1:42.
- 3.3.5 Land to the east of Watercourse 1 falls southwest from 59.80m AOD (located in the north-easterly corner) to 50.79m AOD (located along the southern boundary). The fall of ~9 m over ~354m is a gradient of 1:39. Within this area, contour information also demonstrates the presence of former meander cut-off features which would have represented a former alignment of Pendleton Brook.

3.4 Soils and Geology

Soils Mapping

- 3.4.1 The Soilsmap online soils map viewer shows that most of the Northern Land Parcel and the north of the Southern Land Parcel is underlain by slowly permeable, seasonally wet loamy and clayey soils (Figure 3.2). The southernmost corner of the Northern Land Parcel and the south

of the Southern Land Parcel is underlain by loamy and clayey floodplain soils with naturally high groundwater.

- 3.4.2 The soils beneath the Site are indicative of low infiltration potential due to the high groundwater, slow permeability and wet soil.

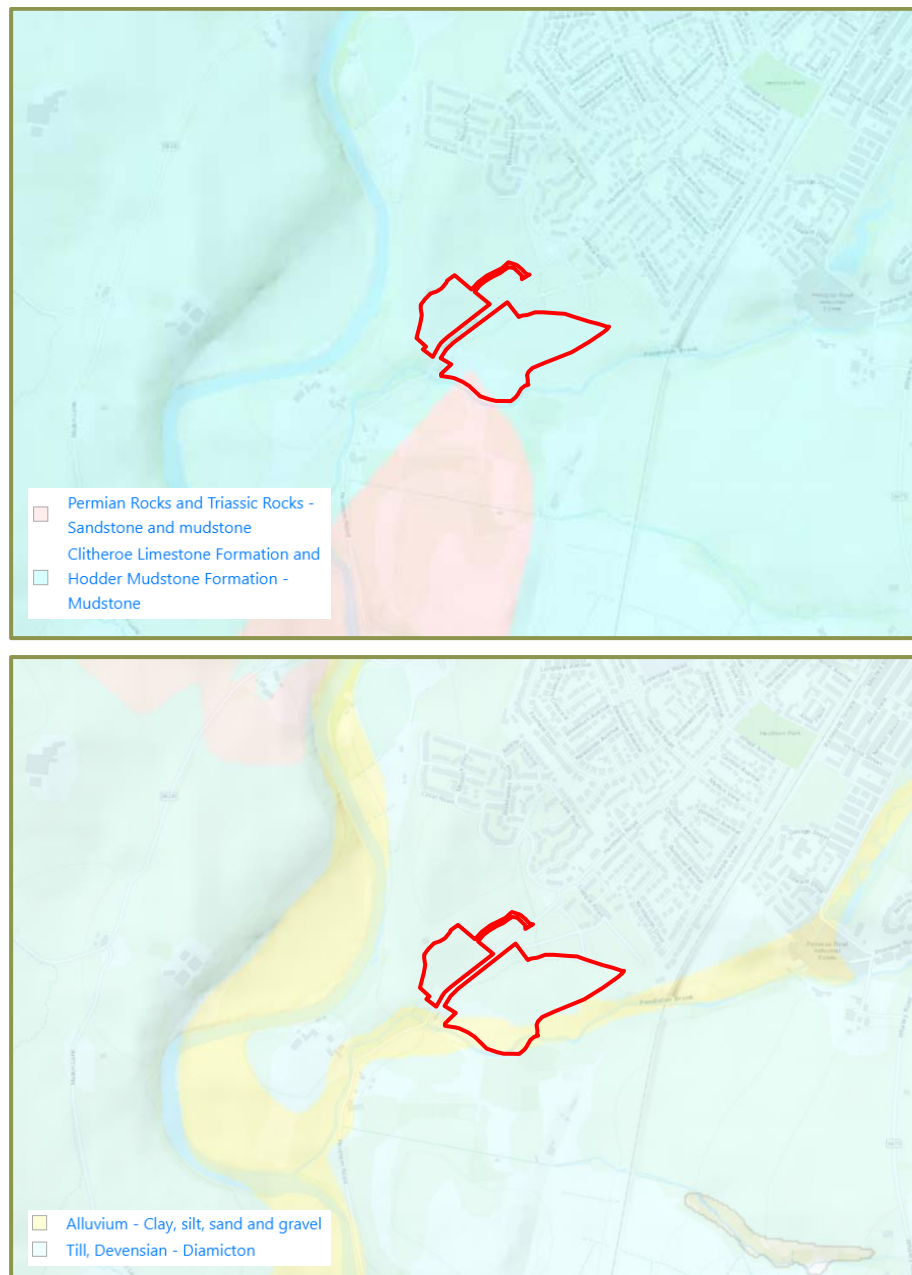
Figure 3.2: Soils Mapping



Soils Data © Cranfield University (NSRI) and for the Controller of HMSO [2019].

Geology Mapping

- 3.4.3 The Geology of Britain online map viewer (Figure 3.3) shows the bedrock beneath most of the Site is the Clitheroe Limestone Formation and Hodder Mudstone Formation. The southernmost extent of the Southern Land Parcel is underlain by Permian and Triassic sandstone and mudstone. The infiltration potential of the bedrock beneath most of the Site is likely to be variable based on variable primary matrix and secondary fissure permeability .
- 3.4.4 The superficial deposits, covering most of the Site are Devensian Till - Diamicton. The southernmost extent of the Southern Land Parcel is underlain by Quaternary Alluvium - Clay, silt, sand and gravel. The infiltration potential of the superficial deposits beneath the Site is likely to varied but low based on the prevalence of clay fraction and local groundwater levels associated with Pendleton Brook.

Figure 3.3: Geology Mapping

Top: Bedrock Geology Bottom: Superficial Deposits. Contains British Geological Survey materials © NERC [2019].

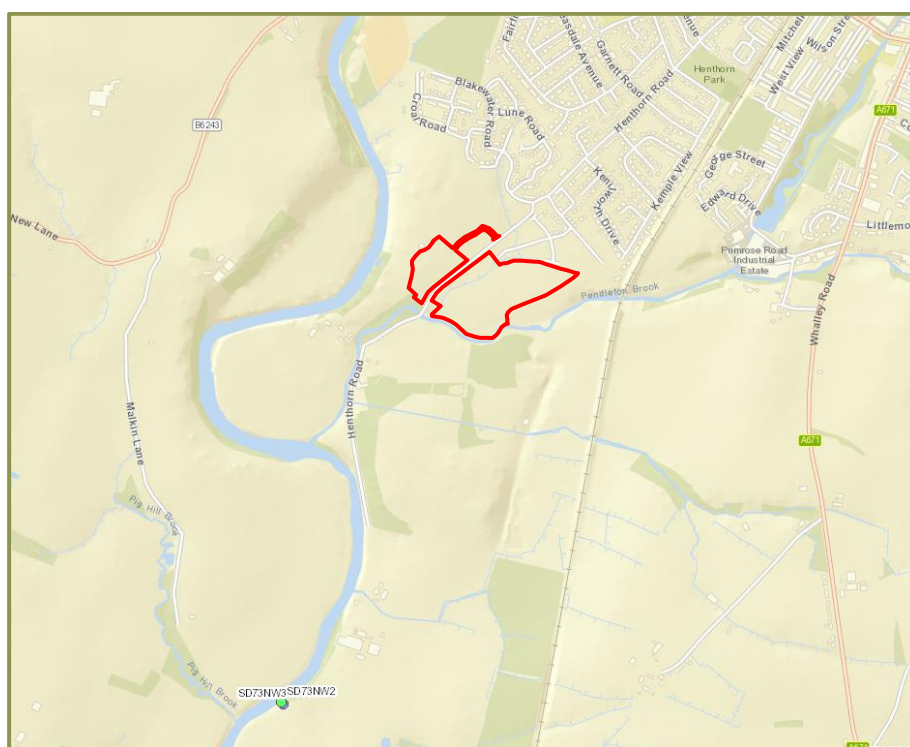
SuDS Infiltration Potential

3.4.5 SuDS Infiltration Mapping (Drawing 007) shows the Site has a moderate infiltration potential.

BGS Borehole Logs

3.4.6 The Geology of Britain online map viewer shows there are no historical boreholes located within the vicinity of the Site (Figure 3.4). The nearest boreholes in the same geology as the Site are 1.2km to the southwest, which is too far to be considered indicative of the Site.

3.4.7 However, the borehole records (Appendix 5) confirm the bedrock geology as shown on the Geology of Britain mapping (Table 3.1).

Figure 3.4: Borehole Mapping

Contains British Geological Survey materials © NERC [2018].

Table 3.1: BGS Borehole Data

Reference	Summary of Strata	Depth (m bgl)	Groundwater Depth (m bgl)
SD73NW2	0.00 - 0.15m = topsoil 0.15 - 1.07m = loam and stones 1.07 - 8.08m = clay and gravel 8.08 - 8.69m = clay and stones 8.69 - 9.14m = sand and gravel 9.14 - 10.36m = clay and gravel 10.36 - 12.34m = marl and stones	12.34	Not recorded
SD73NW3	0.00 - 0.91m = gravel 0.91 - 4.72m = clay and gravel 4.72 - 5.33m = sandstone 5.33 - 9.14m = marl and stones	9.14	Not recorded

Contains British Geological Survey materials © NERC [2018].

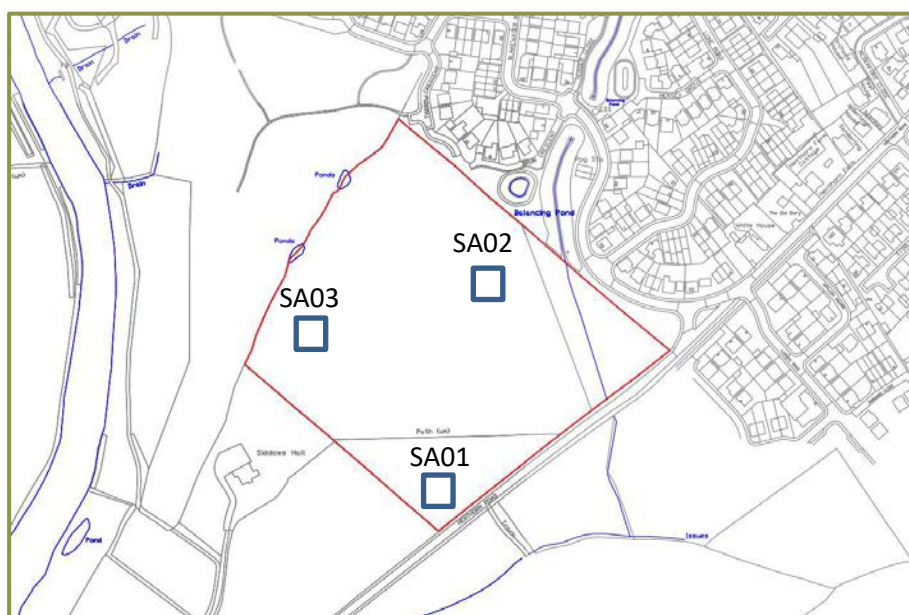
Soakaway Testing

- 3.4.8 Testing was undertaken in July 2018 (Appendix 5) in the neighbouring field north-east of the Northern Land Parcel. As the geology maps demonstrate the Northern Land Parcel and majority of Southern Land Parcel share the same bedrock unit, the infiltration tests should be taken to demonstrate the likely infiltration within the Site. The southern extent of the Southern Land Parcel is mapped to have clayey alluvium superficial deposits. Such deposits would suggest a low infiltration potential.

- 3.4.9 Three soakaway test pits were constructed (Figure 3.5) and testing was undertaken in accordance with BRE 365 'Soakaway Design' methodology guidance.
- 3.4.10 The test pits were excavated to a depth of 2.00 to 2.20 metre below ground level (m bgl). A summary of the trial pit logs is summarised in Table 3.2. The borehole logs confirm the soils and geology as depicted by the soils and geology mapping.

Table 3.2: Soakaway Data

Trial Pit	Summary of Strata
SA01	0.00 - 0.30m = topsoil. 0.30 - 2.00m = grey/ brownish slightly sandy clay.
SA02	0.00 - 0.28m = topsoil. 0.28 - 0.80m = grey clay with sand. 0.80 - 2.00m = grey clay with gravel.
SA03	0.00 - 0.30m = topsoil. 0.30 - 2.20m = grey/ brown clay with sand and gravel.

Figure 3.5: Trial Pit Location Plan

Geological Indicators of Flooding

- 3.4.11 The Geological Indicators of Flooding mapping (Drawing 008) shows the southern extent of the Southern Land Parcel has geological indicators of inland flooding.

3.5 Hydrogeology

Soakaway Testing

- 3.5.1 Soakaway testing on a Site north-east of the Northern Land Parcel demonstrated low infiltration potential. Groundwater ingress was not encountered in any of the soakaway trial pits.

Defra Magic Map

- 3.5.2 Defra Magic Map online mapping (Figure 3.6) shows the Site is not located in a groundwater Source Protection Zone (SPZ).

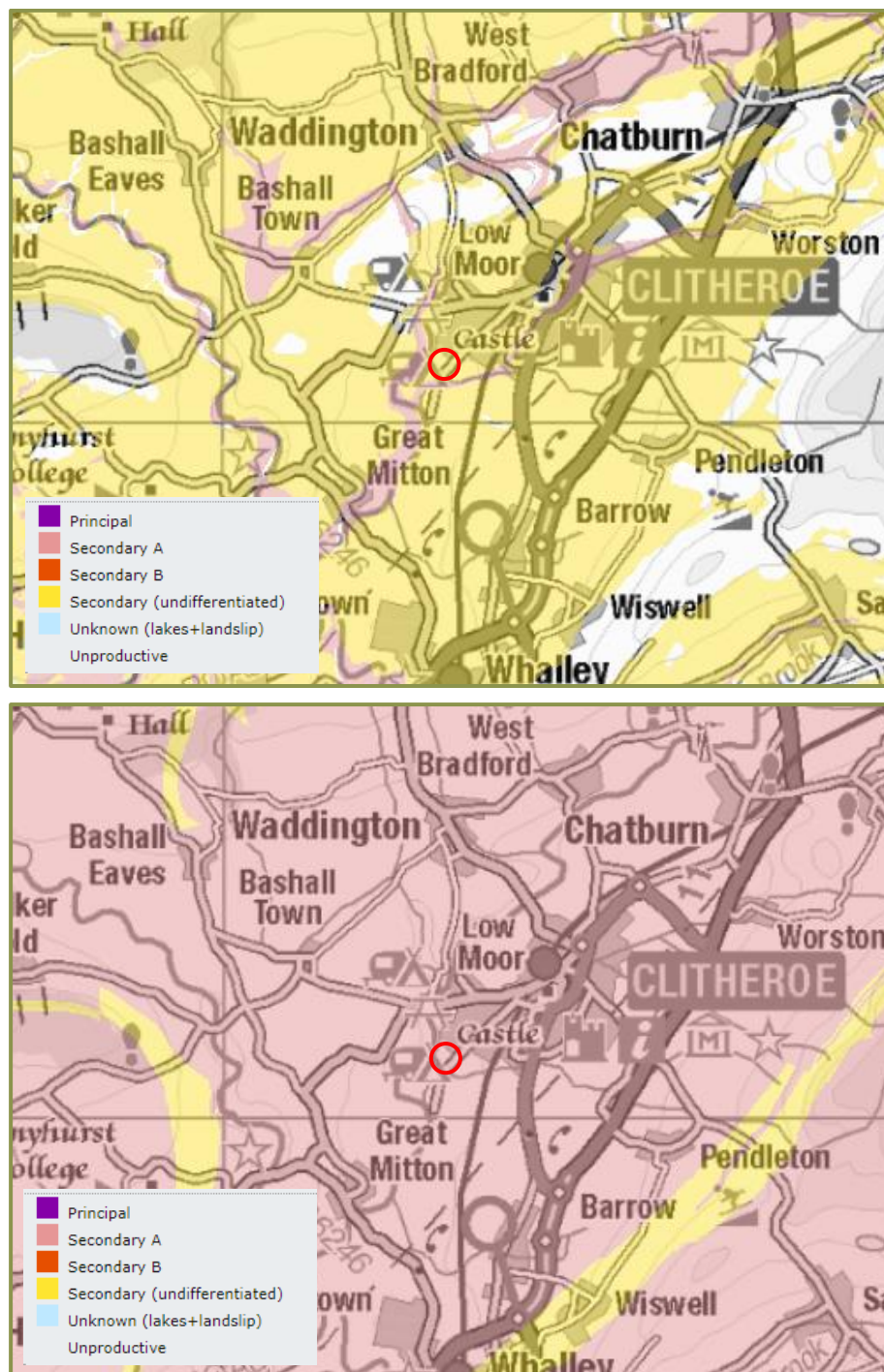
Figure 3.6: Source Protection Zone Map



From Magic Map. Contains Environment Agency information © Environment Agency and database right.

- 3.5.3 The Site is not located above a Principal Aquifer. The Site is located above a Secondary A Aquifer (bedrock designation) (Figure 3.7). A Secondary Undifferentiated Aquifer (superficial designation) also underlies most of the Site, with a Secondary A Aquifer (superficial designation) beneath the southernmost extent of the Southern Land Parcel.

Figure 3.7: Aquifer Designation Map



Top: Aquifer Designation (superficial deposits). Bottom: Aquifer Designation (bedrock). From Magic Map. Contains Environment Agency information © Environment Agency and database right [2019].

3.6 Catchment Hydrology

OS Mapping and Topographic Survey

i. Pendleton Brook

3.6.1 OS mapping shows Pendleton Brook conveying flows west along the southern boundary of the Southern Land Parcel (Figure 3.8). Pendleton Brook is a 'main river' which is further discussed, including its wider connectivity in the Main Rivers Map section overleaf.

3.6.2 The topographical survey (Appendix 1) shows Pendleton Brook has a bed level of 49.16m AOD towards the east of the Site and 47.60m AOD towards the west of the Site.

ii. Watercourse 1

3.6.3 OS mapping also shows Watercourse 1 conveys flow south-west, through the west of the Southern Land Parcel (Figure 3.8). Watercourse 1 is a tributary of Pendleton Brook and is classified as an 'ordinary watercourse', where flood risk work is carried out by the local drainage authority/riparian landowner.

3.6.4 The topographical survey (Appendix 1) shows Watercourse 1 has a bed level of 52.85m AOD towards the north of the Site and 49.45m AOD towards the south of the Site. The topographical survey and OS mapping also shows Watercourse 1 to enter a Ø750mm culvert beneath a path towards the south of the Site.

iii. Drain 1

3.6.5 OS mapping shows an unnamed land drain ('Drain 1') conveying flows in a south-westerly direction from the access track to the south of the Northern Land Parcel. Drain 1 outfalls into Pendleton Brook.

iv. Drain 2

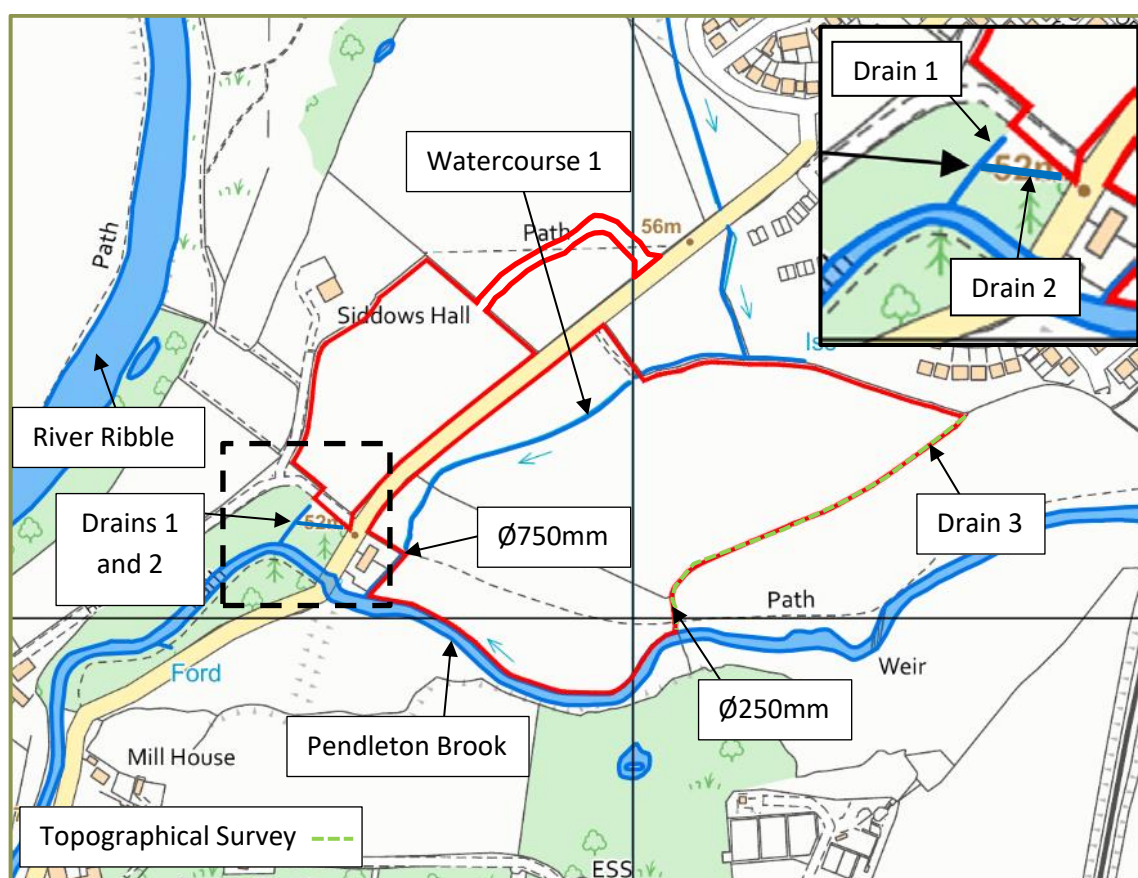
3.6.6 A Site walkover by the client has determined an unmapped drain (Drain 2) located adjacent the public footpath in the vicinity of Drain 1.

v. Drain 3

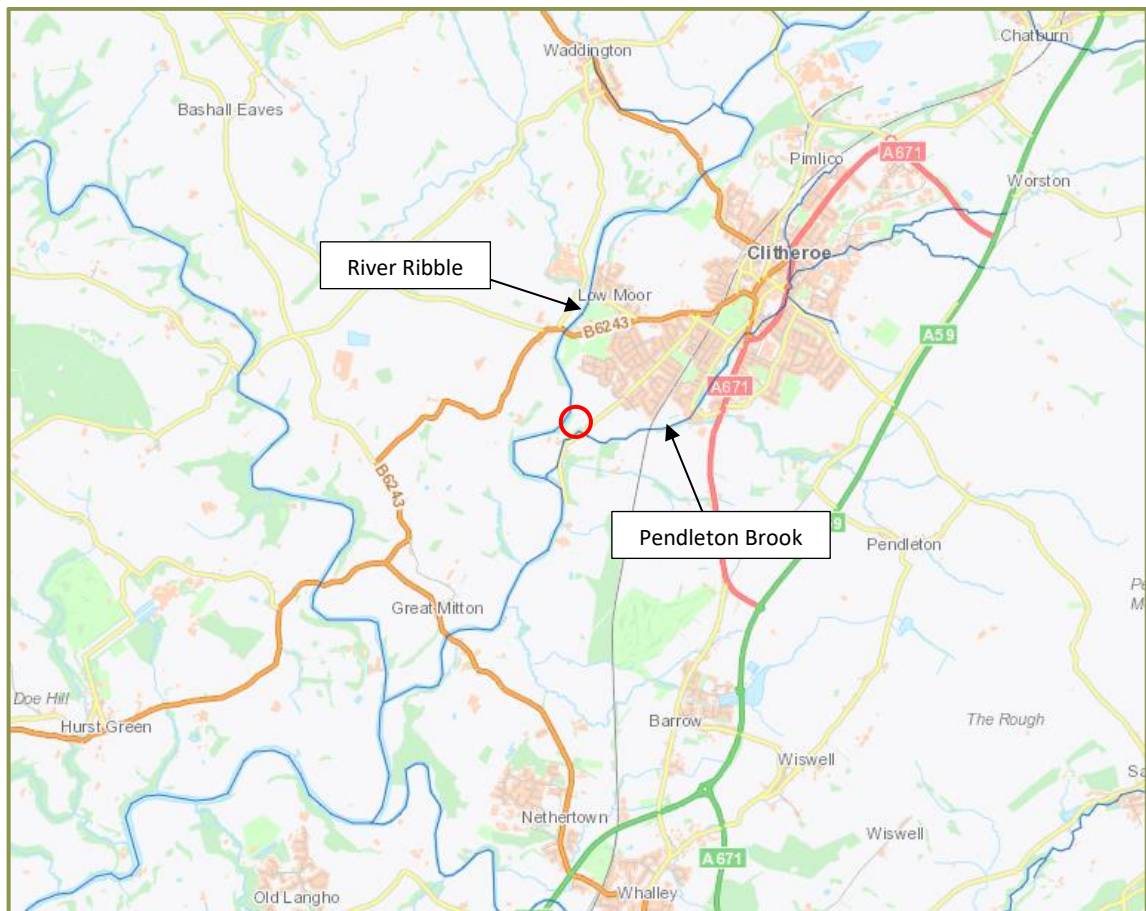
3.6.7 The topographical survey (Appendix 1) also shows an unmarked land drain ('Drain 3') conveying flows south-west along the eastern boundary of the Southern Land Parcel. The drain has a bed level of 51.96m AOD. Drain 3 also has a Ø250mm culvert towards the south of the Site.

vi. Pond

3.6.8 A pond is located 20m west of the Site. The pond is likely associated with the River Ribble.

Figure 3.8: Map of WatercoursesMain Rivers Map

- 3.6.9 The Environment Agency online main river map (Figure 3.9) identifies Pendleton Brook, conveying flows west along the southern boundary of the Southern Land Parcel. Pendleton Brook outfalls into the River Ribble, which conveys flows south and is located 35m west of the Site at the closest point. Both the River Ribble and Pendleton Brook are 'main rivers', which are watercourses where flood risk work is carried out by the Environment Agency.

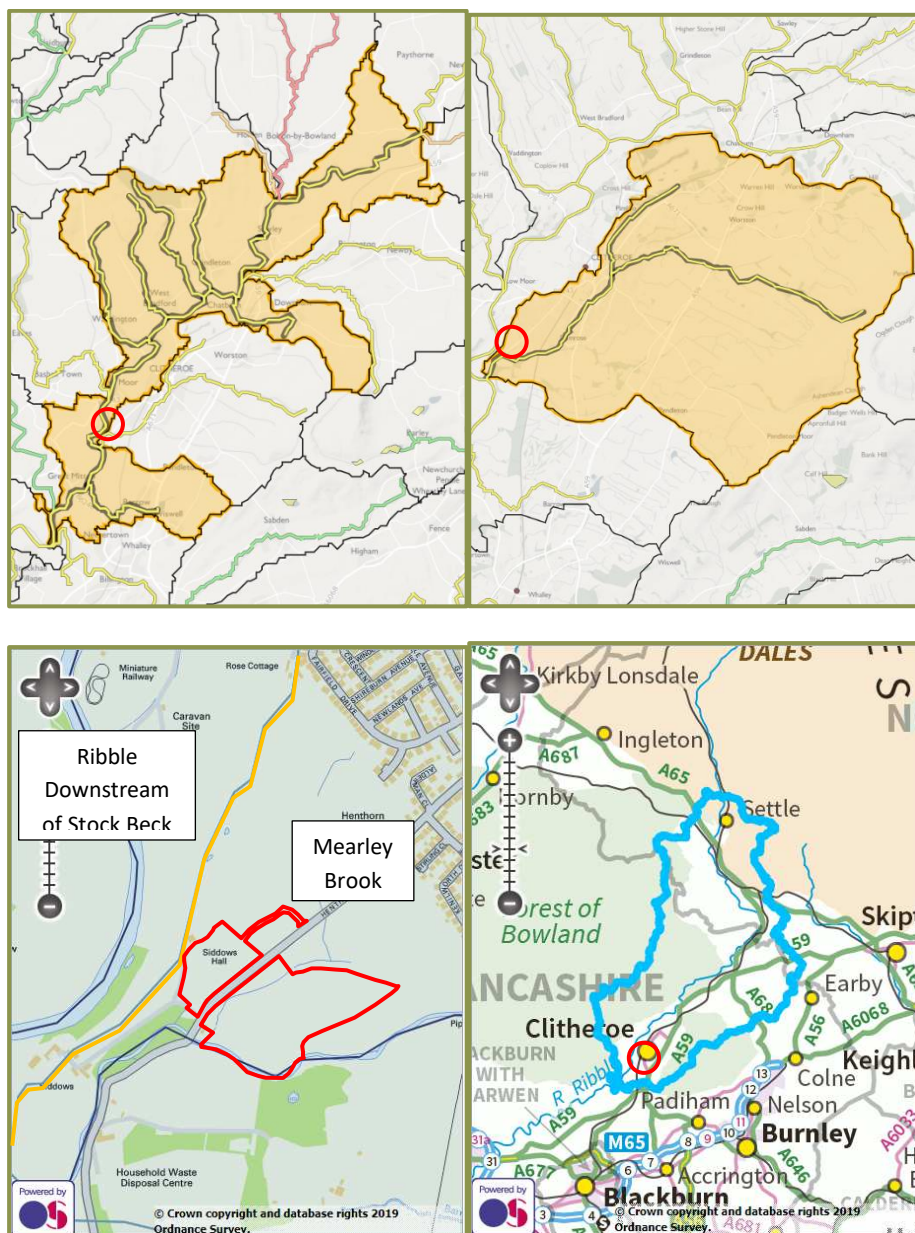
Figure 3.9: Main River Map

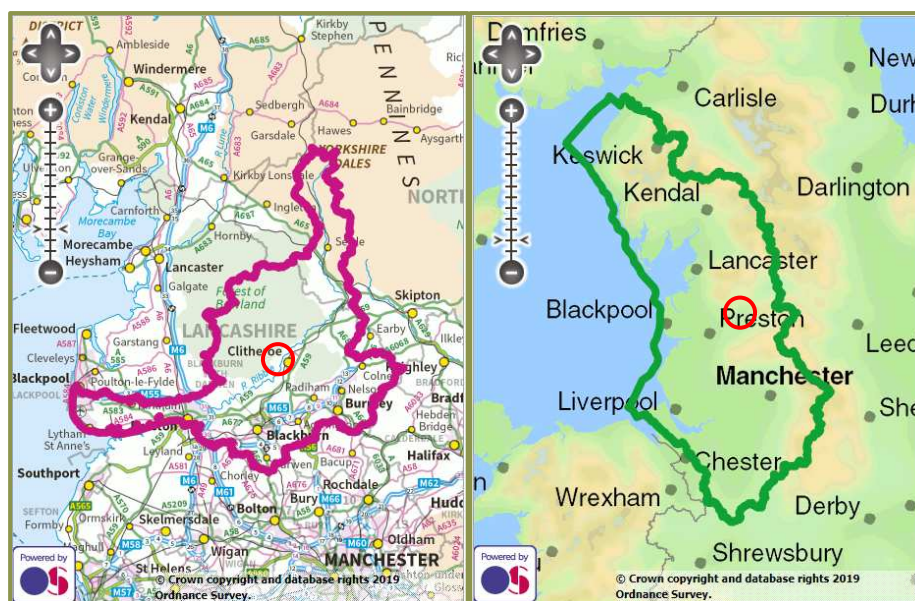
Contains Environment Agency information © Environment Agency and database right [2019].

Environment Agency Catchment Data Explorer Mapping

- 3.6.10 The Site resides within two river catchments; the Southern Land Parcel and the majority of the Northern Land Parcel are within the Mearley Brook Catchment (Figure 3.10) and the western most part of the Northern Land Parcel is within the Ribble Downstream of Stock Beck Catchment. Both river catchments are within the Ribble Middle - Settle to Calder Operational Catchment, Ribble Management Catchment and North West River Basin District.

Figure 3.10: Catchment Data Explorer (continues over page)





Top Left: Ribble Downstream of Stock Beck Catchment. **Top Right:** Mearley Brook Catchment. **Centre Left:** River catchment split. **Centre Right:** Ribble Middle - Settle to Calder Operational Catchment. **Bottom Left:** Ribble Management Catchment. **Bottom Right:** North West River Basin District. Contains Environment Agency information © Environment Agency and database right [2019].

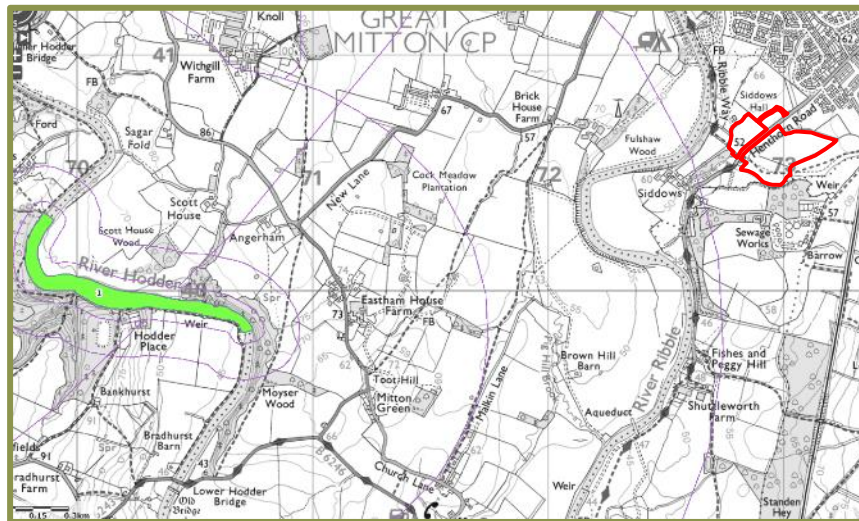
3.7 Sewerage Assets

- 3.7.1 United Utilities asset plans show that there is a combined Ø375mm public sewer along the southern boundary of the Northern Land Parcel. The sewer conveys flows in a south-easterly direction and has two outfall points; one into Pendleton Brook (which is a sewer overflow shown to follow the alignment of Drain 1), and one into a pumping station located 200m south of the Site. The pumping station pumps the water to the sewage works, which is located 125m south of the Site.
- 3.7.2 The nearest surface water sewer is a private sewer, located 10m north of the southern land parcel. The sewer conveys flows in a westerly direction and is shown to outfall 25m north of the Site.

3.8 Designated Sites

- 3.8.1 The DEFRA Magic Map (England and Wales) (Figure 3.11) shows there are no designated sites in or close to the Site including downstream (from a flood risk and drainage perspective). The Site is shown to be in a Site of Special Scientific Interest (SSSI) impact zone for the River Hodder Section. However, this is location on the River and a tributary of the River Ribble and no flows from the Site can affect this SSSI.

Figure 3.11: Hodder River Section SSSI and associated impact zone



4.0 Flood Risk Assessment

4.1 Potential Sources of Flooding

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

Table 4.1: Potential Risk Posed by Flooding Sources

Flooding Source	Potential Flood Risk at Application Site (Yes/No)	Potential Source	Data Sources
Fluvial	Yes	Pendleton Brook, Watercourse 1	Environment Agency flood mapping (Drawing 005), JBA Flooding from Rivers (Drawing 004.2) and SFRA mapping.
Tidal	No	None identified	Environment Agency flood mapping (Drawing 005)
Groundwater	Yes	Aquifer	BGS mapping (Drawing 003) and Geosmart Groundwater (Drawing 006)
Surface Water	Yes	Poor permeability and Site topography	Environment Agency online flood mapping, JBA Surface Water Flooding (Drawing 004.1) and Environment Agency Complex mapping (Drawings 009.1 to 009.4).
Sewer	No	None identified	Asset plans
Infrastructure Failure	No	None identified	Environment Agency online flood mapping and JBA Flooding from Rivers (Drawing 004.2)

4.2 Fluvial Flooding

Environment Agency Flood Zone Mapping

- 4.2.1 The Environment Agency Flood Zones are the current best information on the extent of the extremes of flooding from rivers or the sea that would occur without the presence of flood defences, since these can be breached, overtopped and may not be in existence for the lifetime of a development.
- 4.2.2 The Environment Agency Flood Mapping (Drawing 005) shows the Northern Land Parcel and most of the Southern Land Parcel are located within Flood Zone 1; which is land located outside the extent of the 1 in 1000-year (<0.1% Annual Exceedance Probability [AEP]) risk of fluvial (river) flooding, at 'low' risk.
- 4.2.3 The southern extent of the southern land parcel, extending along Watercourse 1, is located in Flood Zones 2 and 3. Flood Zone 2 is land located within the 1 in 1000-year (0.1% AEP) extent of fluvial flooding, at 'medium' risk. Flood Zone 3 is land located within the 1 in 100-year (1% AEP) extent of fluvial flooding; considered 'high' risk.

- 4.2.4 The Environment Agency Flood Zone mapping does not delineate between Flood Zone 3a (High Risk) and Flood Zone 3b (Functional Floodplain).

JBA Flooding from Rivers

- 4.2.5 The JBA mapping (Drawing 004.2) shows the Northern Land Parcel and most of the Southern Land Parcel are located outside the mapped area of flooding from rivers. The southern extent of the Southern Land Parcel is located within the mapped outline for flooding from rivers between the 1 in 20 year to 1 in 1000-year flood events.
- 4.2.6 The 1 in 20-year fluvial flood zone can be used to approximate the extent of Flood Zone 3b (Functional Floodplain) with the Site.

SFRA Mapping

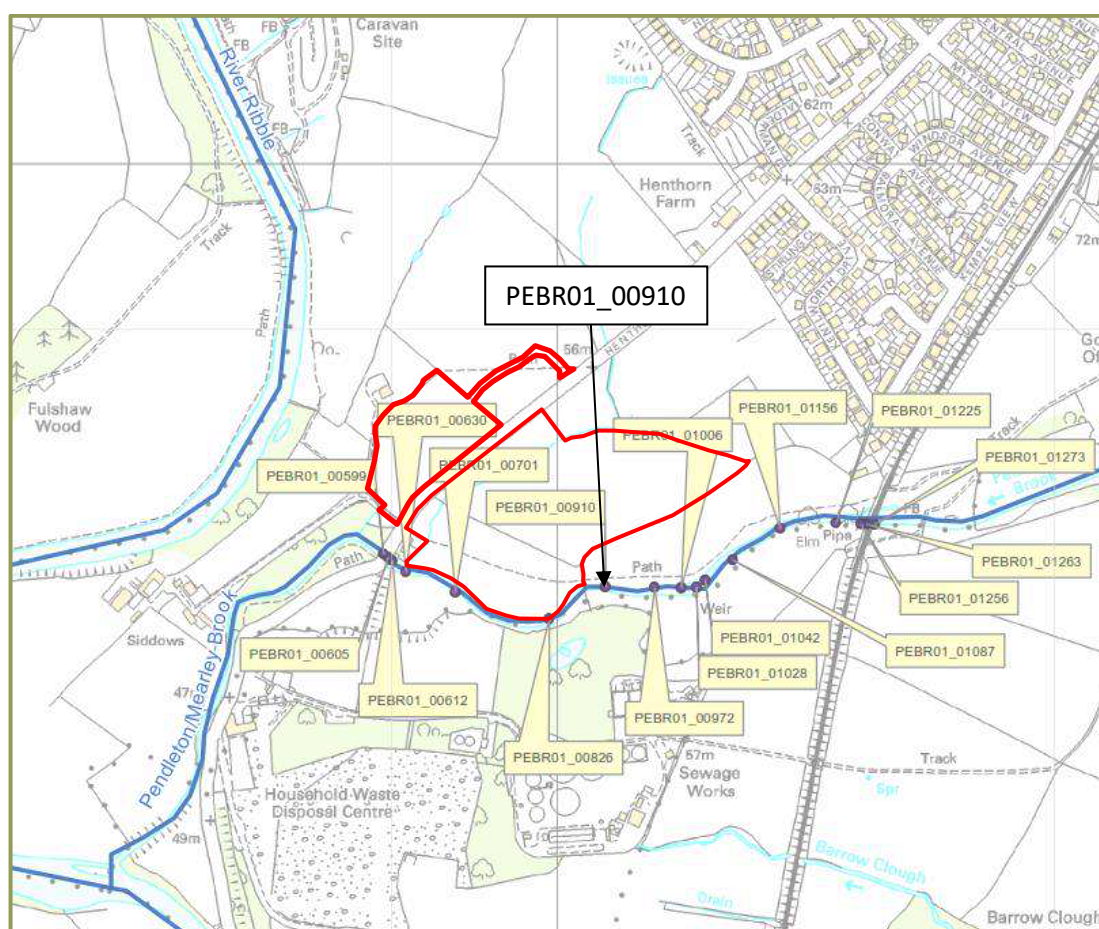
- 4.2.7 SFRA mapping (Appendix 2) confirms part of the Site is located within Flood Zone 3. The mapping does not confirm the location of Flood Zone 3b (Functional Floodplain).

Modelled Flood Levels

- i. Modelled Levels Comparison with Detailed Topographic Survey
- 4.2.8 The Environment Agency provided modelled flood levels for Pendleton Brook. Modelled flood levels were provided for a number of adjacent nodes, for a range of return periods including the undefended and defended 1 in 20-year, 100-year and 1000-year. The 100-year plus 70% climate change was also provided for the defended scenario and represents the 'upper end' for the North West RBD.
- 4.2.9 Node PEBR01_00910 is considered the most relevant to the Site, which located just upstream (east), as it is the most extreme (conservative) level.
- 4.2.10 A summary of the modelled flood levels is included in Table 4.2 and a node location plan is included in Figure 4.1. Note that the defended and undefended scenarios for the 1 in 1000-year event have the same modelled level.

Table 4.2: Modelled Flood Levels- Node PEBR01_00910

Protection	Return Period			
	20 year (5%)	100 year (1%)	1000 year (0.1%)	100 year +70% Climate Change
Defended	51.85	52.14	52.88	52.75
Undefended	51.84	52.17	52.88	No data

Figure 4.1: Model Node Locations

4.2.11 A reality check of the 1 in 1000-year modelled flood level (this is considered the conservative level to steer sequential development) was made using a Site-specific topographic survey (Drawing 010). The drawing demonstrates the southern extent of the Southern Land Parcel is inundated during the 1000-year event (i.e. Flood Zone 2, medium risk).

ii. Climate Change

4.2.12 The Environment Agency has not provided undefended modelled flood levels for the Site considering climate change. However, the Environment Agency have provided defended modelled levels and flows with a 70% flow addition for climate change (+70%CC). This represents 'upper end' allowance up to 2115 in the North West RBD. It is standard practice to apply this allowance to the 1 in 100-year fluvial event to assess climate change.

4.2.13 The defended and undefended scenarios during a 1 in 1000-year event produce the same modelled flood level at Node PEBR01_00910. Therefore, the modelled flows for this node location should also be the same, regardless of the presence of flood defences.

4.2.14 This allows a comparison of modelled flows at this node which by proxy, demonstrates a similar relationship in flood level. We assessed the data to determine if the 1 in 100-year +70% flood level is higher than the 1 in 1000-year flood level. Should the 1 in 1000-year flow be highest in the comparison, then its associated flood level can be used to sequentially steer development without further detailed analysis for climate change.

4.2.15 The 1 in 100-year+70%CC is 83.11 m³/s, and the 1000-year defended flow is 91.48m³/s. The 1 in 1000-year flow is higher and therefore its associated flood level would be higher than the 1 in 100-year +70%CC event. Therefore, the 1000-year event is considered to also incorporate

the 1 in 100-year +CC flood outline. The 1 in 1000-year fluvial flood outline (Drawing 010) will be carried forward to guide sequential development.

Flood Defences

- 4.2.16 Environment Agency online flood mapping shows that the Site does not benefit directly from flood defences. However, there are defences present on other reaches of the river that may affect flood levels at the Site.
- 4.2.17 There is a disbenefit during the defended 1 in 20-year flood event (+0.01m). However, there is a small reduction (-0.03m) in flood level is provided by defences during a 1 in 100-year flood event.
- 4.2.18 Furthermore, the above modelled fluvial levels analysis demonstrates there is no benefit to the Site from a defended scenario during a 1 in 1000-year event.

Flood Warning Service

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

Summary Flood Risk

- 4.2.20 The risk of fluvial flooding is assessed as negligible for most of the Site, with an area of medium to high risk within the southern extent of the Southern Land Parcel. Mitigation measures to address this risk is discussed in Section 5.

4.3 Tidal Flooding

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

4.4 Groundwater Flooding

Introduction

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

BGS Groundwater Flooding Susceptibility Map

- 4.4.1 The BGS Groundwater Flooding Susceptibility Map (Drawing 003) shows the Site is located within the mapped extent of groundwater flooding.
- 4.4.2 Most of the Southern Land Parcel and the south-east of the Northern Land Parcel is in an area where there is potential for groundwater flooding to occur at the surface, most likely associated with the alluvial superficial deposits along Pendleton Brook. Groundwater levels are likely to be hydraulically linked to water levels along Pendleton Brook and Watercourse 1.

- 4.4.3 Most of the Northern Land Parcel (excluding the north-western and south-eastern boundaries of the parcel) has potential for groundwater flooding of property situated below ground level. The easternmost corner of the Southern Land Parcel has a similar potential for such flooding. The BGS mapping assumes this potential based on the Site's proximity to the watercourses and alluvium mapped nearby, though it does not reflect the presence of clayey till underlying the Site. The superficial deposits and soils have a low infiltration potential and so it is unlikely that groundwater would rise to the surface.
- 4.4.4 The north-western extent of the Northern Land Parcel has limited potential for groundwater flooding to occur.
- 4.4.5 The BGS susceptibility mapping is coarse-scaled and should be superseded by the Geosmart groundwater flood risk map.

Geosmart Groundwater Flood Risk Map

- 4.4.6 The Geosmart 1 in 100-year groundwater flood risk map (Drawing 006) shows that most of the Southern Land Parcel and the northwest of the Northern Land Parcel are at negligible risk of groundwater flooding and fall within Risk Class 4 (Table 4.2). The south-east of the Northern Land Parcel, and the west and southern boundary of the Southern Land Parcel are at low risk and fall within Risk Class 3. The risk of groundwater flooding is likely associated with Watercourse 1 and Pendleton Brook.
- 4.4.7 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

Risk Class	Probability of Groundwater Flooding	Effect
		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.

Summary Flood Risk

4.4.8 The risk of groundwater flooding is assessed as negligible for most of the Site, with a low risk in the south-east of the Northern Land Parcel, and in the west and along the southern boundary of the Southern Land Parcel.

4.4.9 Mitigation measures against 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.

JBA Surface Water Flood Map

4.5.2 The JBA Surface Water Flood Map (Drawing 004.1) shows most of the Site is located outside the mapped extent of surface water flooding. There are, however, two surface water pathways. One is associated with Watercourse 1 and the other with Pendleton Brook. The surface water flooding is associated with the 1 in 75-year, 200-year and 1000-year events.

4.5.3 There is also areas of surface water ponding associated with the 1 in 1000-year event, in the Northern Land Parcel (west of Watercourse 1) and in the Southern Land Parcel (west of Watercourse 1).

4.5.4 The JBA Surface Water Flood mapping is superseded by the more detailed Environment Agency Complex Surface Water Flood mapping.

Environment Agency Complex Surface Water Flood Mapping

4.5.5 The Environment Agency Complex Surface Water Flood mapping (Drawings 009.1 to 009.4) shows three surface water flow pathways through the Site; one along the path of Watercourse 1, a second pathway along the eastern boundary of the Northern Land Parcel; and a pathway within the south-east of the Southern Land Parcel. There is also a pathway along the southern boundary of the Southern Land Parcel, associated with Pendleton Brook.

4.5.6 Along Watercourse 1, the flood outline is associated with the 1 in 30-year, 100-year and 1000-year events. Flood depths are greater than 1.20m during the extreme 1 in 1000-year event.

The flood velocity is 2.00m/s or greater and the flood hazard is 'low' (0.50-0.75) to 'extreme' (>2.00).

- 4.5.7 The pathway along the eastern boundary of the Northern Land Parcel is associated with the 1 in 30-year, 100-year and 1000-year events. Flood depths are up to 0.90m during the extreme 1 in 1000-year event. The flood velocity is up to 2.00m/s and the flood hazard is 'low' (0.50-0.75) to 'significant' (1.25-2.00). The pathway is likely associated with topographical low points.
- 4.5.8 The pathway in the south-eastern extent of the Southern Land Parcel is associated with the 1 in 1000-year event and aligns with the meander cut off features described in Section 3. Flood depths are up to 0.60m during the extreme 1 in 1000-year event. The flood velocity is up to 2.00m/s and the flood hazard is 'low' (0.50-0.75) to 'significant' (1.25-2.00).
- 4.5.9 The pathway along Pendleton Brook at the southern boundary of the Southern Land Parcel is associated with the 1 in 100-year and 1000-year events. Flood depths are up to 0.90m during the extreme 1 in 1000-year event. The flood velocity is 2.00m/s or greater and the flood hazard is 'low' (0.50-0.75) to 'extreme' (>2.00).

Summary Flood Risk

- 4.5.10 The risk of surface water flooding is assessed as negligible for most of the Site, with an area of low to high risk associated with the surface water flow pathways.
- 4.5.11 Mitigation measures for surface water flooding are discussed in Section 5.

4.6 Sewer 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 sewers are built to the guidelines within Sewers for Adoption¹⁸ and have a design standard to the 1 in 30-year flood 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).

Sewerage Assets

- 4.6.3 There are no public sewers located within the Site boundary or on the nearby Henthorn Road. The closest assets to the Site are public combined sewers beyond the southern boundary of the Northern Land Parcel. Elevation difference puts the asset downslope of the Site.

Summary Flood Risk

- 4.6.4 The risk of flooding from sewers is assessed as negligible.

¹⁸ WRC (2012) Sewers for Adoption 7th Edition.

4.7 Flooding from Infrastructure Failure

Reservoir

- 4.7.1 The Environment Agency online flood mapping shows the Site is located outside the extent of flooding sourced from reservoirs.
- 4.7.2 However, the JBA Flooding from Rivers mapping (Drawing 004.2) shows the south of the Southern Land Parcel is within the mapped outline of a dam break.
- 4.7.3 Reservoir flooding is extremely unlikely to happen. There has been no loss of life in the UK from reservoir flooding since 1925. All large reservoirs must be inspected and supervised by reservoir panel engineers. As the enforcement authority for the Reservoirs Act 1975 in England, the Environment Agency ensure that reservoirs are inspected regularly, and essential safety work is carried out. As such, the risk of flooding from reservoirs is assessed as negligible.

Pond

- 4.7.4 A pond has been identified 20m west of the Site. The pond is small and not impounded. The risk of flooding from pond failure is assessed as negligible.

5.0 Flood Risk Mitigation Measures

5.1 Introduction

5.1.1 The following sources of flooding were identified:

- Fluvial Flooding.
- Groundwater flooding.
- Surface water flooding.

5.2 Mitigation Measures

Fluvial Flooding

- Sequentially develop the Site, limiting the built development (inclusive of SuDS features) outside the mapped extent of the 1 in 1000-year flood outline (Drawing 010).
- Set the surface water outfalls from the proposed development at an appropriate height, i.e. above the 1 in 1000-year modelled flood level (51.76m AOD as the most conservative level).

Groundwater Flooding

- No below surface habitable buildings (i.e. basements).
- Adoption of a surface water management strategy.
- Set finished floor levels within the vicinity of Watercourse 1 to a minimum of +300mm above external levels. All other floor levels should be a minimum of +150mm above external levels.
- Lined pond to prevent groundwater ingress

Surface Water Flooding

- Sequentially develop the Site, limiting the built development (inclusive of SuDS features) outside the mapped extent of surface water flow pathways generated from land external to the Site boundary.
- Adoption of a surface water management strategy.
- Set finished floor levels as per above.

5.3 Summary of Flood Risk

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

Table 5.1: Probability and Consequences of All Sources of Flooding

Flooding Source	Potential Source	Probability	Consequence & Impact Without Mitigation	Consequence & Impact with Mitigation
Fluvial	Pendleton Brook	Negligible for most of the Site, with an area of medium - high risk within the southern extent of the Southern Land Parcel.	Negligible for most of the Site, with an area of medium - high risk within the southern extent of the Southern Land Parcel.	Negligible
Tidal	None identified	Negligible	Negligible	Negligible
Groundwater	Aquifer	Negligible for most of the Site, with a low risk in the south-east of the Northern Land Parcel, and in the west and along the southern boundary of the Southern Land Parcel.	Negligible for most of the Site, with a low risk in the south-east of the Northern Land Parcel, and in the west and along the southern boundary of the Southern Land Parcel.	Negligible
Surface Water	Poor permeability and Site topography	Negligible for most of the Site, with an area of low to high risk associated with the surface water flow pathways.	Negligible for most of the Site, with an area of low to high risk associated with the surface water flow pathways.	Negligible
Sewer	None identified	Negligible	Negligible	Negligible
Infrastructure Failure	None identified	Negligible	Negligible	Negligible

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

5.4 Flood Guidance and Sequential Test

- 5.4.1 The proposal is for a residential development. Table 2 of PPG ID: 7 (not included in this report) classifies the proposed use as 'more vulnerable'.
- 5.4.2 The Environment Agency Flood Zones and acceptable development types are listed in Table 5.2. More vulnerable uses are acceptable in Flood Zone 1 and 2 (low to moderate risk). More vulnerable development in Flood Zone 3a would require the Exception Test as indicated in Table 5.3.

Table 5.2: Environment Agency Flood Zones and Appropriate Land Use

Flood Zone	Probability	Explanation	Appropriate Land use
Zone 1	Low	Less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).	All development types generally acceptable.
Zone 2	Medium	Between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1%) in any year.	Most development type are generally acceptable.
Zone 3a	High	A 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.	Some development types not acceptable.
Zone 3b	'Functional Floodplain'	Land where water must flow or be stored in times of flood. SFRAs should identify this zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1% flood, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes).	Some development types not acceptable.

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

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

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

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

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6.0 Site Drainage

6.1 Surface Water Drainage

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

6.2 Existing Drainage System

- 6.2.1 The 6.96ha Site land use comprises two land parcels of agricultural (arable and grassed) land.
- 6.2.2 The Site is underlain by impermeable soils and bedrock. It is likely that drainage is predominantly via overland flow, following the topography of the Site to the topographic low points (Land Drain 1 from Northern Land Parcel, Watercourse 1 and Pendleton Brook from Southern Land Parcel), with a small amount of infiltration to bedrock, and throughflow to the watercourses.
- 6.2.3 There is currently no foul water discharging from the undeveloped Site. Please note that foul drainage is not considered within this FRA but is dealt with in a separate standalone report.

6.3 Developable and Impermeable Areas

- 6.3.1 For drainage purposes, the Site has been split into three catchments; Catchment 1 within the Northern Land Parcel and Catchment 2 and 3 within the Southern Land Parcel (Drawing 011). This is a reflection of topographic levels.
- 6.3.2 The proposal is for a residential development. An allowance of 55% impermeable area (inclusive of 10% for urban creep) was applied to the 4.01ha developable area. The existing and proposed impermeable areas are shown in Table 6.1.

Table 6.1: Impermeable Area

Catchment	Area	Existing Buildings and Hardstanding	Proposed Buildings and Hardstanding	Difference
1	Area (ha)	0.00	0.56	+0.56
	Percentage of Total Site Area (%)	0.00	8.05	+8.05
2	Area (ha)	0.00	0.90	+0.90
	Percentage of Total Site Area (%)	0.00	12.93	+12.93
3	Area (ha)	0.00	0.74	+0.74
	Percentage of Total Site Area (%)	0.00	10.63	+10.63

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

6.4 Greenfield Runoff Rates

6.4.1 An assessment of greenfield runoff rates was undertaken to determine the attenuation requirements for the proposed development.

6.4.2 The runoff rates (Appendix 6) were calculated using Causeway Flow design software following the current 'industry best practice' guidelines, as outlined in the Interim Code of Practice for SuDS¹⁹ and Environment Agency Report SC030219 – Rainfall runoff management for developments. This is a recommended methodology for Sites up to 50ha in area.

6.4.3 The following parameters were used in the runoff calculations:

- Developable Area (Drawing 011): **Catchment 1:** 1.02ha, **Catchment 2:** 1.64ha, **Catchment 3:** 1.35ha.
- Average Annual Rainfall (SAAR): 1178 mm/year;
- Soil: 4/0.47;
- Region No.: 10

6.4.4 The soil type/SPR assigned on HR Wallingford website was 4/0.47, indicating clayey or loamy soils with an impermeable layer at shallow depth, which is representative of the Site (Figure 6.1).

¹⁹ Office of the Deputy Prime Minister, National SuDS Working Group, July 2004, Interim Code of Practice for sustainable drainage systems.

Figure 6.1: Soil Index (Sourced from Microdrainage)

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

6.4.5 Table 6.2 shows the calculated greenfield runoff rates using the FEH method (Appendix 6).

Table 6.2: Greenfield Runoff Rates

Annual Probability (Return Period, years)	Greenfield Runoff (l/s)		
	Catchment 1	Catchment 2	Catchment 3
QBAR	13.5	21.7	17.8
100% (1)	11.7	18.8	15.5
3.33% (30)	22.9	36.8	30.3
1% (100)	28.0	45.1	37.1
1% Plus Climate Change	39.2	63.1	51.9

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

6.5 Sustainable Drainage Options (SuDS)

Feasibility of SuDS

- 6.5.1 Soakaway testing was undertaken during July 2018 for the neighbouring field to the north-east of the Northern Land Parcel. A copy of the Infiltration Test Report is included in Appendix 5. Findings show that infiltration-based SuDS would not be feasible due to the low permeability of the loamy and clayey soils, superficial till deposits, and mudstone bedrock.
- 6.5.2 The Site shares the same geological unit, save for clayey alluvium superficial deposits in the southern extent of the Southern Land Parcel. Therefore, the test results for the neighbouring Site should be considered representative of the Site.

Choice of SuDS Options

- 6.5.3 Sustainable water management measures should be used to control the surface water runoff from the proposed development Site, thereby managing the flood risk to the Site and surrounding areas from surface water runoff. These measures will also improve the quality of water discharged from the Site.

- 6.5.4 Current guidance promotes sustainable water management using SuDS. Options applicable to this Site are identified in Table 6.3.

Table 6.3: SuDS Options

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

Note: SuDS appropriate to the development are highlighted green.

- 6.5.5 A hierarchy of SuDS techniques is identified²⁰:

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

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

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

SuDS Maintenance

- 6.5.7 Three detention basins will form the main attenuation features within the development Site. There will be one detention basin per catchment.

²⁰ CIRIA (2004) Report C609, Sustainable Drainage Systems – Hydraulic, Structural and Water Quality advice.

- 6.5.8 Maintenance of the SuDS features would be in line with the SuDS Manual (CIRIA C753, 2015), as detailed in Figure 6.2. The maintenance would be undertaken by a private maintenance company.
- 6.5.9 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 several of them would be appointed to its board. This will ensure maintenance throughout the lifetime of the development.
- 6.5.10 Details of other SuDS features, and maintenance would be considered further at detailed design, when a detailed layout has been produced. The level of detail provided within this FRA should be sufficient at outline stage to demonstrate that SuDS would be deliverable.

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

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

6.6 Surface Water Management Strategy

Hierarchy of Discharge

6.6.1 In accordance with requirement H3 of the Building Regulations 2010²¹ rainwater runoff must discharge to one of the following, listed in order of priority:

1. **An adequate soakaway or some other adequate infiltration system; or, where that is not reasonably practicable:** The use of infiltration-based SuDS is not feasible due to low infiltration potential.
2. **A watercourse; or where that is not reasonably practicable:** Drains 1 and 2 are located on the southern boundary of the Northern Land Parcel. Watercourse 1 is in the western extent of the Southern Land Parcel. Pendleton Brook is also located along the southern boundary of the Southern Land Parcel.
3. **A sewer:** There are no public surface water sewers located within the immediate vicinity of the Site.

6.6.2 The potential route to discharge from the existing Site will be by outfall to watercourses. Catchment 1 (Northern Land Parcel) will discharge to Drain 1 (Drawing 011). Catchments 2 and 3 (Southern Land Parcel) will outfall to Pendleton Brook.

Drainage Design

6.6.3 Surface water runoff would be directed to the drainage system through drainage gullies located around the perimeter of the buildings and through contouring of the hardstanding areas.

6.6.4 Landscaped areas should be incorporated into the layout where possible, and the associated gardens of each unit will allow a proportion of the rainfall to infiltrate into the soil substrate.

6.6.5 Surface water will be directed to one of the three onsite detention basins, positioned to achieve a gravity fed connection to Drain 1 or Pendleton Brook.

6.6.6 An indicative drainage layout is provided in Drawing 011.

Attenuation Requirements

6.6.7 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 (+40%CC) rainfall event, assuming no infiltration losses.

6.6.8 The following input parameters were assumed in the calculations:

- Impermeable Area: **Catchment 1:** 0.56ha (8.05%), **Catchment 2:** 0.90ha (12.93%), **Catchment 3:** 0.74ha (10.63%);
- Cv (proportion of rainfall forming surface water runoff): 75% summer, 84% winter;
- Infiltration losses: 0.00m/hour;
- With outfall: using QBAR rates (Table 6.2).

6.6.9 The attenuation volume for the 1 in 100-year event (plus climate change) is:

- Catchment 1: 281m³.

²¹ Office of the Deputy Prime Minister, The Building Regulations 2010, amended 2015.

- Catchment 2: 454m³.
- Catchment 3: 321m³.

6.6.10 Causeway Flow 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 The detention basin will be designed with a capacity up to a 1 in 100-year (plus 40% climate change) event, with a +300mm freeboard allowance, based on the greenfield restricted discharge rate. 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 basin to overtop (with no sudden deluge) and would then shed overland following the topography (south) to the Pendleton Brook from both parcels of land, without affecting potential as per existing conditions (Drawing 011).
- 6.7.3 Finished floor levels of new dwellings will be set above external levels, which will mitigate the residual risk of overtopping, though, all proposed dwellings will be upslope of detention basins.

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7.0 Summary and Conclusions

7.1 Introduction

- 7.1.1 A site-specific Flood Risk Assessment (FRA) has been undertaken for a proposed residential development, located on a 6.96ha Site on land to the north and south of Henthorn Road, Clitheroe.

7.2 Flood Risk

- 7.2.1 The risk of fluvial flooding is assessed as negligible for the developable area of the Site, with an area of medium to high risk within the southern extent of the Southern Land Parcel; proposed to be green space.
- 7.2.2 The risk of groundwater flooding is assessed as negligible for most of the Site, with a low risk in the south-east of the Northern Land Parcel, and in the west and along the southern boundary of the Southern Land Parcel.
- 7.2.3 The risk of surface water flooding is assessed as negligible for most of the Site, with an area of low to high risk associated with surface water flow pathways.
- 7.2.4 The risk of flooding from all other sources is assessed as negligible.

7.3 Mitigation Measures

- 7.3.1 Flood risk can be mitigated to a negligible or low and acceptable level through the following approach:
- Sequentially develop the Site, limiting the built development (inclusive of SuDS features) outside the mapped extent of fluvial flooding.
 - Set the surface water outfall from the proposed development at an appropriate height, i.e. above the 1 in 1000-year modelled flood level (51.76m AOD as the most conservative level).
 - No below surface habitable buildings (i.e. basements).
 - Adoption of a surface water management strategy.
 - Set finished floor levels within the vicinity of Watercourse 1 to a minimum of +300mm above external levels. All other floor levels should be a minimum of +150mm above external levels.
 - Lined pond to prevent groundwater ingress
 - Sequentially develop the Site, limiting the built development (inclusive of SuDS features) outside the mapped extent of surface water flooding.
 - Adoption of a surface water management strategy.
 - Set finished floor levels as per above.

7.4 Flood Guidance

- 7.4.1 The proposed residential use is classified as more vulnerable. More vulnerable uses are considered acceptable in terms of flood risk in Flood Zones 1 and 2. More vulnerable

development in Flood Zone 3 requires the Exception Test. Sequential development addresses these issues.

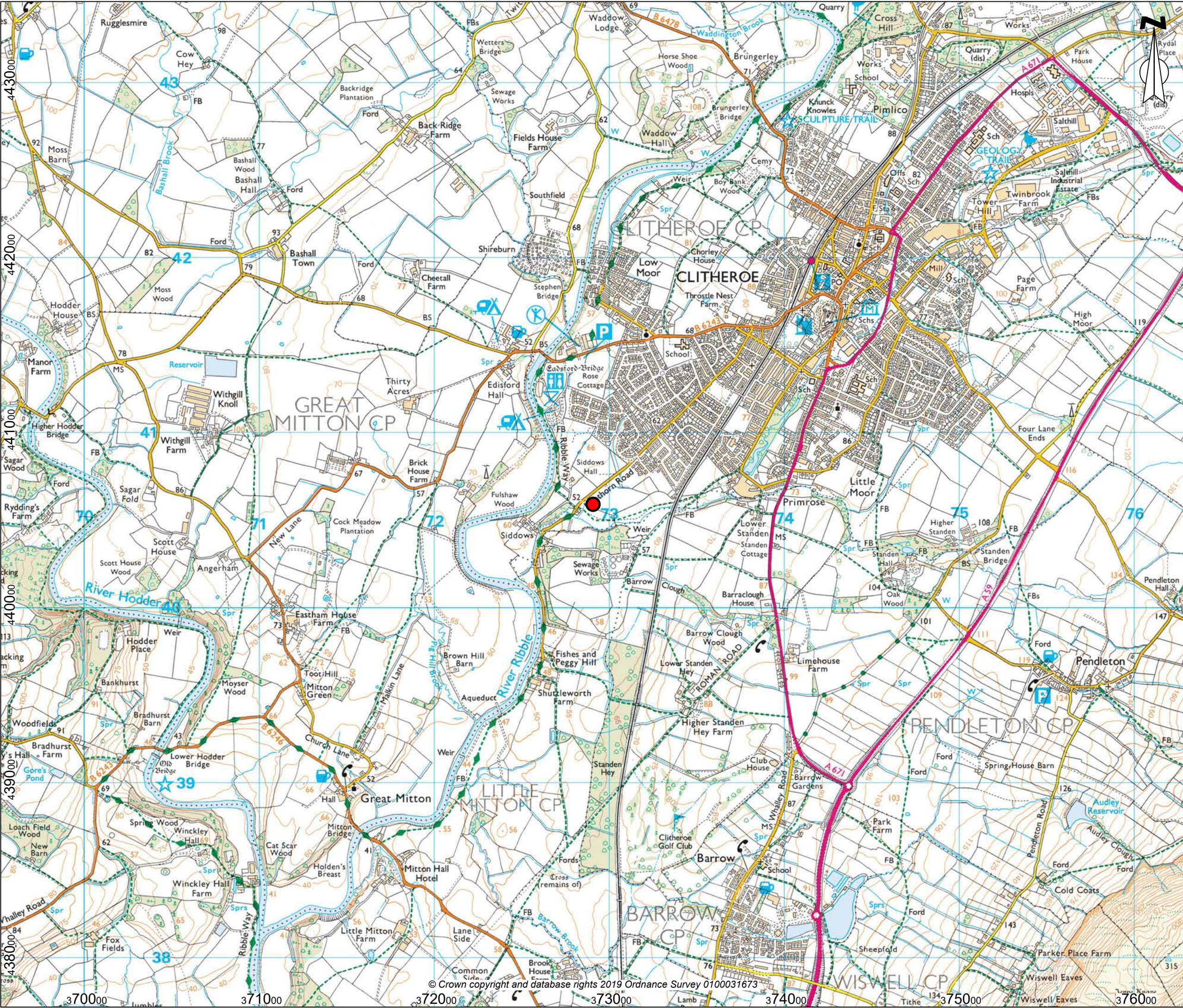
7.5 Site Drainage

- 7.5.1 The proposed development will increase the area of impermeable surfaces and therefore increase the amount of runoff without mitigation.
- 7.5.2 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.
- 7.5.3 Surface water runoff from the proposed development would be attenuated on-site up to and including the 1 in 100-year event, plus 40% climate change.
- 7.5.4 A SuDS drainage scheme is proposed to manage excess runoff from the development, comprising three detention basins designed to maintain runoff at pre-development rates, with an outfall to Drain 1 and Pendleton Brook.

7.6 Conclusion

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

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Key

Site Location
(SD 7290 4058)

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environmental consultants

Samuel House, 5 Fox Valley Way, Stocksbridge, Sheffield, S36 2AA

CLIENT:

Gladman Developments Ltd

SCALE:

1:20,000@A3

PROJECT REF:

SHF.1132.227

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DATE:

Oct 2019

PROJECT:

Henthorn Road, Clitheroe

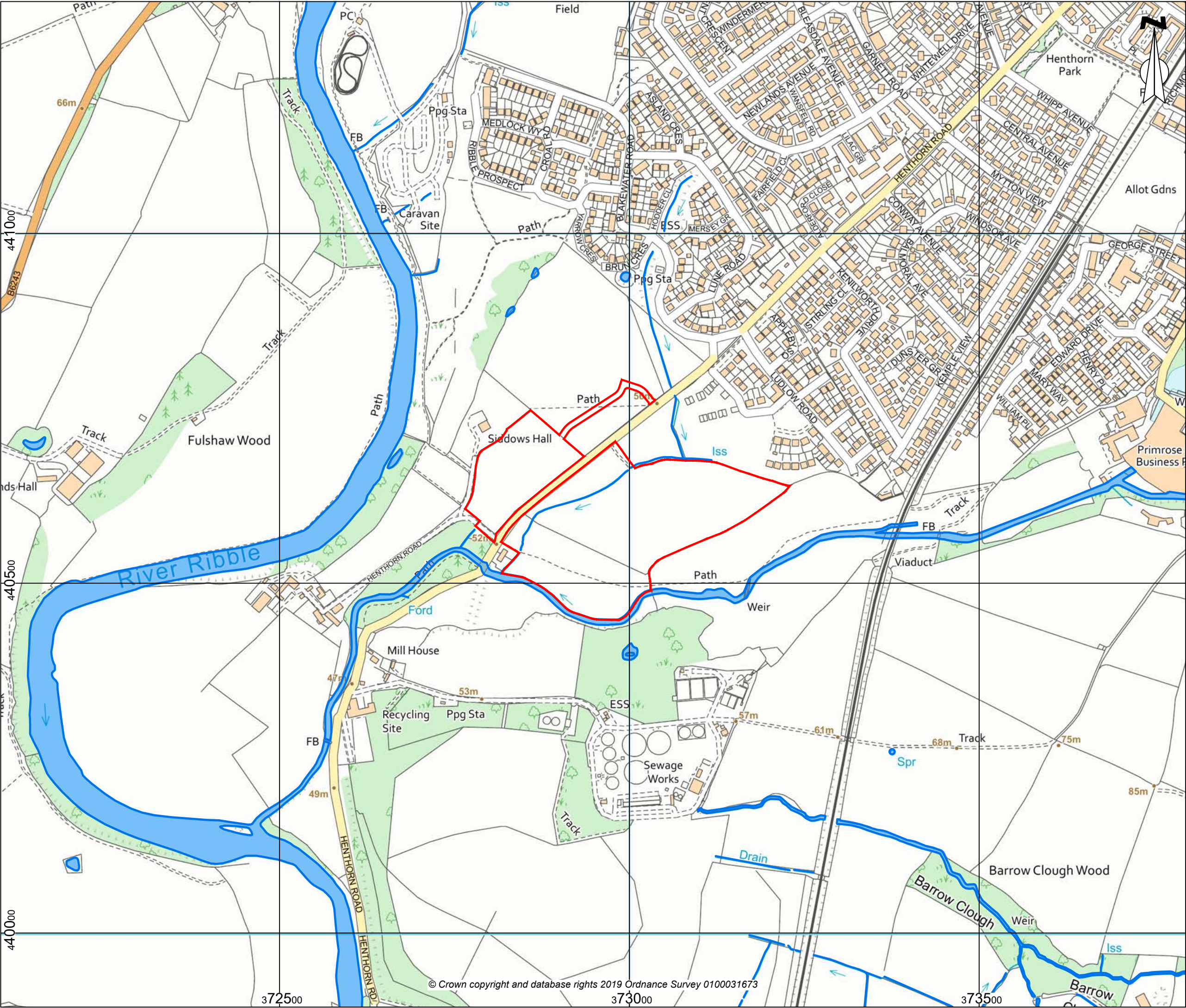
TITLE:

Site Location Plan

DRAWING NO:

SHF.1132.227.HY.D.001

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Key

Site Boundary

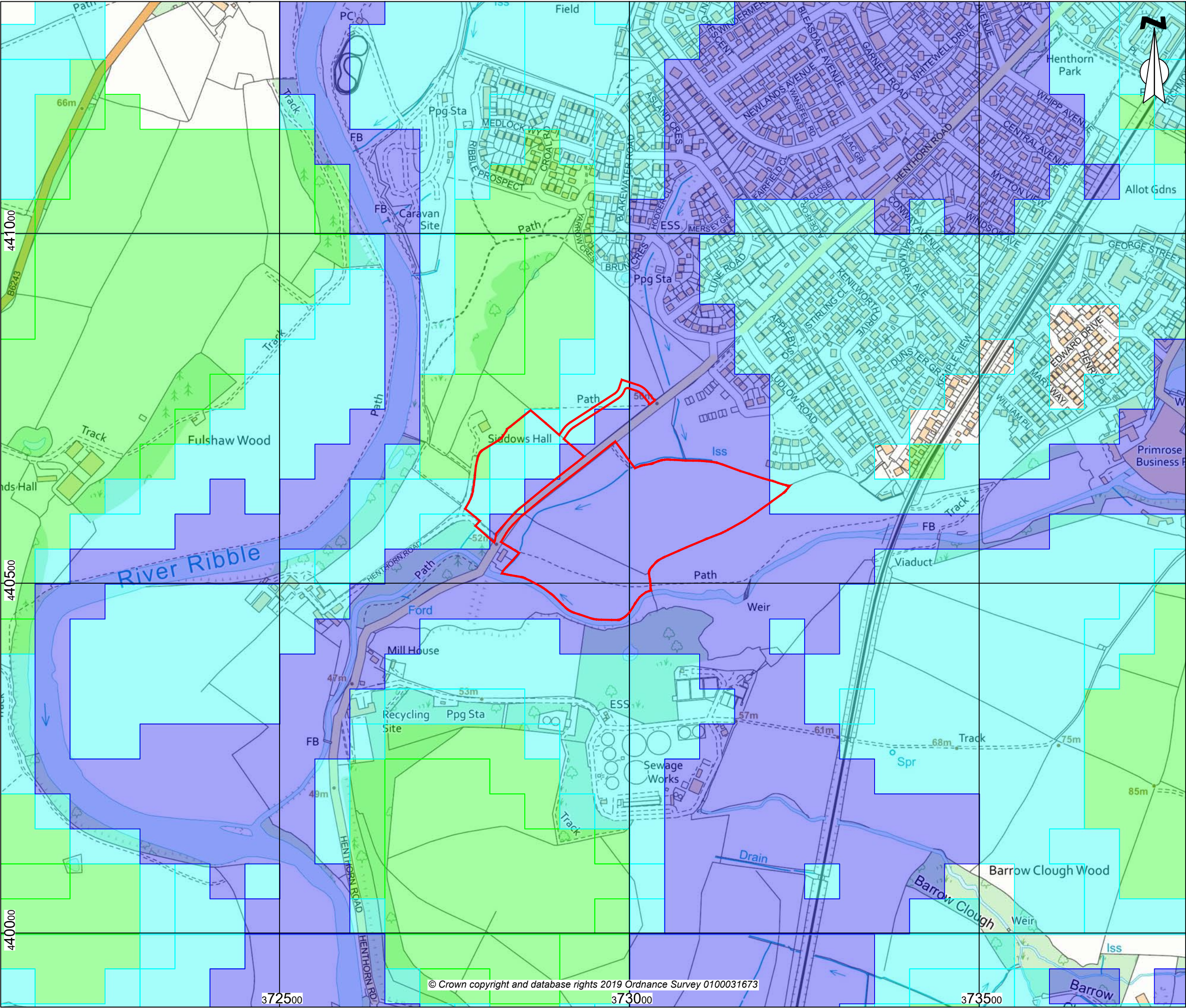
Surface Water Features



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		TITLE:	
		Surface Water Features	
		DRAWING NO:	
		SHF.1132.227.HY.D.002	

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Key

- Site Boundary
- Potential for Groundwater Flooding to Occur at Surface
- Potential for Groundwater Flooding of Property Situated Below Ground Level
- Limited Potential for Groundwater Flooding to Occur



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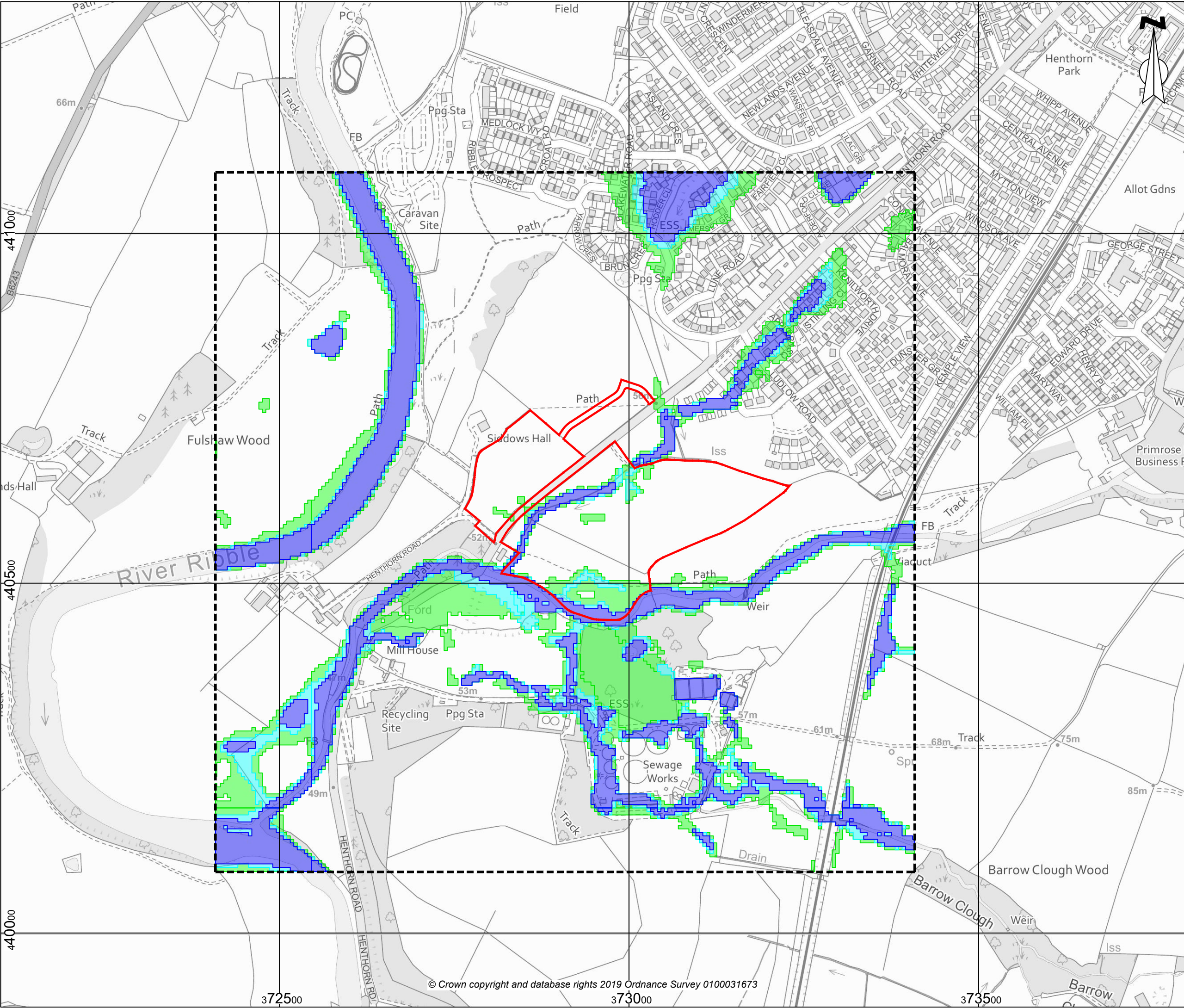
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Oct 2019

PROJECT:
Henthorn Road, Clitheroe

TITLE:
BGS Groundwater Flooding Susceptibility

DRAWING NO:
SHF.1132.227.HY.D.003

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Key

Site Boundary

Search Extent

1 in 75 Year Surface Water Flooding

1 in 200 Year Surface Water Flooding

1 in 1000 Year Surface Water Flooding



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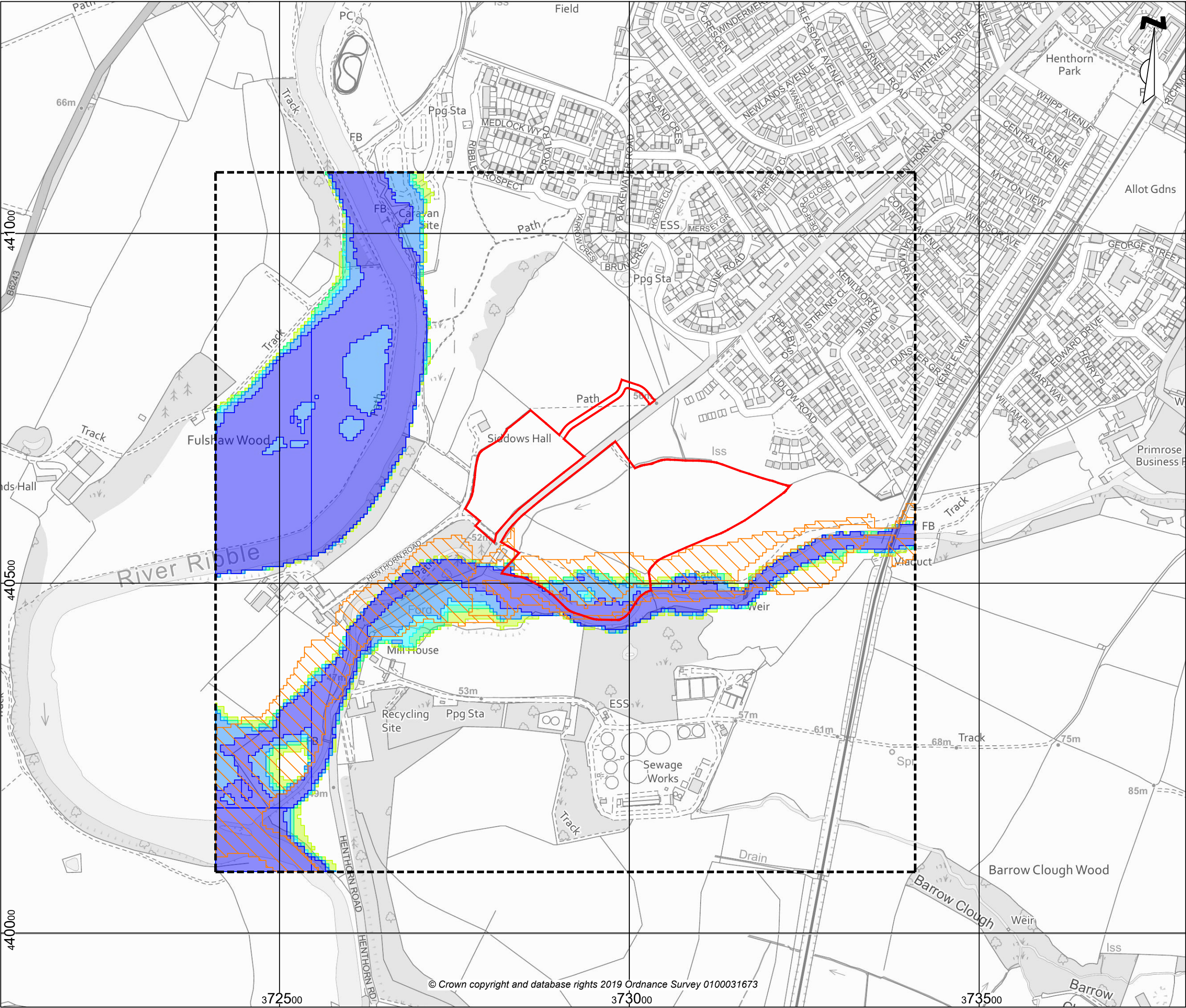
TITLE:

JBA Surface Water Flooding

DRAWING NO:

SHF.1132.227.HY.D.004.1

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Key

Site Boundary

Search Extent

Flooding from Dam Break

1 in 20 Year Flooding from Rivers

1 in 75 Year Flooding from Rivers

1 in 100 Year Flooding from Rivers

1 in 200 Year Flooding from Rivers

1 in 1000 Year Flooding from Rivers

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PROJECT:

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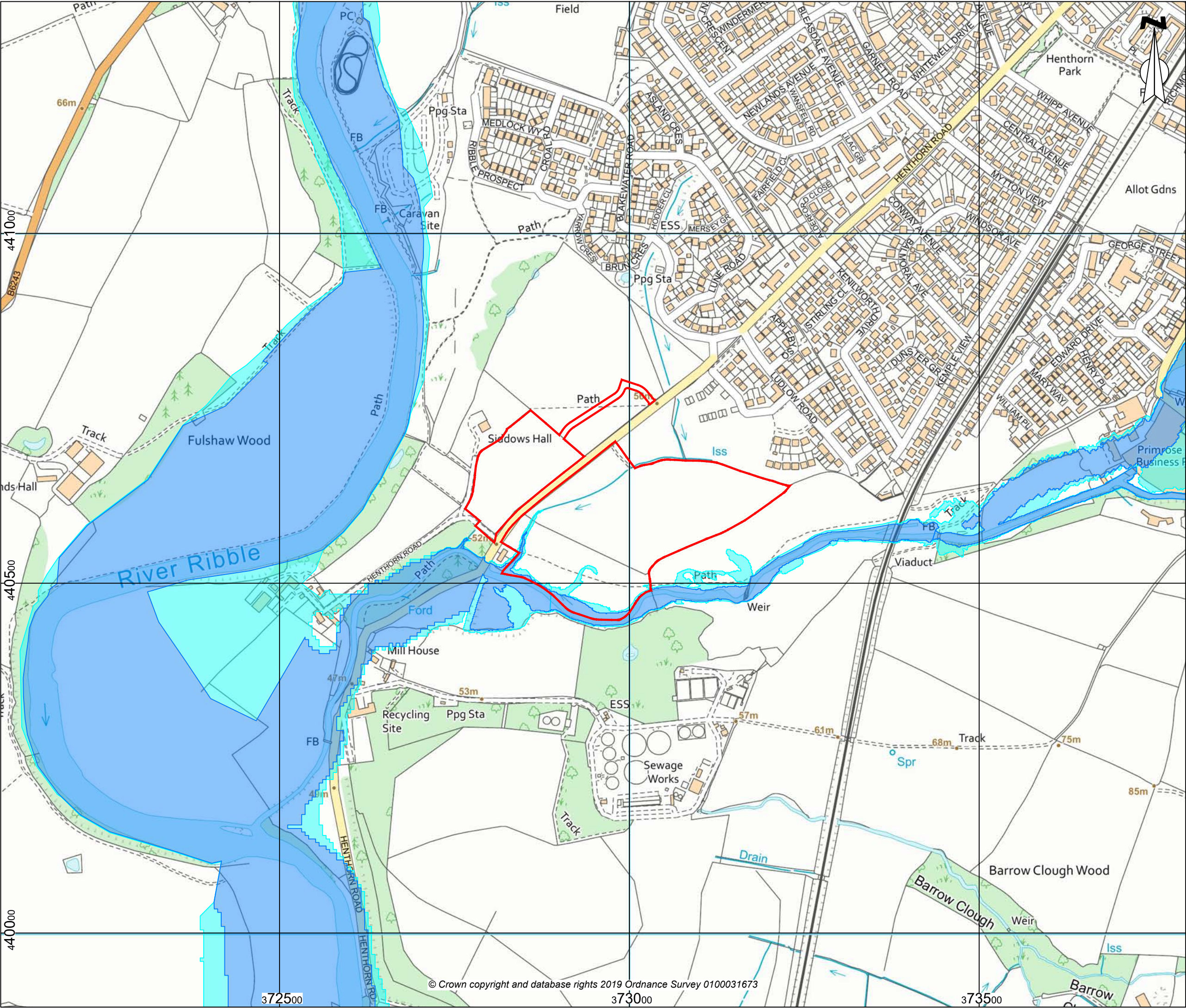
TITLE:

JBA Flooding from Rivers

DRAWING NO:

SHF.1132.227.HY.D.004.2

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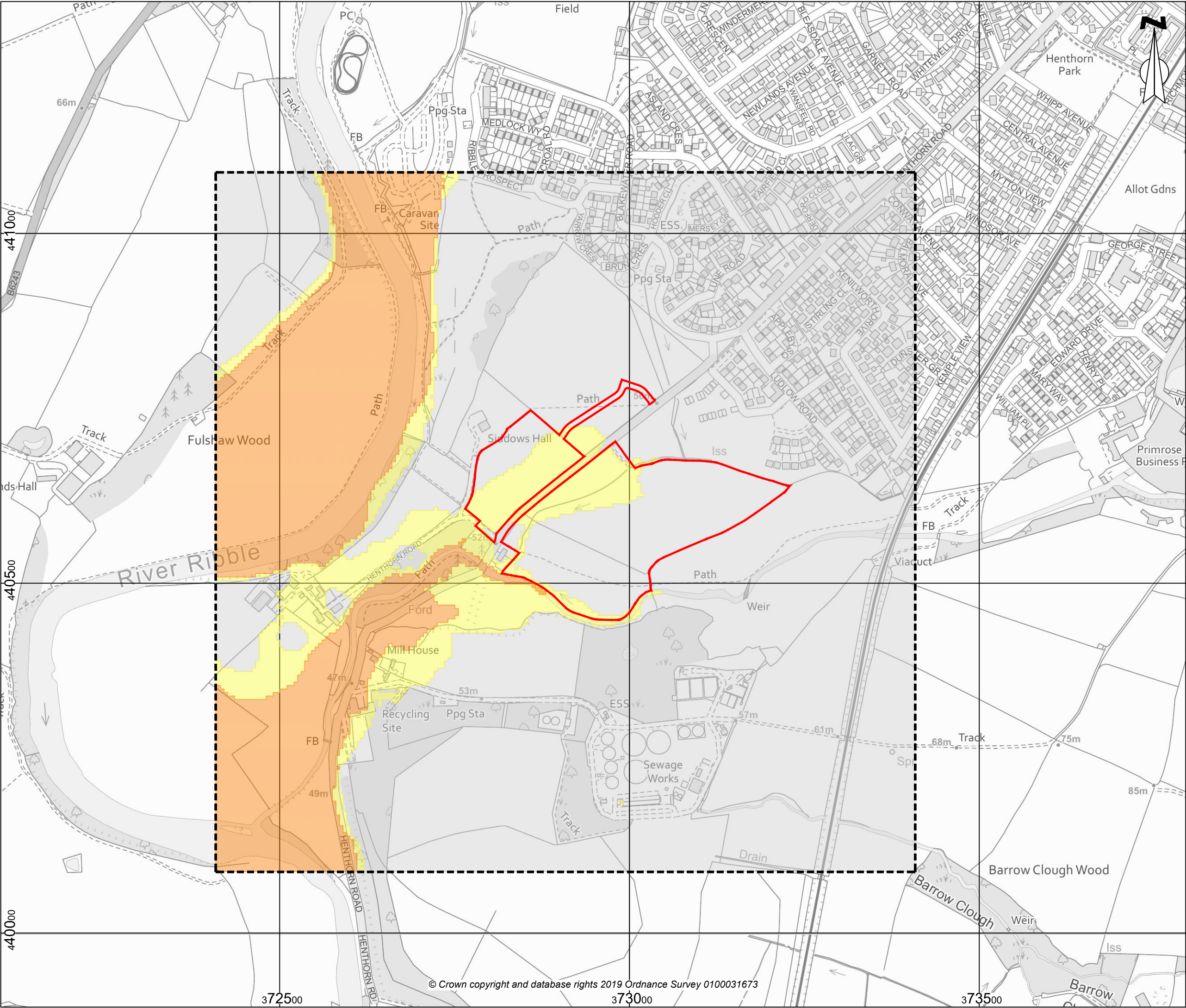
- Site Boundary
- Flood Zone 3
- Flood Zone 2
- Flood Zone 1



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SCALE: 1:5,000@A3	PROJECT REF: SHF.1132.227	
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PROJECT: Henthorn Road, Clitheroe		
TITLE: Environment Agency Flood Zones		
DRAWING NO: SHF.1132.227.HY.D.005		

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Site Boundary

Search Extent

Class 1 - High Risk

Class 2 - Moderate Risk

Class 3 - Low Risk

Class 4 - Negligible Risk

Notes:

GEOSMART GROUNDWATER FLOOD RISK MAP GW5
Version 2.2© - www.geosmartinfo.co.uk

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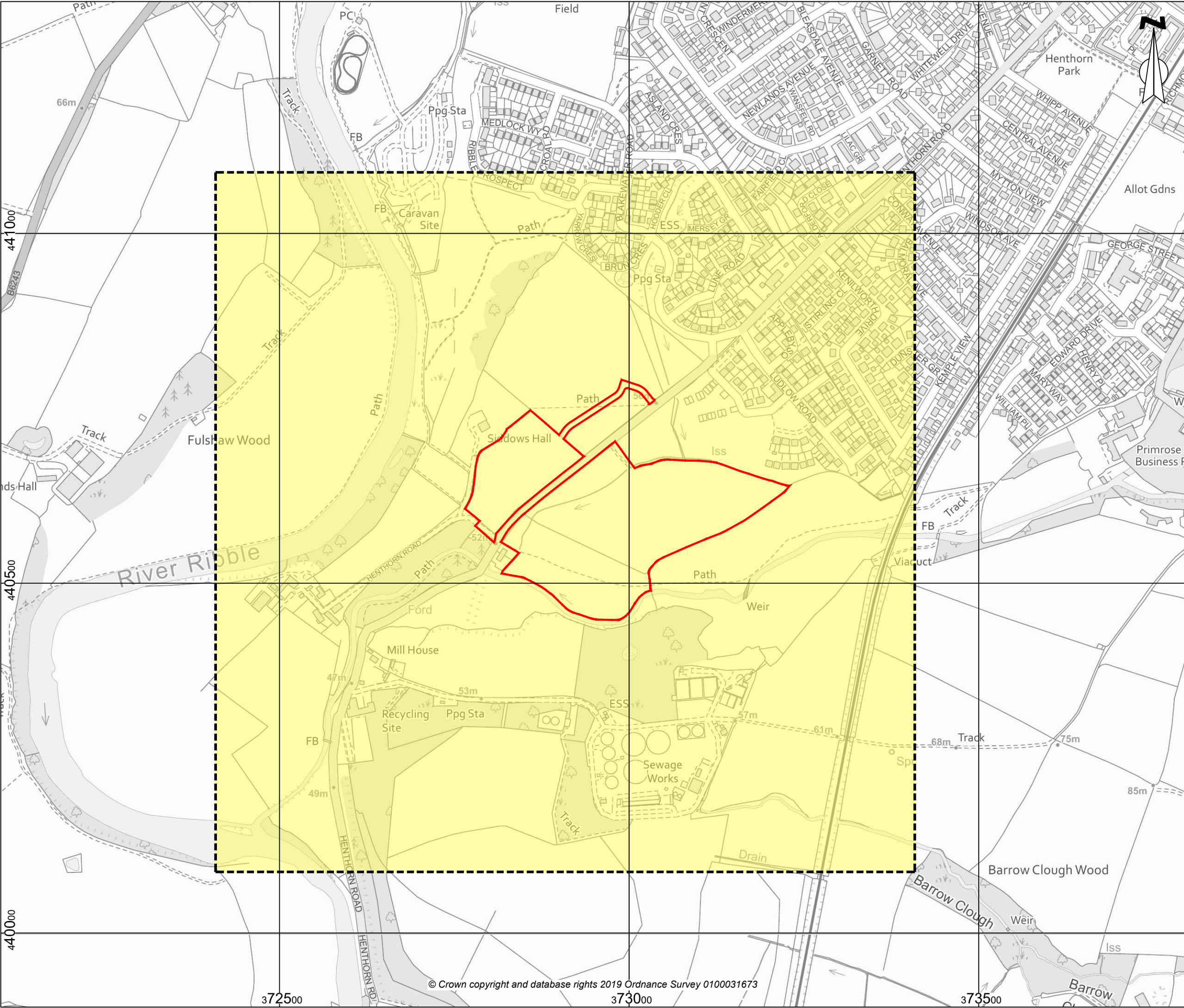
TITLE:

Groundwater Flood Risk Map

DRAWING NO:

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Key

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

Notes:

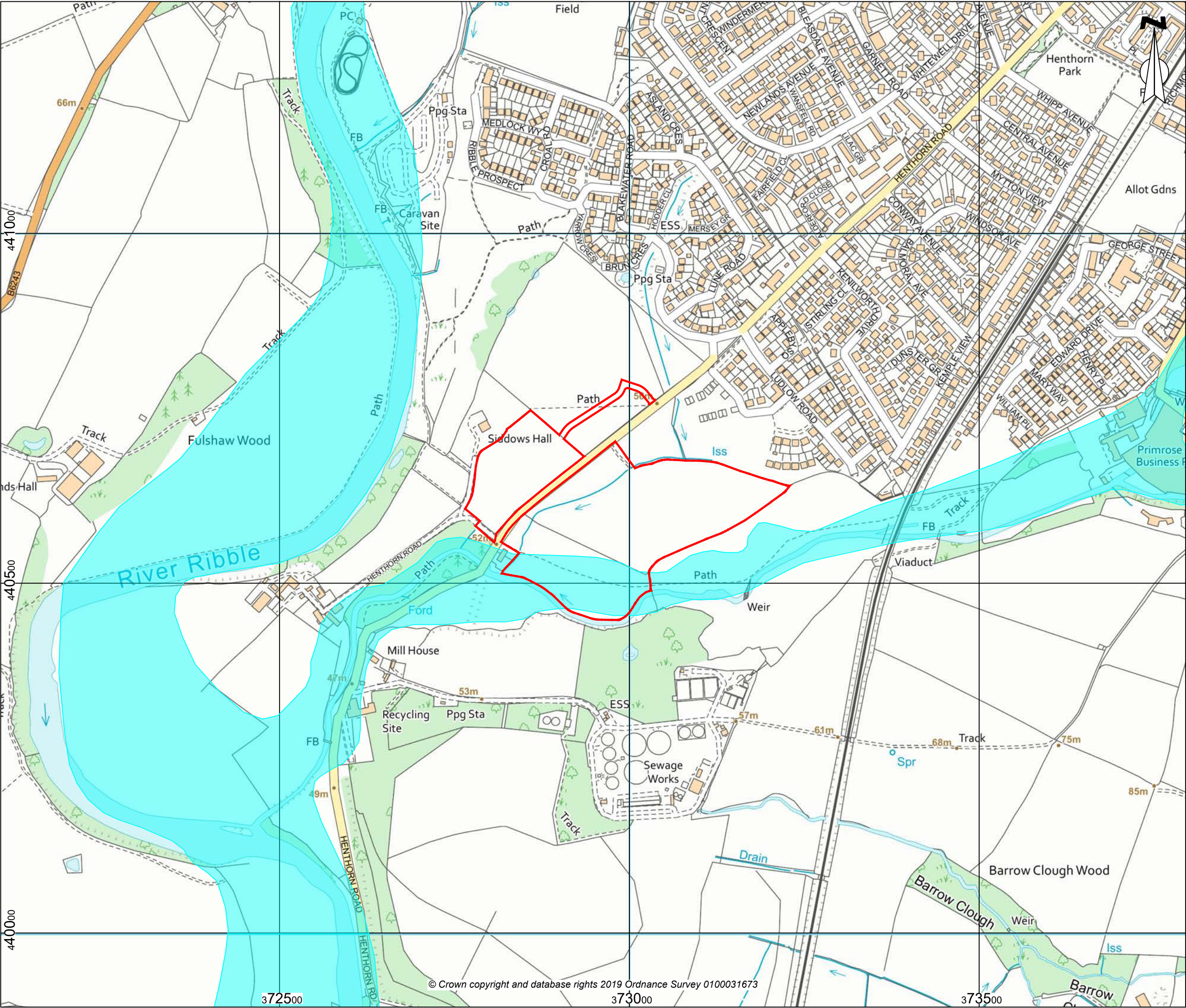
GEOSMART SUDS INFILTRATION POTENTIAL MAP SD50
Version 1.0© - www.geosmartinfo.co.uk



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		TITLE:	
		SuDS Infiltration Potential Map	
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Key

- Site Boundary
- Geological Indicators of Flooding from Inland Flooding

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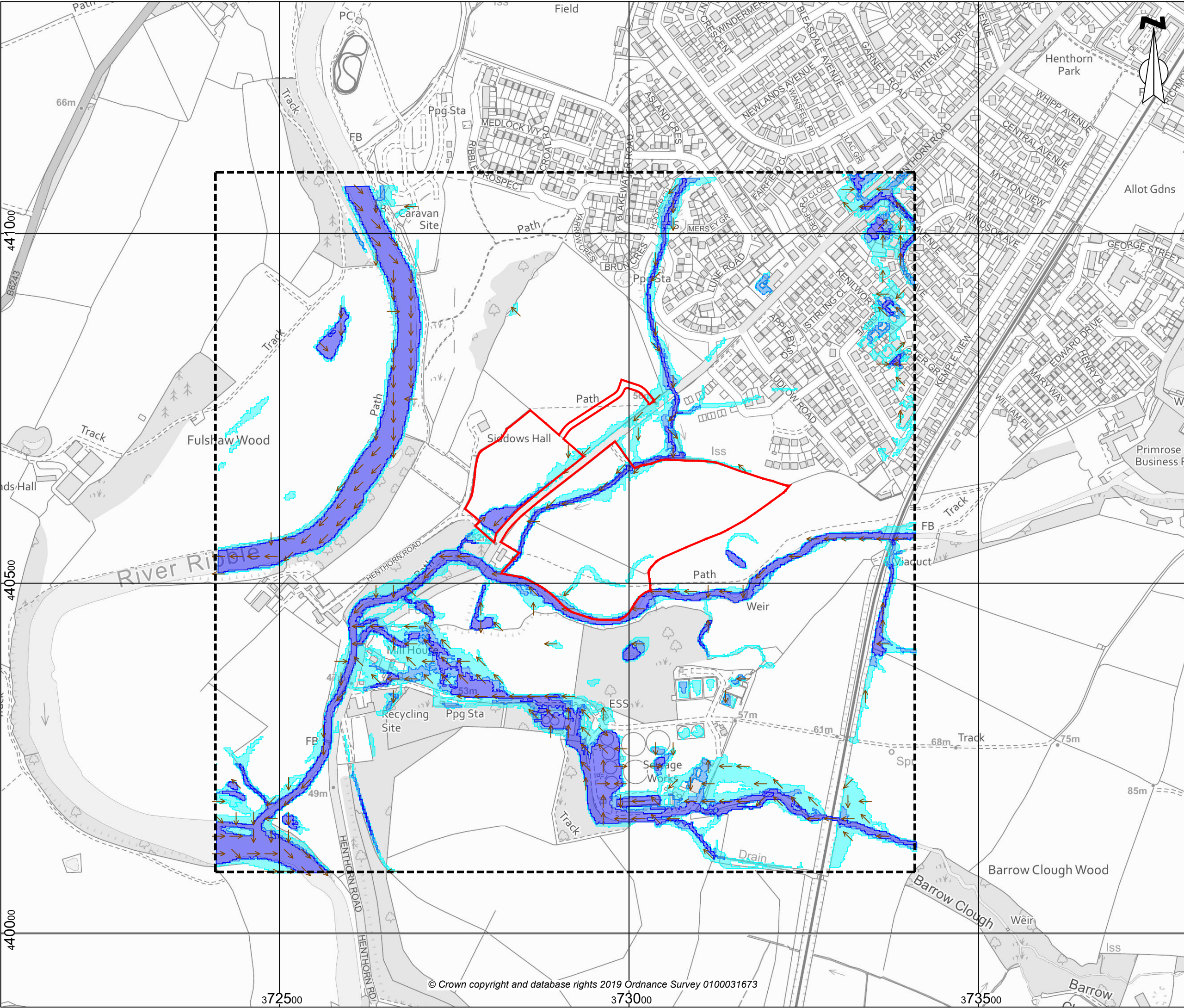
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PROJECT: Henthorn Road, Clitheroe

TITLE: Geological Indicators of Flooding (based on geological deposits)

DRAWING NO: SHF.1132.227.HY.D.008

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Key

Site Boundary

Search Extent

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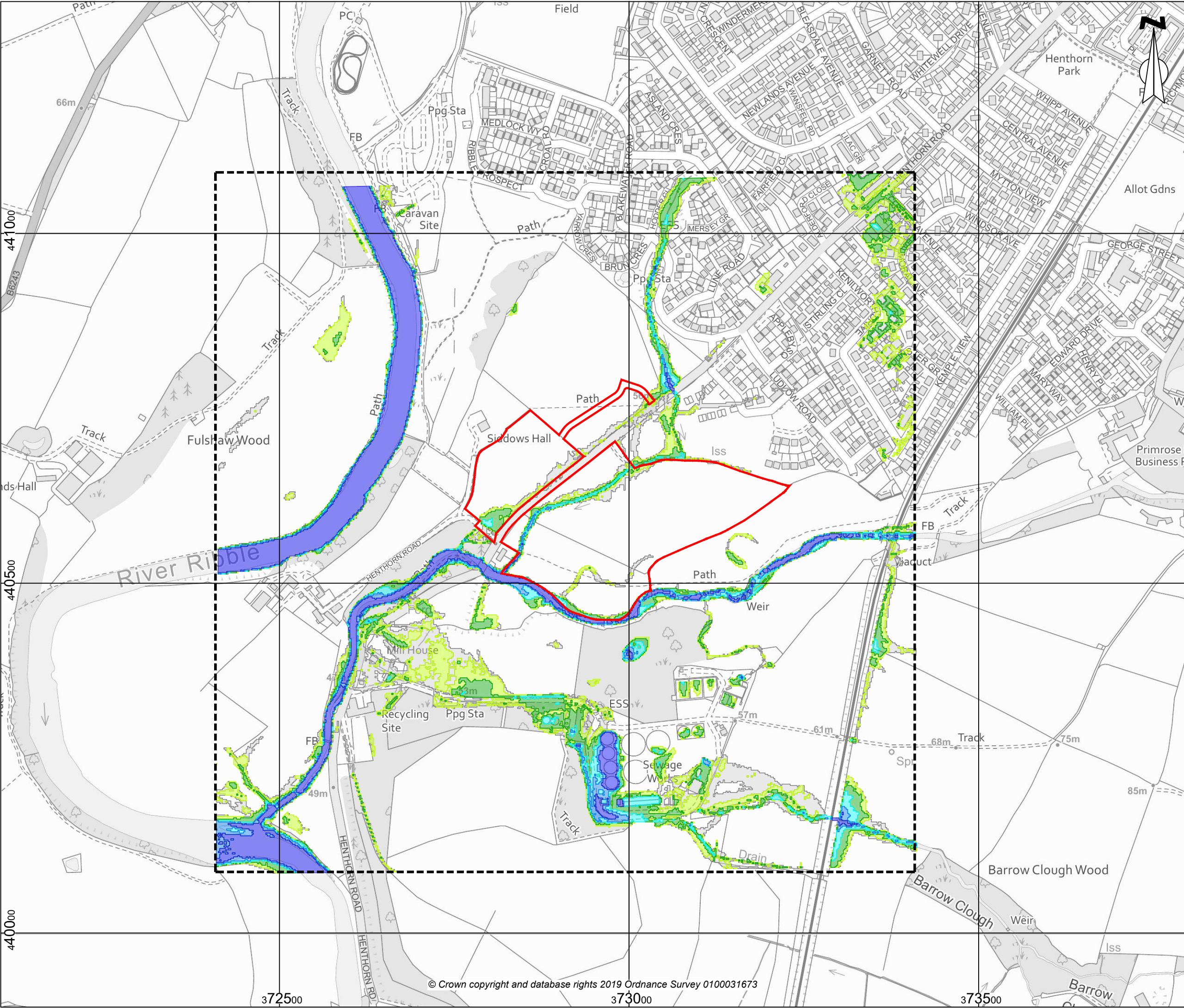
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Environment Agency Surface Water Flow Paths

DRAWING NO:

SHF.1132.227.HY.D.009.1

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Key

Site Boundary

Search Extent

Depth greater than 1.20 (m)

Depth 0.90 - 1.20 (m)

Depth 0.60 - 0.90 (m)

Depth 0.30 - 0.60 (m)

Depth 0.15 - 0.30 (m)

Depth 0.0 - 0.15 (m)

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DATE:

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PROJECT:

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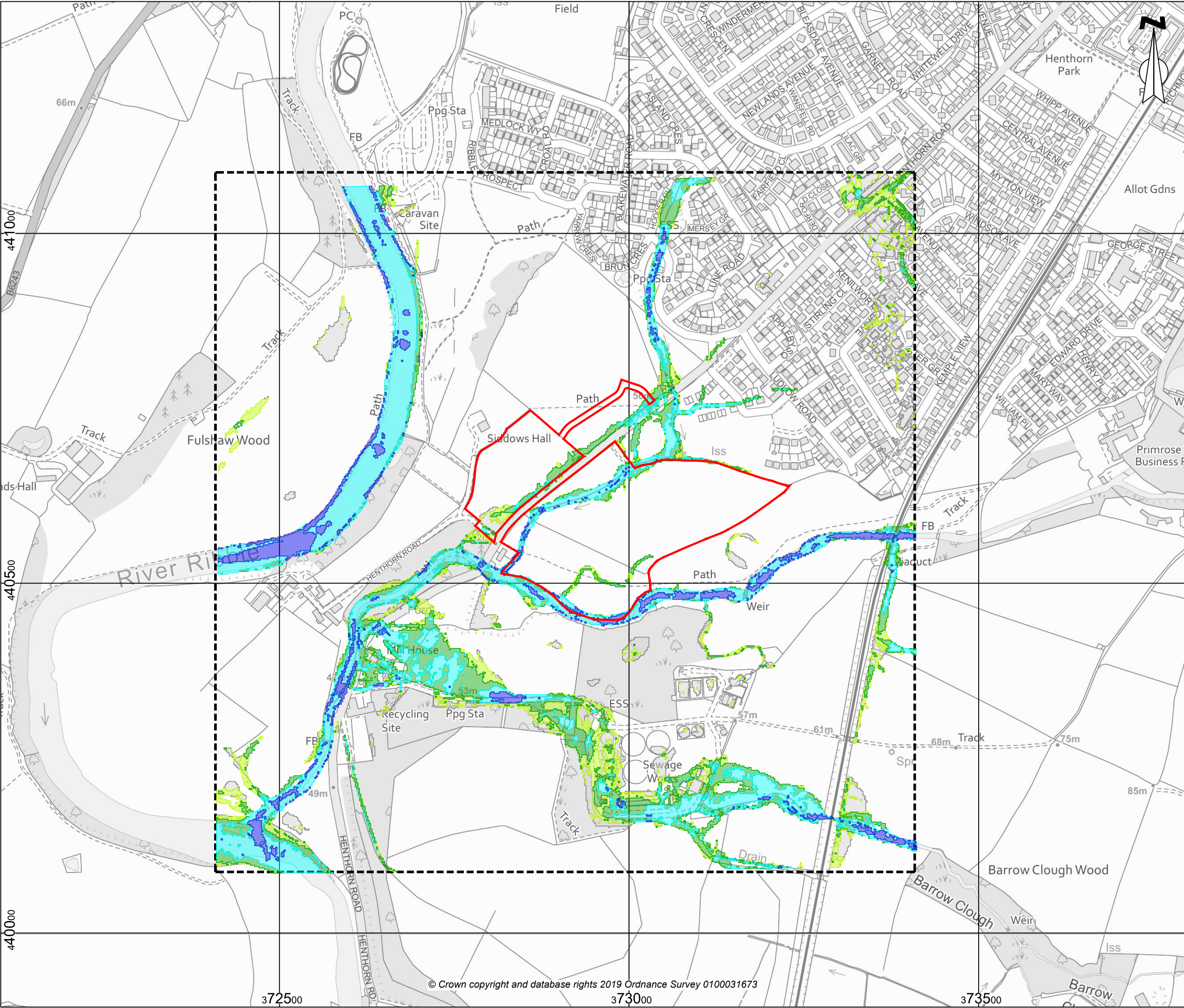
TITLE:

Environment Agency 1 in 1000
Year Surface Water Depth

DRAWING NO:

SHF.1132.227.HY.D.009.2

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Key

- Site Boundary
- Search Extent
- Velocity 2.00 or greater (m/s)
- Velocity 1.00 - 2.00 (m/s)
- Velocity 0.50 - 1.00 (m/s)
- Velocity 0.25 - 0.50 (m/s)
- Velocity 0.00 - 0.25 (m/s)

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SCALE: 1:5,000@A3 PROJECT REF: SHF.1132.227

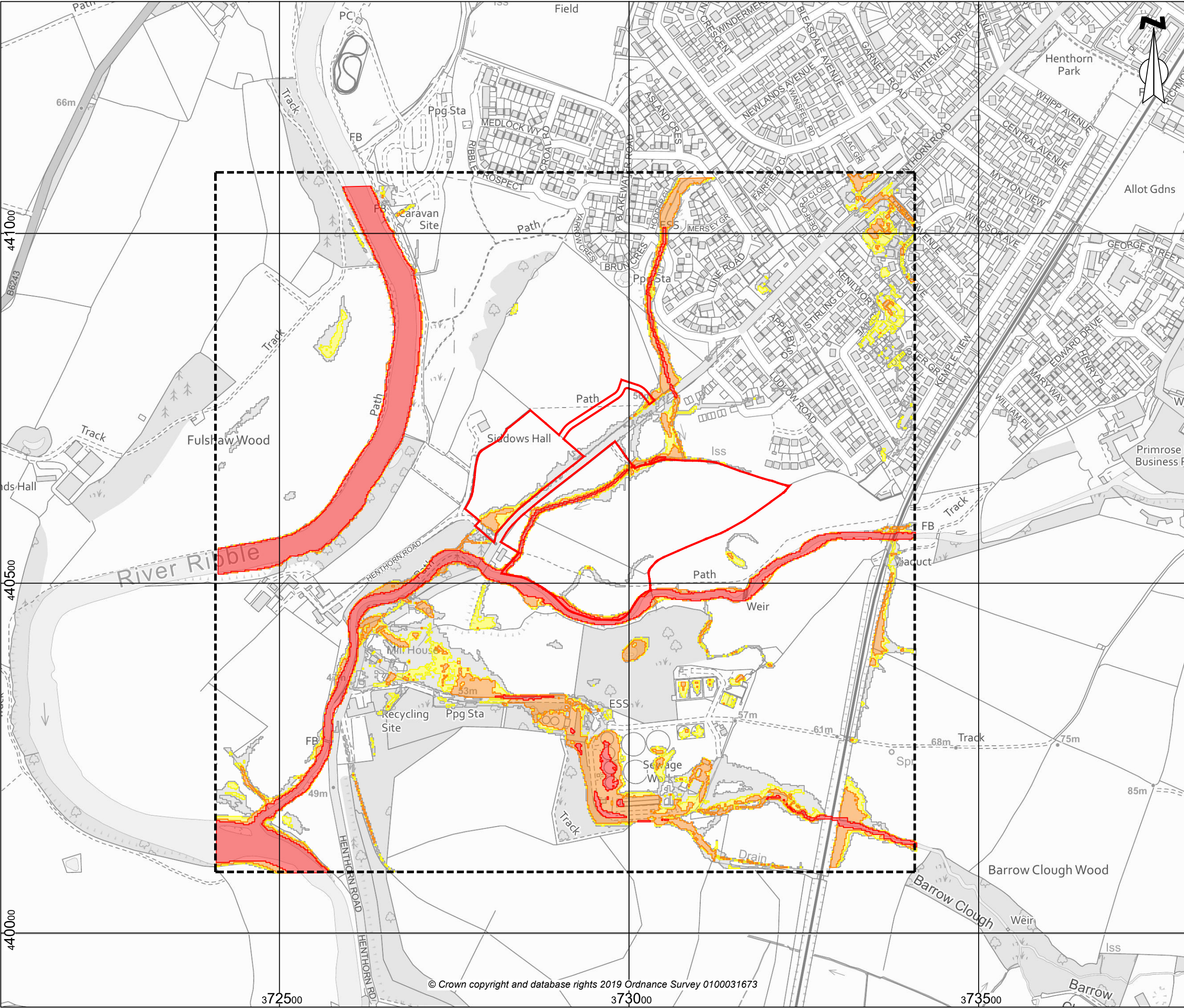
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PROJECT:
Henthorn Road, Clitheroe

TITLE:
Environment Agency 1 in 1000 Year Surface Water Velocity

DRAWING NO:
SHF.1132.227.HY.D.009.3

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Key

- Site Boundary
- Search Extent
- Extreme Hazard (> 2.0)
- Significant Hazard (1.25 - 2.00)
- Moderate Hazard (0.75 - 1.25)
- Low Hazard (0.50 - 0.75)

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SCALE: 1:5,000@A3 PROJECT REF: SHF.1132.227

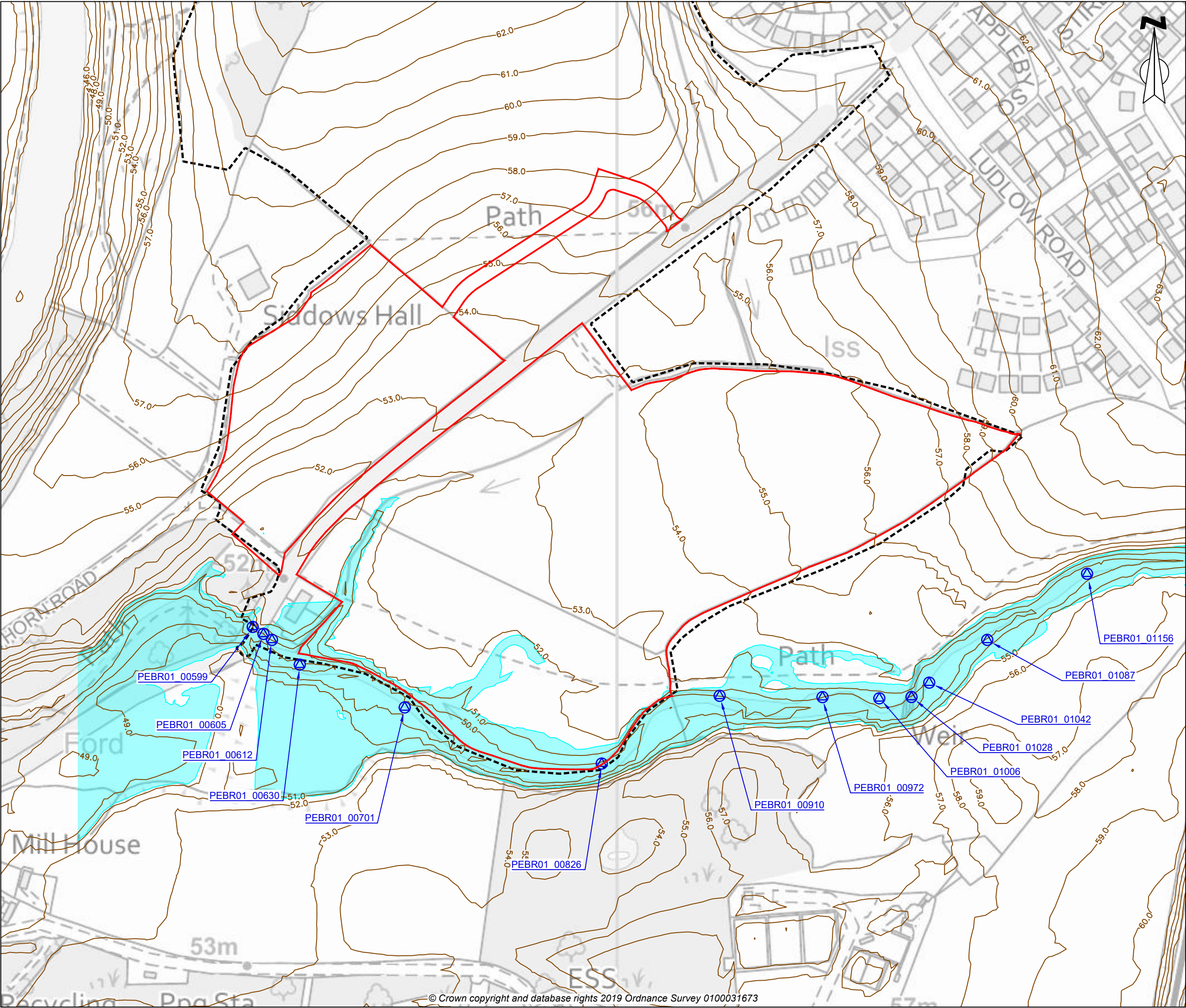
DRAWN: CH CHECKED: MG DATE: Oct 2019

PROJECT:
Henthorn Road, Clitheroe

TITLE:
Environment Agency Surface Water 1000 Year Hazard Rating

DRAWING NO:
SHF.1132.227.HY.D.009.4

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Key

Site Boundary

Topographical Survey Extent
2m DTM LIDAR used outside of this extent

Contours
At 1m intervals (mAOD)

Node Location

1000 Year Extent (Defended)

PEBR01_00599

49.62mAOD

PEBR01_00605

50.92mAOD

PEBR01_00612

50.89mAOD

PEBR01_00630

50.99mAOD

PEBR01_00701

51.06mAOD

PEBR01_00826

51.76mAOD

PEBR01_00910

52.88mAOD

PEBR01_00972

53.45mAOD

PEBR01_01006

53.91mAOD

PEBR01_01028

54.16mAOD

PEBR01_01042

54.32mAOD

PEBR01_01087

54.78mAOD

PEBR01_01156

55.53mAOD



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CLIENT:

Gladman Developments Ltd

SCALE:

1:2,000@A3

PROJECT REF:

SHF.1132.227

DRAWN:

MG

CHECKED:

CW

DATE:

Oct 2019

PROJECT:

Henthorn Road, Clitheroe

TITLE:

Modelled Flooded Extent

DRAWING NO:

SHF.1132.227.HY.D.010

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Appendix 1 – Topographic Survey

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THIS SURVEY IS ORIENTATED TO ORDNANCE SURVEY GRID NORTH. THE SURVEY TO A PLANE GRID. HORIZONTAL MEASUREMENTS TAKEN FROM THIS SURVEY WILL BE GROUND DISTANCES.

SITE CENTRE: E 372939.9018, N 440622.0644

LOCAL SCALE FACTOR: 0.9996193

ALL LEVELS RELATE TO ORDNANCE SURVEY DATUM GENERATED BY ACTIVE GP NETWORK.

NO ALLOWANCE HAS BEEN MADE FOR SUB-SURFACE ACCESS TO MANHOLES OR CHAMBERS. ANY PIPE SIZES, DEPTHS OR BELOW GROUND DIMENSIONS ARE TAKEN FROM THE SURFACE AND THUS WILL ONLY BE APPROXIMATE. ANY FLOW TYPE (FOUL WATER, SURFACE WATER OR COMBINED) ARE ASSUMED AND THEREFORE REQUIRE VERIFICATION.

ROAD MARKINGS:-
ROAD MARKINGS DISPLAYED ARE SYMBOLIC. LENGTH, SPACING AND THICKNESS
ETC. ARE INDICATIVE ONLY.

LEGEND

-  SPOT LEVEL
 SURVEY STATION
 SAPLING
 BUSH/SHRUB
 TREE (INDICATIVE ONLY)
 HEDGE AREA OF UNDERGROWTH

- CONTOUR
- GATE
- OVERHEAD CABLE
- EDGE

ABBREVIATIONS

- [illegible]

STATION CO-ORDINATES

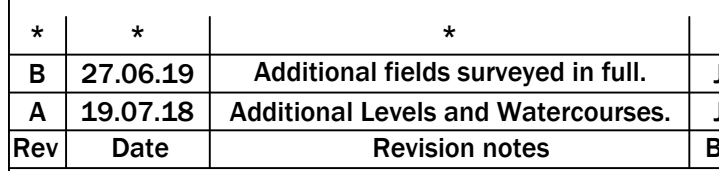
STATION	EASTING	NORTHING	LEVEL	DESCRIPTION
STN3	373124.26	440623.83	58.90	Survey Nail
STN5	373066.78	440646.93	60.36	Survey Nail
STN6	373041.19	440682.09	59.99	Survey Nail

TREE SCHEDULE

Test	DMA	SPREAD	HEIGHT
TE1	0.70	14	14
TE2	1.20	16	16
TE3	1.30	16	16
TE4	1.50	12	14
TE5	1.50	16	16
TE6	2.00	8	8
TE7	1.60	16	16
TE8	1.00	16	16
TE9	1.30	8	8
TE10	0.30	8	10
TE11	1.30	8	10
TE12	0.50	12	14
TE13	1.60	12	14
TE14	0.30	6	6
TE15	1.60	16	16
TE16	0.30	6	6
TE17	1.60	12	16
TE18	0.70	12	16
TE19	1.00	14	14
TE20	0.80	18	18
TE21	0.80	16	16
TE22	1.00	20	20
TE23	2.00	6	6
TE24	1.40	14	14
TE25	0.60	14	14
TE26	1.10	14	14
TE27	0.60	14	14
TE28	0.75	14	14
TE29	1.80	12	15
TE30	0.70	14	16
TE31	0.75	14	16
TE32	0.70	14	16
TE33	0.50	10	8
TE34	1.50	10	10
TE35	0.70	14	14
TE36	0.50	16	16
TE37	0.50	10	8
TE38	0.50	10	8
TE39	0.20	4	4
TE40	1.00	12	12
TE41	0.40	8	8
TE42	1.30	12	12
TE43	0.40	8	8
TE44	1.00	20	20

TREE DIAMETER MEASURED APPROXIMATELY 1.5M ABOVE GROUND LEVEL. TREE SPREADS ARE SYMBOLIC ONLY AND ARE REPRESENTATIVE OF THE GENERALISED CANOPY TYPE. TREE ROLLS MAY NOT FIT CENTRALLY TO THE CANOPEY. TREE GROUPS

PLOT LOCATIONS



	Status
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INFORMATION

	Proje

Clitheroe,
Henthorn Road.

Title	

TOPOGRAPHICAL SURVEY
AS OF 29.05.18
SHEET 1 OF 2

M:\AutoCAD Files\Standards\Images\Drawing block RGB_new.jp

Drawn By	Publish Date	Scale(s)	Sheet Size
JH/JW	13.06.18	1:500	A0
Project no.		Drawing no.	Revision
2018-015		Topo_01_2D	B

Do not print