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environmental consultants

NPPF: Flood Risk Assessment

Hempsted Lane, Gloucester

Gladman Developments Ltd

CRM.1132.021.HY.R.001.A

'Experience and expertise working in union'

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Hempsted Lane, Gloucester

Project:	NPPF: Flood Risk Assessment
For:	Gladman Developments Ltd
Status:	Final
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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 west of Hempsted Lane, Gloucester.

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 12.22-hectare (ha) Site comprises three agricultural (arable) land parcels, divided by hedgerows.
- The Site slopes in a southerly direction and is underlain by clayey soils and geology with low infiltration potential.
- A watercourse conveys flow north-west along the south-west boundary.
- The risk of flooding is assessed as follows:
    - The risk of fluvial/tidal flooding is assessed as negligible within the northern extent of the Site, but medium to high within the southern extent. There is also a residual risk of flooding from onsite drains.
    - The risk of surface water flooding is assessed as negligible for most of the Site, with an area of low risk associated with ponded areas within the western extent.
    - The risk of flooding from sewers is assessed as negligible for most of the Site but low along the reach of the onsite public surface water sewer.
    - 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 (including surface water attenuation) outside the mapped extent of fluvial flooding.
    - Provide an easement free from development along either side of the onsite and bounding watercourses. This easement would provide access for inspection and maintenance purposes.
    - Undertake maintenance activities to keep the watercourses clear from debris and overgrown vegetation to maintain the conveyance of the channels.
    - Set finished floor levels above external levels.
    - Set the surface water outfall from the proposed development at an appropriate height above the bed level of the receiving watercourse or provide a swale outfall from the detention basin to mitigate the risk of the outfall surcharging.
    - Adoption of a surface water management strategy.
    - Provide a development free easement either side of onsite public surface water sewer assets, or re-direct around the Site boundary.
- The proposed residential development is classified as more vulnerable. More vulnerable uses are considered acceptable in terms of flood risk in Flood Zone 1. Subject to the implementation of the above mitigation measures, the Sequential Test would be passed, and the Exception Test would not be required.

The FRA has considered the potential impact of the development on surface water runoff rates, given the increase in impermeable areas post-development. 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 an appropriately sized detention basin with an outfall to the bounding watercourse.

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 west of Hempsted Lane, Gloucester (the 'Site').

1.1.2 The proposal is for up to 245 dwellings, public open space, landscaping, sustainable drainage system (SuDS) within the 12.22ha Site, with vehicular access point from Hempsted Lane. All matters reserved except for means of access.

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 FRA[1] 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 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 development would remain safe throughout its lifetime, that the development would not

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

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 change[4] 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 policies within the Gloucester, Cheltenham and Tewkesbury Joint Core Strategy 2011-2031 Council Local Plan:

- Policy SD3: Sustainable Design and Construction - All development will be expected to be adaptable to climate change in respect of the design, layout, siting, orientation and function of both buildings and associated external spaces. Proposals must demonstrate that development is designed to use water efficiently, will not adversely affect water quality, and will not hinder the ability of a water body to meet the requirements of the Water Framework Directive.
- Policy INF2: Flood Risk Management - Development proposals must avoid areas at risk of flooding, in accordance with a risk-based sequential approach. Proposals must not increase the level of risk to the safety of occupiers of a site, the local community or the wider environment either on the site or elsewhere. For sites of a strategic scale, the cumulative impact of the proposed development on flood risk in relation to existing settlements, communities or allocated sites must be assessed and effectively mitigated.

Report Structure

1.4.3 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 179: Gloucester, Cheltenham & Stroud).
- Detailed topographic survey (Appendix 1).
- Environment Agency online mapping (Flood Map for Planning[5], Long Term Flood Risk Assessment for Locations in England[6], Catchment Data Explorer[7] and Main River Map[8]).
- River Basin District (RBD) Maps[9] (Severn RBD) together with guidance on climate change allowances[10].
- National River Flow Archive[11].
- Gloucestershire County Council Strategic Flood Risk Assessment (SFRA) and associated mapping[12] (Appendix 2).
- Gloucester, Cheltenham and Tewkesbury Joint Core Strategy 2011-2031.
- British Hydrological Society Chronology of British Hydrological Events[13].
- National Soils Resources Institute (NSRI): Soilscapes online mapping[14].
- British Geological Survey [BGS] online mapping: Geology of Britain Viewer[15].
- Landmark's Promap: Flood Data package: Additional flood mapping.
- Geosmart 1 in 100-year groundwater flood risk map.
- Severn Trent Water sewer asset plans (Appendix 3).
- DEFRA's Magic Map[16] 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.gloucestershire.gov.uk/planning-and-environment/flood-risk-management/flood-planning-information/
[13] http://www.cbhe.hydrology.org.uk/search.php
[14] http://www.landis.org.uk/soilscapes/
[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 Advice[17] and the NPPF/PPG ID: 7 was consulted and reviewed.

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

Gloucestershire County Council

2.2.5 Gloucestershire 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.

2.2.6 Gloucestershire County Council as the LLFA was consulted on flood risk issues at this Site. Correspondence with the LLFA is included in Appendix 5.

Severn Trent Water

2.2.7 Drainage and sewerage services in the UK are provided by a number of water and sewerage companies. Severn Trent Water 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.

2.3 Site Walkover

2.3.1 Enzygo staff carried out a walkover of the Site during September 2019. Observations made were used to inform the Site description.

[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 west of Hempsted Lane, Gloucester, GL2 5DB.

3.1.2 The Site is centred on National Grid Reference (NGR) 381526, 216546.

3.1.3 The 12.22ha Site location is shown in Drawing 001 and in more detail in Drawing 002.

3.2 Land Use

3.2.1 The land use comprises three agricultural (arable) land parcels, divided by hedgerows (Figures 3.1 and 3.2).

3.2.2 The Site is bounded by Hempsted Lane with residential dwelling beyond to the north-east, A430 with a commercial development beyond to the south-east, an unnamed watercourse with agricultural land beyond to the south-west, Rea Lane with agricultural land beyond to the west, and residential dwelling to the north.

3.2.3 The Site is currently accessed via gated access off Hempsted and Rea Lane.

Figure 3.1: Photographs of the Site

View north across the Site from the south-east corner.

View east across the Site from the western boundary.

Figure 3.2: Aerial Photograph of the Site

Image © 2019 Digital Globe.

3.3 Topographic Information

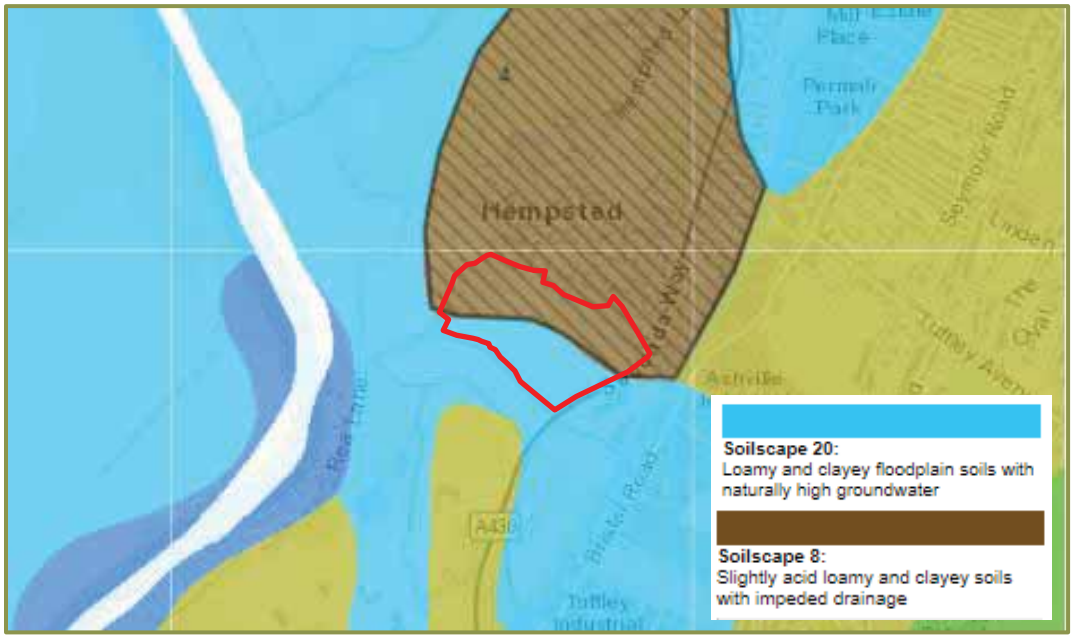
3.3.1 A detailed topographic survey was carried out during August 2019 and a copy is included as (Appendix 1). The Site falls in southerly direction from 25.84 metres Above Ordnance Datum (m AOD) along the northern boundary, to 8.41m AOD in the south-west corner. The fall of 17.43m over 300m gives a gradient of 1:17.

3.4 Soils and Geology

Soils Mapping

3.4.1 The Soilscapes online soils map viewer shows that the northern extent of the Site is underlain by loamy and clayey soils. The southern extent is underlain by loamy and clayey soils with high groundwater (Figure 3.3). The soils mapping is indicative and there may be localised variation in soil type.

Figure 3.3: Soils Mapping

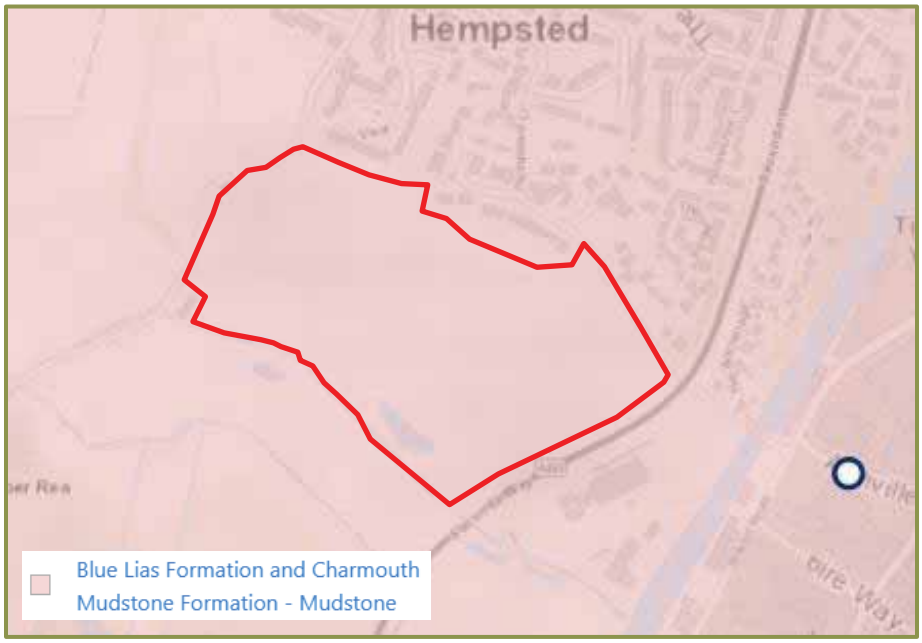


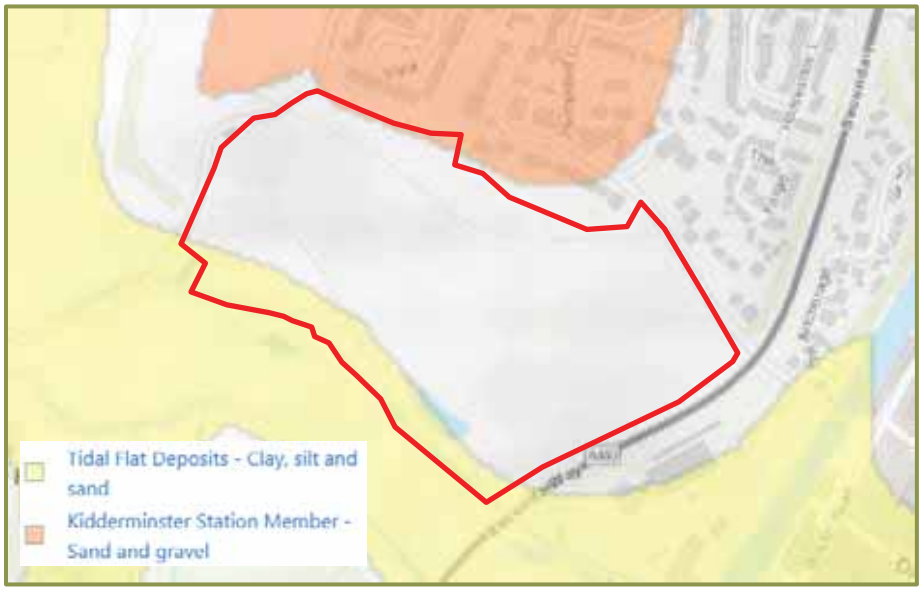
Soils Data © Cranfield University (NSRI) and for the Controller of HMSO [2019].

Geology Mapping

The Geology of Britain online map viewer (Figure 3.4) shows the bedrock beneath the Site is Blue Lias formation - mudstone. There are no superficial deposits beneath most of the Site. There are tidal flat deposits (Clay silt and sand) within the southernmost extent and Kidderminster Station member (Sand and gravel). The geology mapping is indicative and there may be localised variation in the superficial deposits.

Figure 3.4: Geology Mapping (continues over page)





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

BGS Borehole Logs

3.4.2 The Geology of Britain online map viewer shows there are no unrestricted historical boreholes located within the Site boundary or its immediate vicinity.

Soakaway Testing

3.4.3 Soakaway testing was undertaken during September 2019 and was undertaken in accordance with DG 365 'Soakaway Design' methodology guidance. A copy of the Soakaway Test Report is included in Appendix 6.

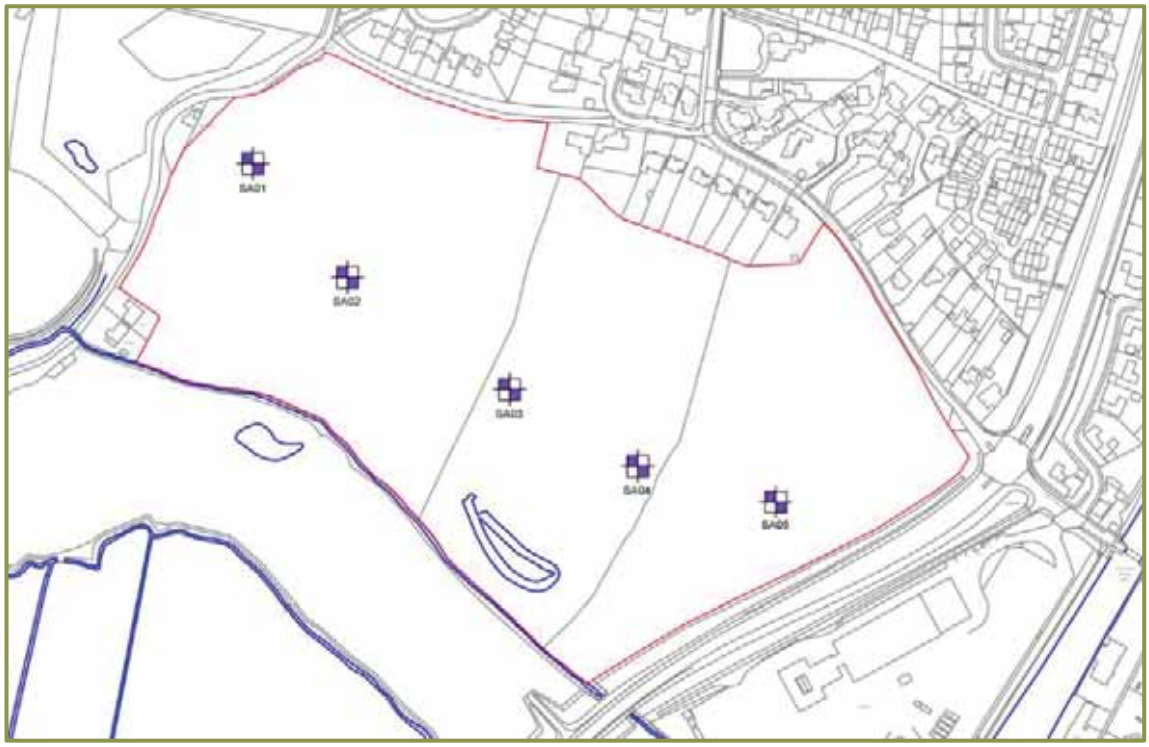
3.4.4 A total of five soakaway test pits were established through the southern extent of the Site (Figure 3.5). The positioning of the test pits was based around the flood risk constraints (i.e. sequential development of the Site, limiting built development outside the mapped extent of fluvial flooding [see Section 4 and 5]) and the proposed surface water drainage strategy (detention basin positioned at the topography low to achieve a gravity connection [see Section 6]).

3.4.5 The test pits were excavated to depths between 2.5m and 2.7m below existing ground level (mbgl). A summary of the trial pit logs is summarised in Table 3.1. The soakaway logs confirm the soils and geology as depicted by the soils and geology mapping, albeit trial pits were not positioned above the Tidal Flat Deposits or Kidderminster Station Member.

Table 3.1: Soakaway Log Summary

Strata	Summary Description	Depth (m bgl)
Made Ground (topsoil)	Brown slightly gravelly clayey sandy topsoil	0.00 - 0.40
Superficial	Firm orange brown clayey SILT	0.25 - 0.70
	Firm to stiff consistency orange brown mottled blue grey silty sandy gravelly CLAY	0.60 - 1.20
Bedrock	Firm to stiff consistency orange brown mottled blue grey laminated sandy gravelly CLAY	0.60 - 2.70
	Stiff consistency dark blue grey mottled orange brown laminated silty CLAY	1.30 - 2.50
Groundwater	Groundwater was not encountered	

Figure 3.5: Trial Pit Location Plan



3.5 Hydrogeology

Infiltration potential

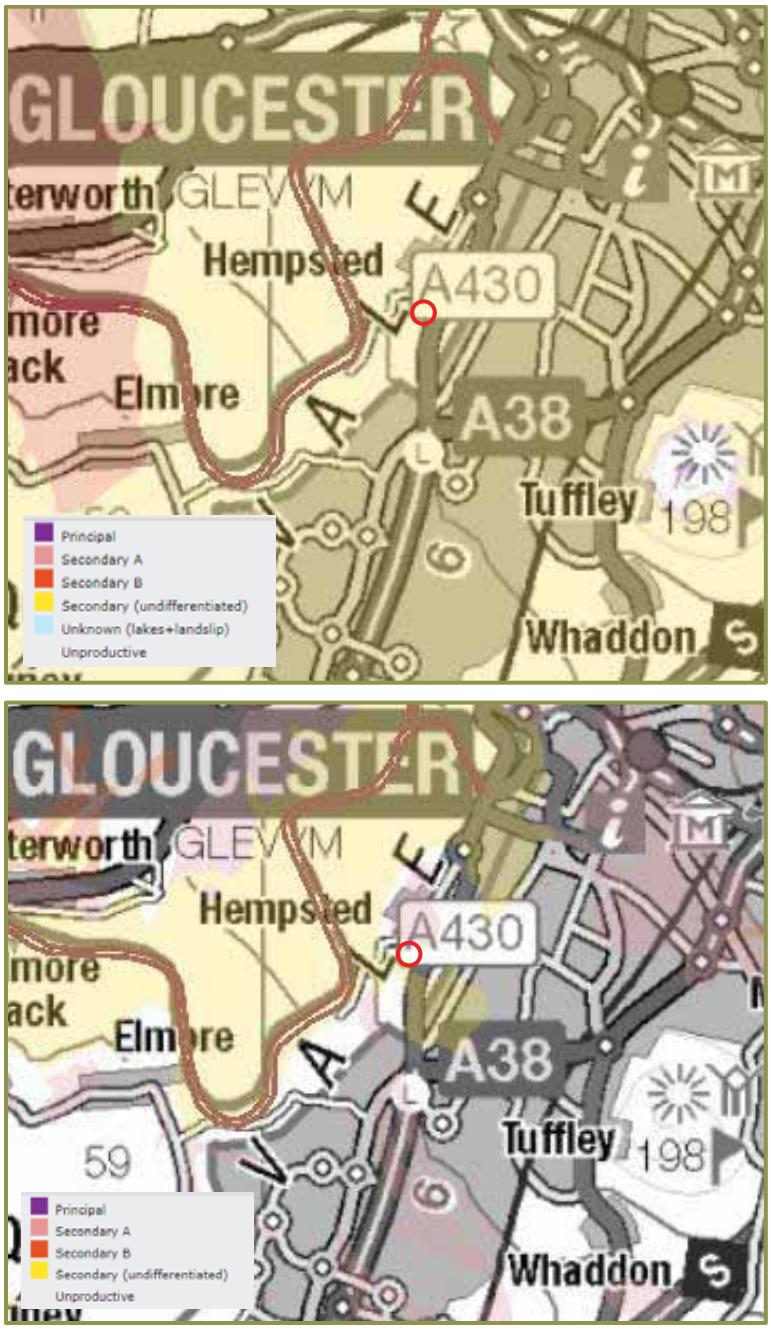
3.5.1 Soakaway testing (Appendix 6) demonstrated low infiltration potential. Groundwater ingress was not encountered in any of the soakaway trial pits.

Defra Magic Map

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

3.5.3 The Site is not located above a Principal Aquifer. The Site is however located above a Secondary Undifferentiated bedrock Aquifer (Figure 3.6).

Figure 3.6: Aquifer Designation Map



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

3.6 Catchment Hydrology

OS Mapping

i. River Severn

3.6.1 The fluvially dominated River Severn conveys flows south, approximately 365m to the west of the Site at its closest point. The River Severn is a 'main river', which is a watercourse where flood risk work is carried out by the Environment Agency.

ii. Hempsted Brook

3.6.2 An unnamed watercourse ('Hempsted Brook') conveys flows north-west, along the south-west boundary (Figure 3.7). Hempsted Brook is a tributary of the River Severn, with the confluence located approximately 375m to the south-west of the Site. OS Mapping identifies a sluice at the downstream reach of the unnamed watercourse, before it converges with the River Severn. Hempsted Brook is an 'ordinary watercourse', which is a watercourse where flood risk work is carried out by the local drainage authority/riparian landowner.

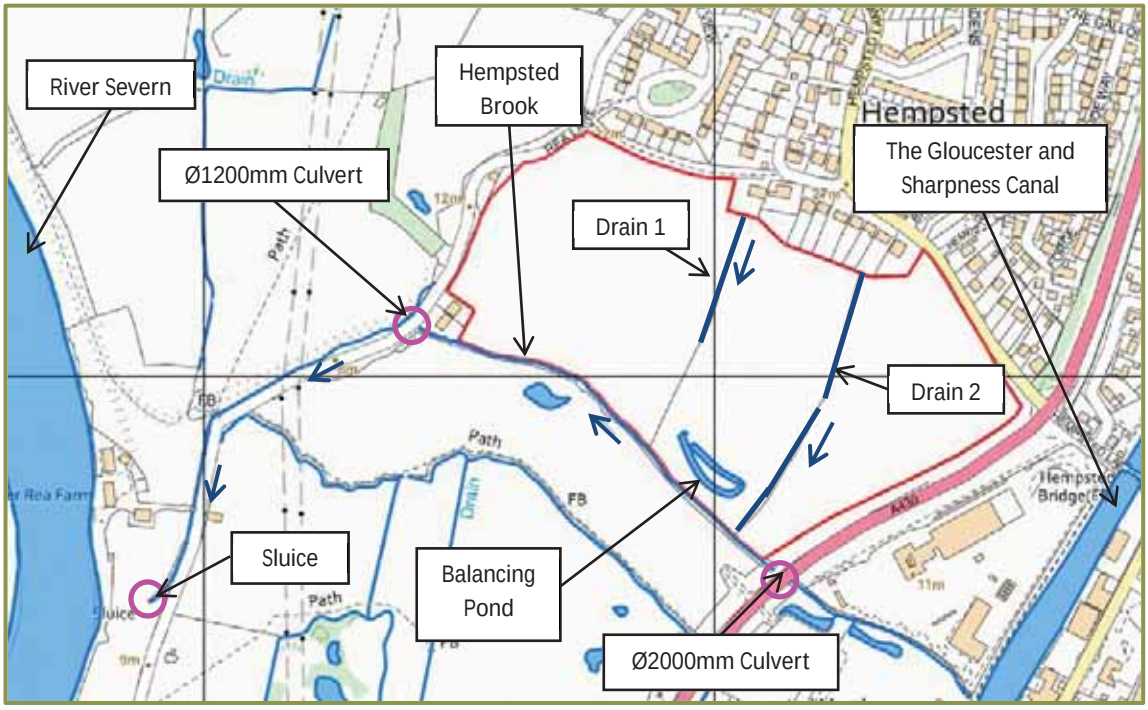
iii. River Severn

3.6.3 The Gloucester and Sharpness Canal is orientated north to south, approximately 120m to the east of the Site at its closest point. The canal is under the authority of the Canal and River Trust.

iv. Balancing Pond

3.6.4 There is a pond located within the southern extent of the Site, which is a Severn Trent Water offline balancing pond.

Figure 3.7: Map of Watercourses



Topographic Survey

i. Drains 1 and 2

3.6.5 The topographic survey (Appendix 1) identifies two drains ('Drain 1' and 'Drain 2') orientated north to south through the Site, along the field boundaries.

3.6.6 The bed levels of Drain 1 indicate that flow would be conveyed south. Mid-way through the Site boundary, the drain is shown to enter into a Ø150mm culvert inlet. The landowner confirmed that this ditch has been filled in at this point and does not have onward connectivity.

3.6.7 The bed levels of Drain 2 indicate that flow would be conveyed south, with an outfall to Hempsted Brook to the south.

ii. Balancing Pond

3.6.8 The topographic survey (Appendix 1) shows a Ø400mm and Ø225mm inlet/outlet from the public surface water sewer network, which conveys flows south-west through the eastern extent of the Site (Appendix 3).

Site Walkover Observations

i. Hempsted Brook

3.6.9 Hempsted Brook was observed to be conveying approximately 300mm depth of flow, north-west along the southern boundary.

3.6.10 The channel profile is approximately; 3m width (left to right bank), 1m bed width, 1m depth and 1:3 side slope. The channel was overgrown with vegetation, which is considered normal for the time of year when the walkover was undertaken (Figure 3.8)

3.6.11 The Hempsted Brook enters the Site at the south-east corner from an approximate Ø2000mm culvert from beneath the A430 to the east (Figure 3.9). The watercourse exists the Site at the western corner via a Ø1200m culvert beneath Rea Lane (Figure 3.10).

Figure 3.8: Hempsted Brook

Figure 3.9: Ø2000mm A430 Culvert Outfall

Figure 3.10: Ø1200m Rea Lane Culvert Inlet

ii. Drains 1 and 2

3.6.12 The channel profiles were approximately; 3m width (left to right bank), 1m bed width, 0.5m depth and 1:3 side slope. The ditches were overgrown with vegetation, which is considered normal for the time of year when the walkover was undertaken.

iii. Balancing Pond

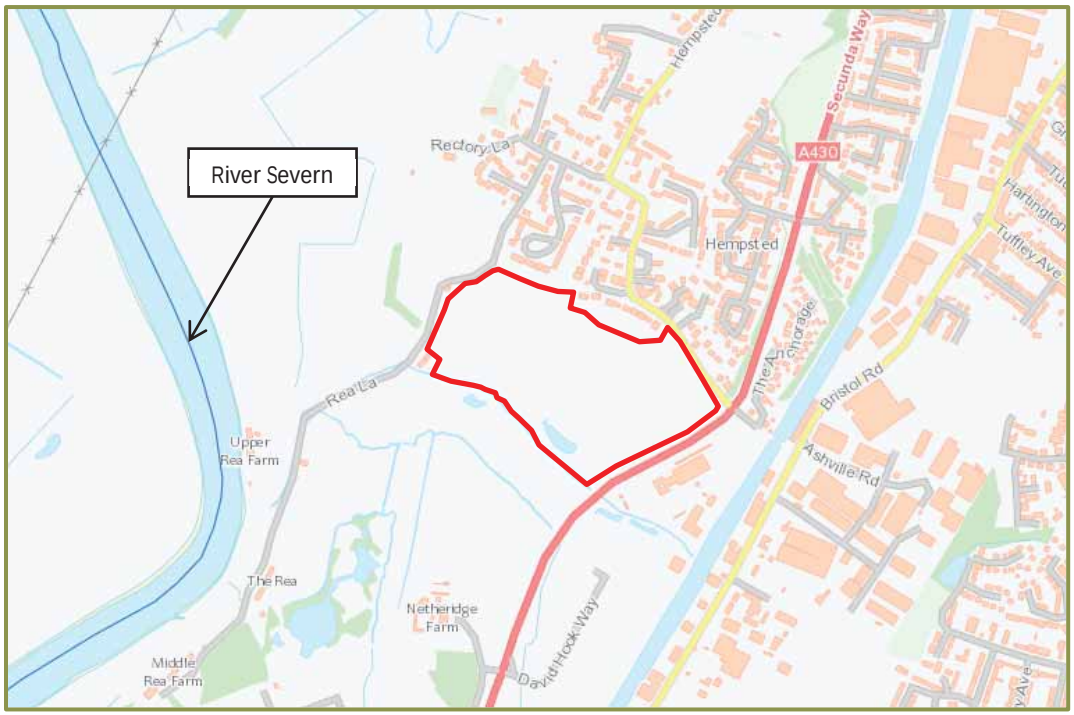
3.6.13 The onsite balancing pond was observed to wet and is not impounded. The balancing pond is assumed to serve the residential development to the north and is shown as being an offline feature on the Severn Trent Water Asset Plans (Appendix 3).

Figure 3.11: Balancing Pond

Main River Map

3.6.14 The Environment Agency online main river map (Figure 3.12) identifies the River Severn, which conveys flows south, approximately 375m to the -west of the Site at its closest point.

Figure 3.12: Main River Map

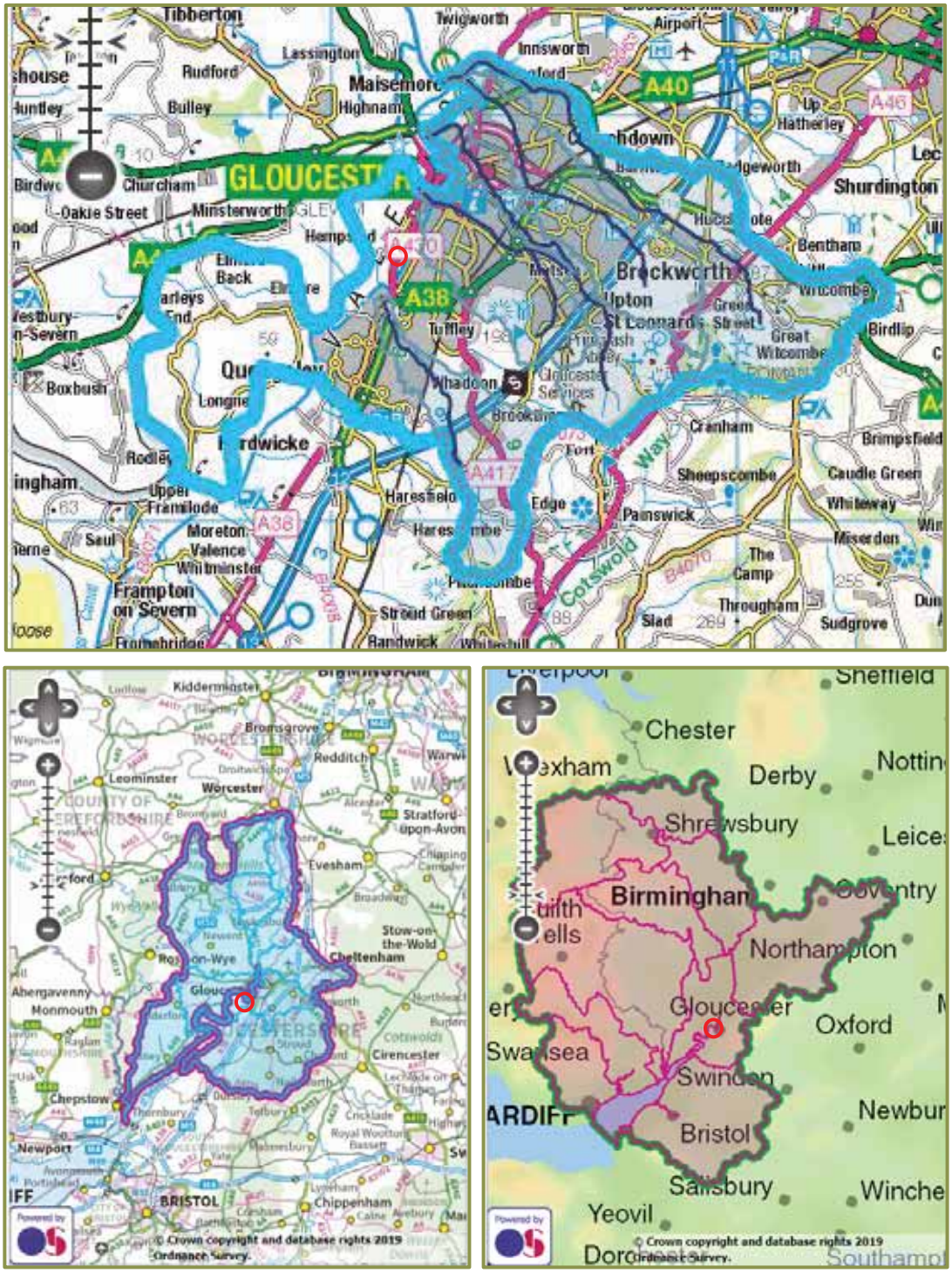


Contains Environment Agency information © Environment Agency and database right [2019].

Environment Agency Catchment Data Explorer Mapping

3.6.15 The Site resides within the Gloucester Trib Operational Catchment (Figure 3.13), which is within the Severn Vale Management Catchment and Severn River Basin District.

Figure 3.13: Catchment Data Explorer



Top: Gloucester Trib Operational Catchment. Bottom Left: Severn Vale Management Catchment. Bottom Right: Severn River Basin District. Contains Environment Agency information © Environment Agency and database right [2019].

3.7 Sewerage Assets

3.7.1 Severn Trent Water asset plans show that there is a public surface water sewer conveying flow south-west through the eastern extent of the Site, with an outfall to Hempsted Brook to the south of the onsite balancing pond (Figure 3.14).

Figure 3.14: Sewer Asset Plans

Contain Severn Trent Water information © Crown Copyright and database right [2019].

3.8 Designated Sites

3.8.1 The DEFRA Magic Map (England and Wales) shows there are no designated sites in or close to the Site including downstream (from a flood risk and drainage perspective).

4.0 Flood Risk Assessment

4.1 Potential Sources of Flooding

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

Table 4.1: Potential Risk Posed by Flooding Sources

Flooding Source	Potential Flood Risk at Application Site (Yes/No)	Potential Source	Data Sources
Fluvial	Yes	River Severn, Hempsted Brook and Drains 1 and 2.	Environment Agency flood mapping (Drawing 005), Modelled Flood Levels (Appendix 4), JBA Flooding from Rivers (Drawing 004.2) and SFRA mapping.
Tidal	Yes	River Severn.	Environment Agency flood mapping (Drawing 005), Modelled Flood Levels (Appendix 4), JBA Coastal Flooding (Drawing 004.3) and SFRA mapping.
Groundwater	Yes	Secondary Undifferentiated Aquifer (Bedrock).	BGS mapping (Drawing 003) and Geosmart Groundwater (Drawing 006).
Surface Water	Yes	Poor permeability and Site topography.	JBA Surface Water Flooding (Drawing 004.1) and Environment Agency Complex mapping (Drawings 010.1-010.4).
Sewer	Yes	Public surface water Sewer.	Severn Trent Water Asset plans (Appendix 3) and topographic survey (Appendix 1).
Infrastructure Failure	Yes	Balancing pond, canal and reservoir failure.	Environment Agency online flood mapping and OS mapping.

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 online flood map (Drawing 005) shows the northern and central extents of the Site are located within Flood Zone 1; which is land outside the 1 in 1000-year probability of fluvial (river) flooding (0.1% Annual Exceedance Probability [AEP]), at 'low' risk. The southern extent of the Site, adjacent to Hempsted Brook, is within Flood Zones 2 and 3. 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. Flood Zone 3 is land within the 1 in 100-year (>1% AEP) risk of fluvial flooding, at 'high' risk. The Environment Agency flood mapping does

not differentiate between Flood Zones 3a and 3b ('functional floodplain' - 5% AEP / 1 in 20-year event).

Modelled Flood Levels

4.2.3 The Environment Agency provided modelled levels for nodes along the River Severn, closest to the Site. The levels were taken from a 1D ISIS model (Tidal Severn model 2007) for the Severn Estuary. The correspondence states the watercourse is fluvially dominated in the vicinity of the Site. (Appendix 4).

4.2.4 The modelled flood levels were provided for a range of return periods and nodes for both fluvial and tidal events. Node MC128 was the nearest and most representative node for the Site (Figure 4.1). A summary of the modelled flood levels for node MC128 are included in Table 4.2.

Figure 4.1: Node Locations

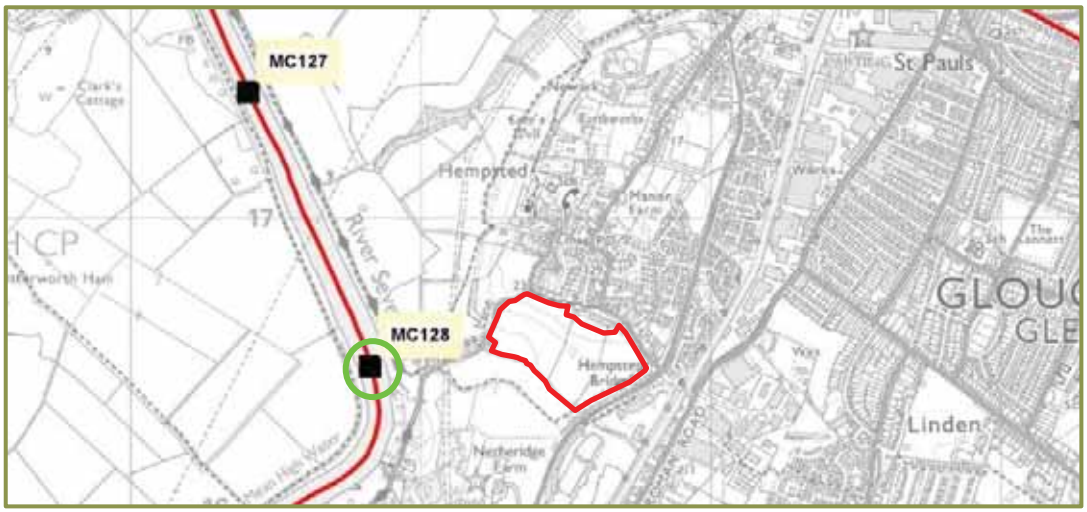


Table 4.2: Modelled Flood Levels

	Maximum Water Levels				
Node Label	**5yr fluvial, 75yr tidal**	**5yr fluvial, 100yr tidal**	**5yr fluvial, 200yr tidal**	**5yr fluvial, 200yr tidal (+20% climate change)**	**5yr fluvial, 1000yr tidal**
MC128	10.29	10.30	10.33	10.61	10.40

	Maximum Water Levels				
Node Label	**75yr fluvial, 2yr tidal**	**100yr fluvial, 2yr tidal**	**100yr fluvial, 2yr tidal (+20% climate change)**	**200yr fluvial, 2yr tidal**	**1000yr fluvial, 2yr tidal**
MC128	10.41	10.43	10.70	10.49	10.91

4.2.5 The Tidal Severn model 2007 does not include levels for updated climate change allowances for the Severn River Basin District (Higher Central 35%, Upper End 70%). As such, Enzygo Ltd undertook a model re-run exercise to obtain the revised climate change flood levels.

4.2.6 Enzygo Ltd have recently undertaken a modelling exercise for a nearby Site for Gladman Developments Ltd, to determine climate change flood levels. The modelling outputs are relevant to this Site.

4.2.7 Fluvial inputs to the 'Tidal Severn model 2007' are derived from the 'River Severn fluvial model'. As such, a re-run of the tidal model also required a re-run of the Severn fluvial model.

4.2.8 In order to update the primary fluvial inputs to the Severn Tidal model, output hydrographs were taken from the Severn fluvial model re-run. Fluvial inputs were amended for updated climate change scenarios (+35% and +70%CC) for the 1 in 100-year and 5-year fluvial events in order to maintain the joint probability as shown in Table 4.1. A 5-year fluvial event has been used to represent the fluvial input during extreme tidal events. No changes to the fluvial inputs were made for the 100-year and 1000-year fluvial (non-climate change) inputs, a methodology which has previously been agreed with the Environment Agency (Appendix 4).

4.2.9 The 1 in 100-year and 5-year climate change fluvial inflow hydrographs, in the Severn tidal model, were replaced with an output hydrograph from the Severn fluvial model re-run, representative of the updated climate change allowances. As a conservative approach, the tidal model was only updated to include fluvial inputs for the +70% climate change increase.

4.2.10 Peak flood levels and hydrographs for a range of flood events (both tidally and fluvially dominated) were extracted for Node MC 128 and are presented in Table 4.3 and Figure 4.2.

4.2.11 Modelled peak levels and hydrographs confirm the Environment Agency statement that flood levels are fluvially dominated at the MC 128 node location. A comparison of non-climate change modelled levels presented in Table 4.3 with supplied levels from the Environment Agency (Table 4.2) shows a very close match, therefore increasing confidence in the derived climate change flood levels (Table 4.2).

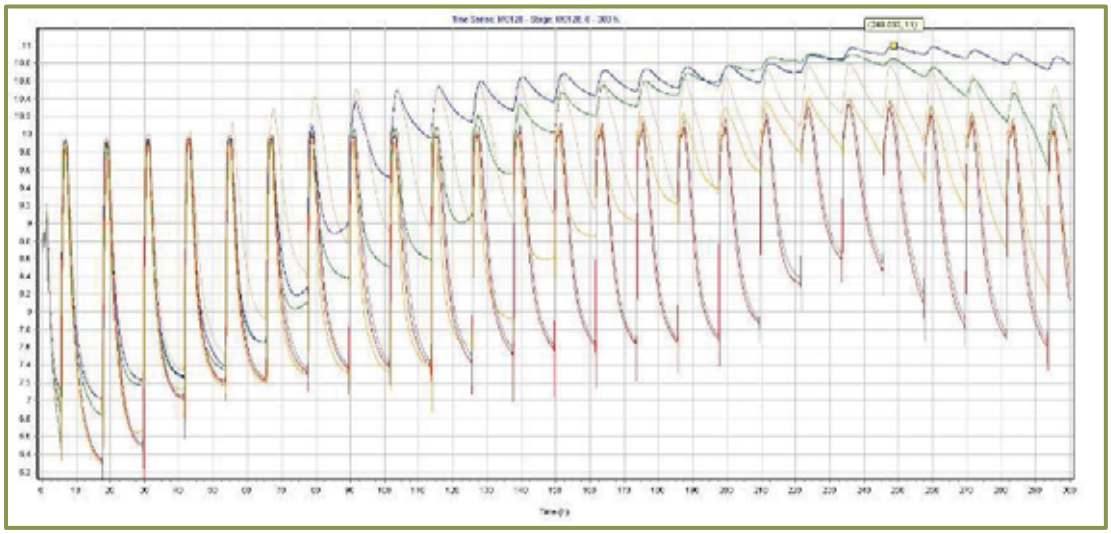
Table 4.2: Modelled Flood Levels

	Annual Exceedance Probability - Maximum Water Levels (m AOD)					
Node Label	**5yr fluvial, 1000yr tidal**	**5yr fluvial, 200yr tidal**	**1000yr fluvial, 2yr tidal**	**5yr fluvial, 200yr tidal (70%CC fluvial and sea level rise)**	**100yr fluvial, 2yr tidal**	**100yr fluvial, 2yr tidal (70%CC and sea level rise)**
MC128	10.40	10.34	10.91	10.80	10.40	11.00

4.2.12 Table 4.3 and Figure 4.2 show that peak flood levels for extreme fluvial events are greater than peak levels from extreme tidal events. Table 4.3 shows that when a +70% climate change allowance is applied to the fluvial 1 in 100-year event, the peak flood level is 11.00mAOD, which is 0.09m (90mm) higher than the 1 in 1000-year present day level (10.91mAOD). The 1 in 100-year (+70% climate change) modelling level therefore represents the greatest fluvial flood risk to the Site during the proposed lifetime of development.

4.2.13 The modelled flood level of 11.00 mAOD (representing the 100yr fluvial, 2yr tidal (70%CC and sea level rise event) was contoured and mapped against the topographic survey (Appendix 1) to produce a flood outline within the Site (Figure 4.3).

Figure 4.2: Modelled Hydrographs for all Scenarios at Node MC128



Blue: 1 in 100-year fluvial +2-year tide (70%CC fluvial and sea level rise). Orange: 1 in 100-year fluvial +2-year tide. Brown: 1 in 5-year fluvial and 200-year tide (70%CC fluvial and sea level rise). Green: 1 in 1000-year fluvial and 2-year tide. Red: 5-year fluvial and 200-year tide. Grey: 5-year fluvial and 1000-year tide.

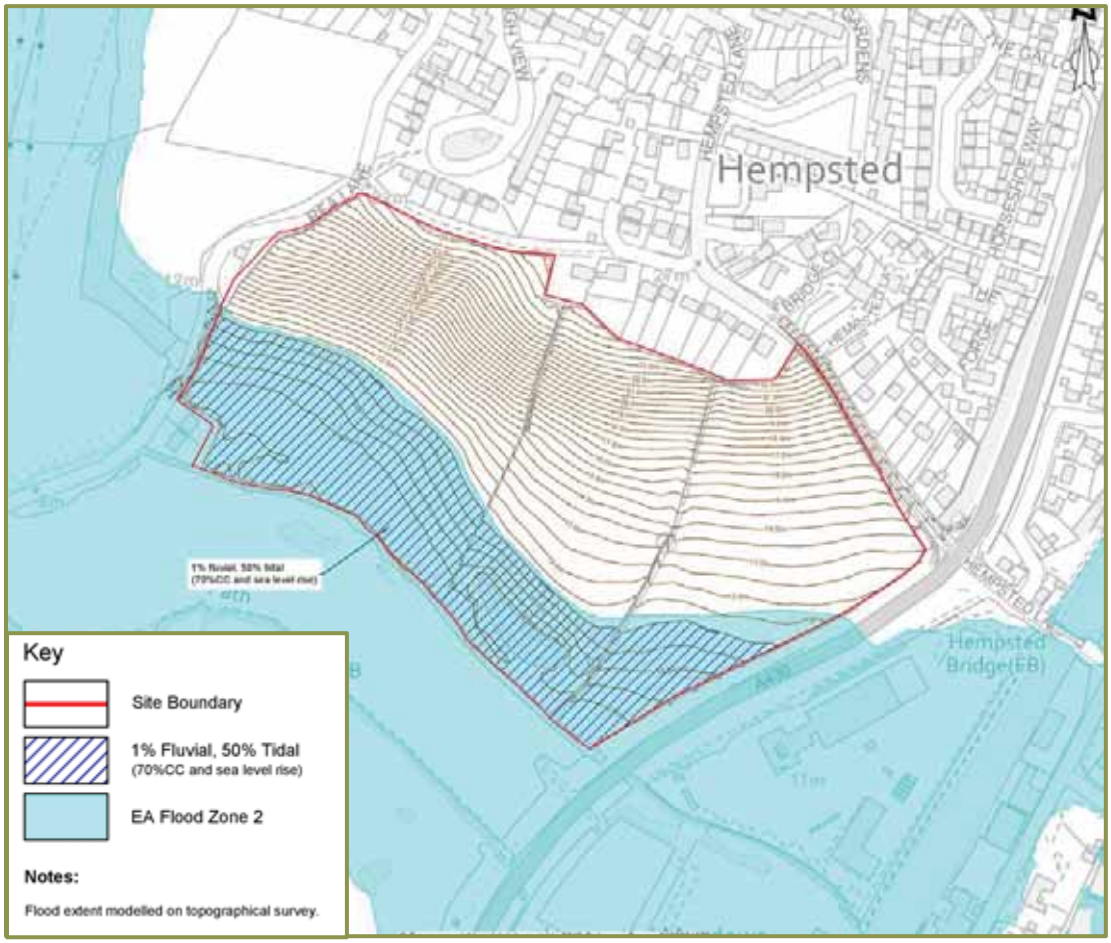
4.2.14 When the 11.00mAOD flood outline is compared to Environment Agency Flood Zone 2, it has a lesser extent (Figure 4.3). This is despite the 1 in 100-year +70%CC event being 0.09m higher than the 1 in 1000-year fluvial event, which is representative of Flood Zone 2. As such, Flood Zone 2, as shown in Figure 4.3, is representative of a flood level greater than the 1 in 100-year +70%CC flood event.

4.2.15 Where significant historical flood events have occurred, the outlines are often used in place of model results to inform Flood Zone 2. It is assumed that Flood Zone 2 within the Site is a composite outline representing the 1/2/1947 and 5/12/2000 to 20/12/2000 historical flood events (Drawing 009.1 and 009.2).

4.2.16 Whilst the 1 in 100-year +70%CC event model re-run provides the greatest flood level, the Environment Agency Flood Zone 2 has a greater flood outline (Figure 4.3). As a conservative approach, the Environment Agency Flood Zone 2 flood outline has been carried forward within this FRA.

4.2.17 It is assumed that Hempsted Brook along the southern boundary of the Site has not been modelled. The fluvial flood risk from this watercourse is likely to be represented by surface water flood mapping (Drawing 010.1), which shows floodwater being largely contained within channel. The fluvial flood risk on Site would be dominated by the River Severn backing up along the unnamed watercourse. Therefore, fluvial flood risk from the unnamed watercourse will be secondary to that described for the River Severn.

Figure 4.3: Modelled Flood Outline Vs Environment Agency Flood Zone 2



JBA Flooding from Rivers

4.2.18 The JBA mapping (Drawing 004.2) shows that the northern and central extents of the Site are located outside the mapped extent of fluvial flooding. The southern extent of the Site, adjacent to Hempsted Brook, is within the mapped extent of fluvial flooding associated with the 1 in 20-year, 75-yar, 100-year, 200-year and 1000-year events.

SFRA Mapping

4.2.19 SFRA mapping (Appendix 2) shows that the northern and central extents of the Site are located outside the mapped extent of fluvial flooding. The southern extent of the Site, adjacent to Hempsted Brook, is within the mapped extent of Flood Zones 2, 3a, 3a+CC and 3b.

Flood History

4.2.20 The SFRA mapping and Drawings 009.1-009.2 shows there have been historic fluvial flood events which have inundated the southern extent of the Site during the February 1990 and December 2000 flood events.

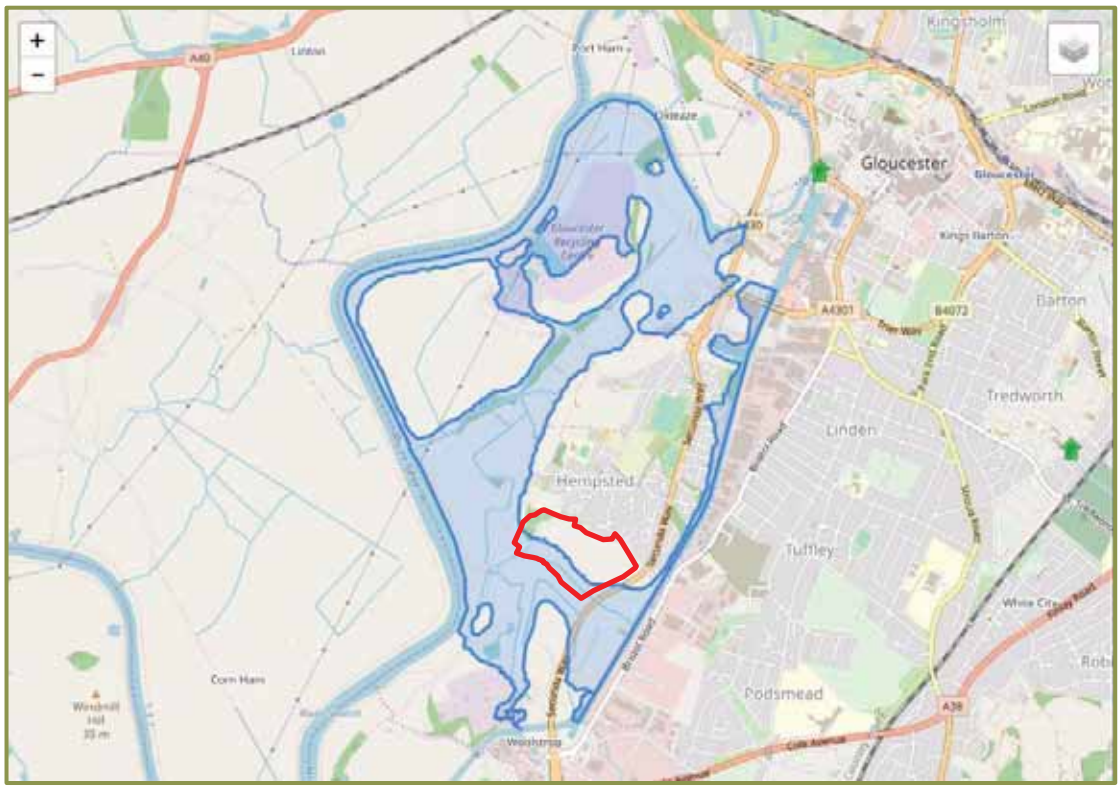
Flood Defences

4.2.21 Environment Agency online flood mapping shows that the Site does not benefit from flood defences.

Flood Warning Service

4.2.22 River Levels UK mapping shows the Site is located within an area which receives flood warnings. The southern extent of the Site is within the mapped coverage from the '*River Severn at Hempsted flood warning area'*.

Figure 4.4: Flood Warning Areas



Flood Risk Summary

4.2.23 Drains 1 and 2 are orientated north to south through the Site, with outfalls to Hempsted Brook.

4.2.24 The risk of fluvial flooding is assessed as negligible within the northern extent of the Site, but medium to high within the southern extent. There is also a residual risk of flooding from onsite drains.

4.2.25 Mitigation measures against fluvial flooding are discussed in Section 5.

4.3 Tidal Flooding

4.3.1 The risk of tidal flooding is moderate to high in the south of the Site from the River Severn.

4.3.2 Although the River Seven is tidal in this location, correspondence with the Environment Agency and modelled flood levels (Figure 4.2) confirm that flooding is fluvially dominated. Therefore, any tidal flood risk would be mitigated by the fluvial flood risk mitigation measures.

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 most of the Site is located outside the mapped extent of groundwater flooding.

4.4.2 There is a negligible area along the northern boundary where there is limited potential for groundwater flooding to occur. The risk of flooding is likely to be associated with the underlying Kidderminster Station member (Sand and gravel) superficial deposits. The superficial deposits are overlain by loamy and clayey soils; therefore, it is unlikely that groundwater would rise to the surface.

4.4.3 The BGS mapping is coarse and should be superseded by the Geosmart groundwater flood risk map.

Geosmart Groundwater Flood Risk Map

4.4.4 The Geosmart 1 in 100-year groundwater flood risk map (Drawing 006) shows that the Site is at negligible risk of groundwater flooding and falls within Risk Class 4 (Table 4.4).

4.4.5 Mapped classes combine understanding of likelihood, model and data uncertainty, and possible severity. Likelihood is ranked according to whether we expect groundwater flooding at a site due to extreme elevated groundwater levels with an annual probability of occurrence greater than 1%, considering model and data uncertainty. Severity relates to expectations of the amount of property damage or other harm that groundwater flooding at that location might cause (Table 4.4).

Table 4.4: 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.

Risk Class	Probability of Groundwater Flooding	Effect
2: Moderate	Annual probability greater than 1%.	Significant possibility of damage to property or harm to other sensitive receptors at or near this location. flooding is likely to be in the form of shallow pools or streams. Surface water flooding and failure of drainage systems may be worsened when groundwater levels are high.
1: High	Annual probability greater than 1%.	Groundwater flooding will occur which could lead to damage to property or harm to other sensitive receptors at or near this location. Flooding may result in damage to property, road or rail closures and, in exceptional cases, may pose a risk to life. Surface water flooding and failure of drainage systems may be worsened when groundwater levels are high.

Flood Risk

4.4.6 The risk of groundwater flooding is assessed as negligible.

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 that most of the Site is located outside the mapped extent of surface water flooding.

4.5.3 There is a surface water flow pathway orientated south-east to north-west along the reach of Hempsted Brook. The surface water flooding is associated with the 1 in 75-year, 200-year and 1000-year events and is likely to be representative of fluvial flooding. The flow pathway is mostly confined to channel along its reach but appears to back-up at the downstream (western) extent of the Site. It is likely that the flood mapping does not take into consideration the conveyance capacity of the Ø1200mm culvert beneath Rea Lane.

4.5.4 There is an area of ponding associated with the balancing pond in the southern extent of the Site. The surface water flooding is associated with the 1 in 75-year, 200-year and 1000-year events.

4.5.5 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

4.5.6 The Environment Agency Complex Surface Water Flood Mapping (Drawings 010.1 to 010.4) shows that most of the Site is located outside the mapped extent of surface water flooding.

4.5.7 There is a surface water flow pathway orientated south-east to north-west along the reach of Hempsted Brook. The surface water flooding is associated with the 1 in 30-year, 100-year and 1000-year events. The flow pathway is mostly confined to channel along its reach. The pathway has a depth up to 1.20m, a velocity of up to 02.0m/s and a hazard rating up to 'significant' (1.25-2.00). The flow pathway is likely to be representative of fluvial flooding and will be mitigated through the fluvial mitigation measures.

4.5.8 There is an area of ponding associated with the balancing pond in the southern extent of the Site. The ponding is associated with the 1 in 30-year, 100-year and 1000-year events. The ponded area has a depth up to 0.60m, velocity up to 0.50m/s and a hazard rating up to 'significant' (1.25-2.00). The balancing pond is managed by Severn Trent Water; therefore, the risk of flooding is mitigated through inspection and maintenance.

4.5.9 There are small areas of ponding within the western extent of the Site. The ponding is associated with the 1 in 1000-year events, t\he ponded area has a depth up to 0.30m, velocity up to 0.25m/s and a hazard rating up to 'low' (0.50-0.75). The risk of surface water ponding is likely to be associated with topographic low points.

Flood Risk Summary

4.5.10 The risk of surface water flooding is assessed as negligible for most of the Site, with an area of low risk associated with ponded areas within the western extent.

4.5.11 Mitigation measures against 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 Adoption[18] 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).

COMMERCIALDW Drainage and Water Enquiry

4.6.3 There is a public surface water sewer conveying flow south-west through the eastern extent of the Site, with an outfall to Hempsted Brook to the south of the onsite balancing pond. From a review COMMERCIALDW Drainage and Water Enquiry (Appendix 3), there are no recorded sewer flooding incidents located within the Site boundary.

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

Flood Risk Summary

4.6.4 The risk of flooding from sewers is assessed as negligible for most of the Site but low along the reach of the onsite public surface water sewer.

4.6.5 Mitigation measures against sewer flooding is discussed in section 5.

4.7 Flooding from Infrastructure Failure

Balancing Pond

4.7.1 There is a balancing pond located within the southern extent of the Site. The pond is not impounded and is maintained by Severn Trent Water. The risk of flooding from pond failure is assessed as negligible.

Canal

4.7.2 The Gloucester and Sharpness Canal is orientated north to south, approximately 120m to the east of the Site. Utilising LiDAR data it was found the canal is approximately 3m lower than the level of the Site. Therefore, the risk of flooding from canal failure is assessed as negligible.

Reservoir

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

5.0 Flood Risk Mitigation Measures

5.1 Introduction

5.1.1 The following sources of flooding were identified:

- Fluvial/tidal flooding (River Severn backing-up along Hempsted Brook and residual flooding from Drains 1 and 2).
- Surface water flooding (surface water ponding in the western extent)
- Sewer Flooding (public surface eater sewer within the eastern extent).

5.2 Mitigation Measures

Fluvial/Tidal Flooding

- Sequentially develop the Site, limiting the built development (including surface water attenuation) outside the mapped extent of fluvial flooding.
- Provide a 4m easement free from development along either side of the onsite and bounding watercourses. This easement would provide access for inspection and maintenance purposes, including vehicle access.
- Undertake maintenance activities to keep the watercourses clear from debris and overgrown vegetation to maintain the conveyance of the channels.
- Set finished floor levels a minimum of +150mm above external levels.
- Set the surface water outfall from the proposed development at an appropriate height (i.e. above the 1 in 100-year + 70% CC modelled flood level [11.0m AOD]) or provide a swale outfall from the detention basin to mitigate the risk of the outfall surcharging.

Surface Water Flooding

- Adoption of a surface water management strategy.
- Set finished floor levels as per above.

Sewer Flooding

- Provide a development free easement (3m either side) of onsite public surface water sewer assets, or re-direct around the Site boundary.

5.3 Summary of Flood Risk

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

Table 5.1: Probability and Consequences of All Sources of Flooding

Flooding Source	Potential Source	Probability	Consequence & Impact Without Mitigation	Consequence & Impact with Mitigation
Fluvial	River Severn, Hempsted Brook and Drains 1 and 2.	Negligible within the northern and middle extents but high within the southern extent.	Negligible within the northern and middle extents but high within the southern extent.	Low
Tidal	River Severn.	Negligible within the northern and middle extents but high within the southern extent.	Negligible within the northern and middle extents but high within the southern extent.	Low
Groundwater	Secondary Undifferentiated Aquifer (Bedrock).	Negligible	Negligible	Negligible
Surface Water	Poor permeability and Site topography.	Negligible for most of the Site, low for surface water ponding in the western extent.	Negligible for most of the Site, low for surface water ponding in the western extent.	Negligible
Sewer	Public surface water Sewer.	Negligible for most of the Site but low for the reach along the surface water sewer within the eastern extent.	Negligible for most of the Site but low for the reach along the surface water sewer within the eastern extent.	Negligible
Infrastructure Failure	Balancing pond, canal and reservoir failure.	Negligible	Negligible	Negligible

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

5.4 Flood Guidance and Sequential Test

5.4.1 The proposal is for a residential development. Table 2 of PPG ID: 7 (not included in this report) classifies the proposed use as 'more vulnerable'. More vulnerable uses are considered acceptable in terms of flood risk in Flood Zone 1. Subject to the implementation of the above mitigation measures, the Sequential Test would be passed, and the Exception Test would not be required.

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 12.22ha Site is comprised of three agricultural (arable) land parcels, divided by hedgerows.

6.2.2 The Site is underlain by soils and geology with low infiltration potential. It is likely that drainage is predominantly via overland flow, following the topography of the Site to the topographic low points (Hempsted Brook), with a small amount of infiltration to bedrock, and throughflow to watercourse.

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 The proposal is for residential development. An allowance of 55% impermeable area (inclusive of 10% for urban creep) was applied to the 6.4ha developable area. The existing and proposed impermeable areas are shown in Table 6.1. The proposed development will increase the impermeable surfaces and so increase the amount of runoff.

Table 6.1: Impermeable Area

Area	Existing Buildings and Hardstanding	Proposed Buildings and Hardstanding	Difference
Area (ha)	0.00	3.52	+3.52
Percentage of Total Site Area (%)	0	28.8	+28.8

6.4 Greenfield Runoff Rates

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

6.4.2 The runoff rates were calculated using HR Wallingford software utilising the FEH method.

6.4.3 The following parameters were used in the runoff calculations:

- Developable Area: 6.3ha.
- Average Annual Rainfall (SAAR): 655mm/year;
- BFIHOST: 0.4860
- Region No.: 4

6.4.4 Table 6.2 shows the calculated greenfield runoff rates. Drainage Calculations are included in Appendix 7.

Table 6.2: Greenfield Runoff Rates

Annual Probability (Return Period, years)	Greenfield Runoff (l/s)
QBAR	17.3
100% (1)	14.5
3.33% (30)	34.4
1% (100)	44.4
1% Plus Climate Change	65.9

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.*

6.4.5 The LLFA stated in their correspondence that discharge rates equivalent to QBAR greenfield or equivalent would be acceptable. Therefore, the QBAR runoff rate has been utilised to inform the drainage calculations in the remainder of the report.

6.5 Sustainable Drainage Options (SuDS)

Feasibility of SuDS

6.5.1 Soakaway testing was undertaken during September 2019. A copy of the Infiltration Test Report is included in Appendix 6. Findings show that infiltration-based SuDS would not feasible due to low infiltration.

Choice of SuDS Options

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

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

Table 6.3: SuDS Options

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

Note: *SuDS appropriate to the development are highlighted green.*

6.5.4 A hierarchy of SuDS techniques is identified[19]:

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

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

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

SuDS Maintenance

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

6.5.7 Maintenance of the SuDS features would be in line with the SuDS Manual (CIRIA C753, 2015), as detailed in Figure 6.1. The maintenance would be undertaken by a private maintenance company.

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

6.5.8 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.

6.5.9 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 6.1: 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 2000[20] 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:** Hempsted Brook conveys flow north-west along the south-west boundary.
3. **A sewer:** There is a public surface water sewer conveying flow south-west through the eastern extent of the Site, with an outfall to Hempsted Brook.

6.6.2 The potential route to discharge from the existing Site will be by outfall to Hempsted 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 an onsite detention basin, positioned to achieve a gravity fed connection to the Hempsted Brook.

6.6.6 An indicative drainage layout is 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: 3.52ha;
- Cv (proportion of rainfall forming surface water runoff): 75% summer, 84% winter;
- Infiltration losses: 0.00m/hour;
- With outfall at QBAR (Table 6.2).
- The attenuation volume for the 1 in 100-year event (plus climate change) is 3,762m^3.

6.6.9 Drainage calculations are included in Appendix 7. The calculated runoff rates and attenuation volumes will be reviewed at detailed design stage.

[20] Office of the Deputy Prime Minister, The Building Regulations 2000.

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 QBAR 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) towards the unnamed watercourse, 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.

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 12.22ha Site on land west of Hempsted Lane, Gloucester.

7.2 Flood Risk

7.2.1 The risk of fluvial/tidal flooding is assessed as negligible within the northern extent of the Site, but medium to high within the southern extent. There is also a residual risk of flooding from onsite drains.

7.2.2 The risk of surface water flooding is assessed as negligible for most of the Site, with an area of low risk associated with ponded areas within the western extent.

7.2.3 The risk of flooding from sewers is assessed as negligible for most of the Site but low along the reach of the onsite public surface water sewer.

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 (including surface water attenuation) outside the mapped extent of fluvial flooding.
- Provide an easement free from development along either side of the onsite and bounding watercourses. This easement would provide access for inspection and maintenance purposes.
- Undertake maintenance activities to keep the watercourses clear from debris and overgrown vegetation to maintain the conveyance of the channels.
- Set finished floor levels above external levels.
- Set the surface water outfall from the proposed development at an appropriate height above the bed level of the receiving watercourse or provide a swale outfall from the detention basin to mitigate the risk of the outfall surcharging.
- Adoption of a surface water management strategy.
- Provide a development free easement either side of onsite public surface water sewer assets, or re-direct around the Site boundary.

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 Zone 1. Subject to the implementation of the above mitigation measures, the Sequential Test would be passed, and the Exception Test would not be required.

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 a detention basin designed to maintain runoff at pre-development rates, with an outfall to the watercourse.

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.

DRAWINGS

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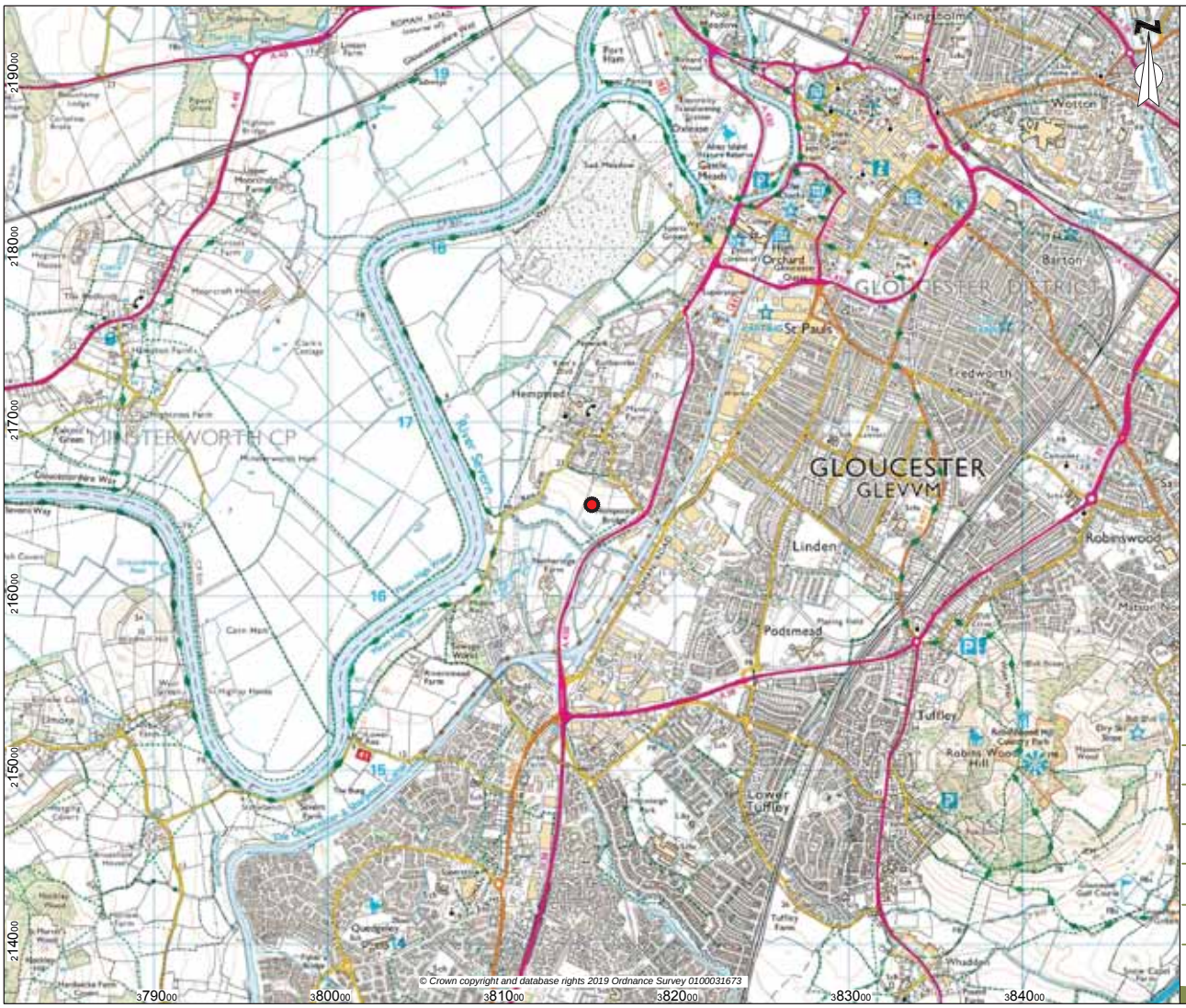


Key

Site Location
(SO 8152 1653)

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

CLIENT:
Glad□an Develop□ents Ltd

SCALE:
1:20,000□ A3

PRO□ECT REF:
CRM.1132.021

DRAWN:
MG

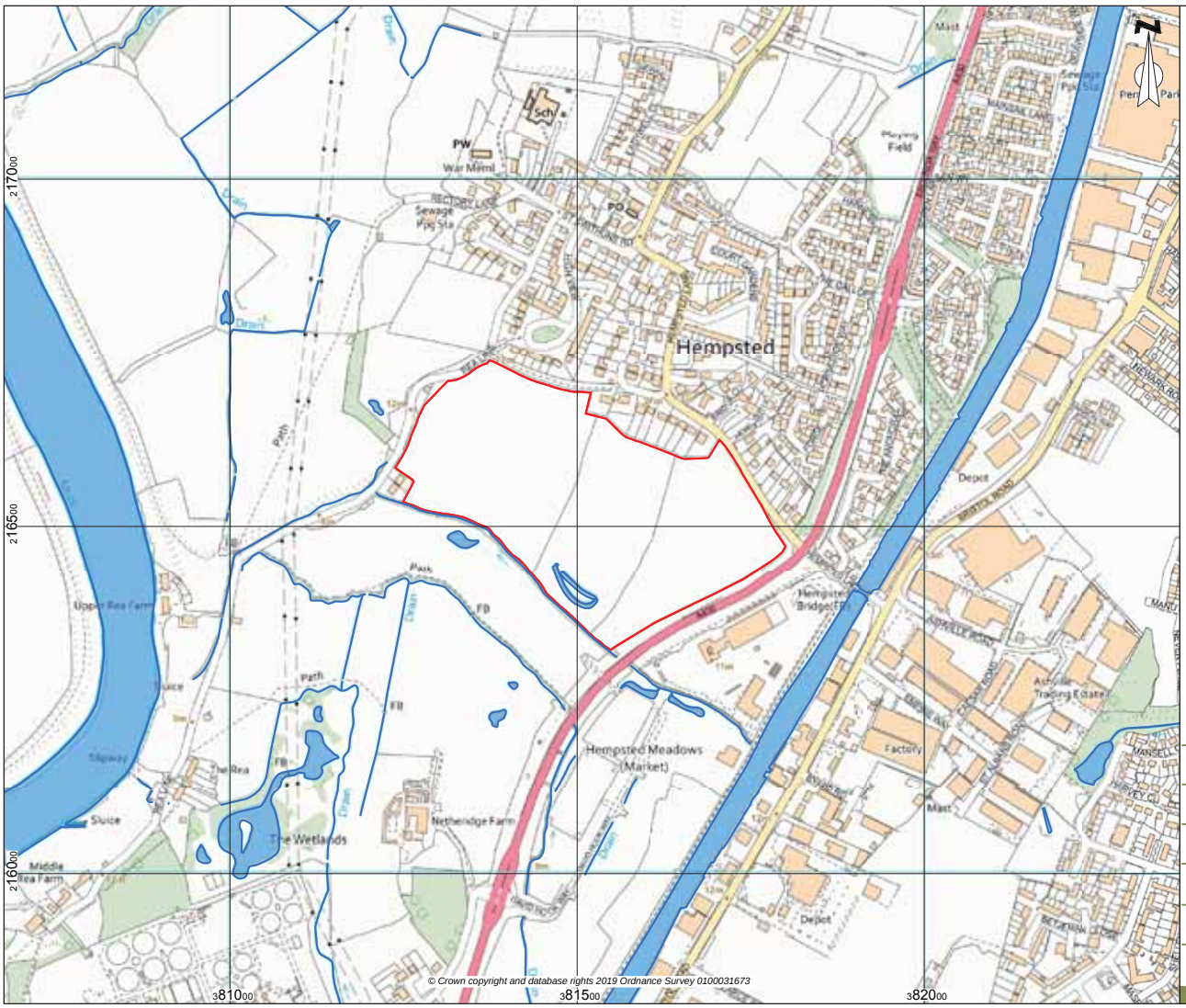
CHECKED:
EO□C

DATE:
Sept 2019

PRO□ECT:
He□psted Lane, Gloucester

TITLE:
Site Location Plan

DRAWING NO:
CRM.1132.021.HY.D.001



Key

Site Boundary

Surface Water Features

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

CLIENT: Gladman Developments Ltd

SCALE: 1:5,000 @ A3

PROJECT REF: CRM.1132.021

DRAWN: MG

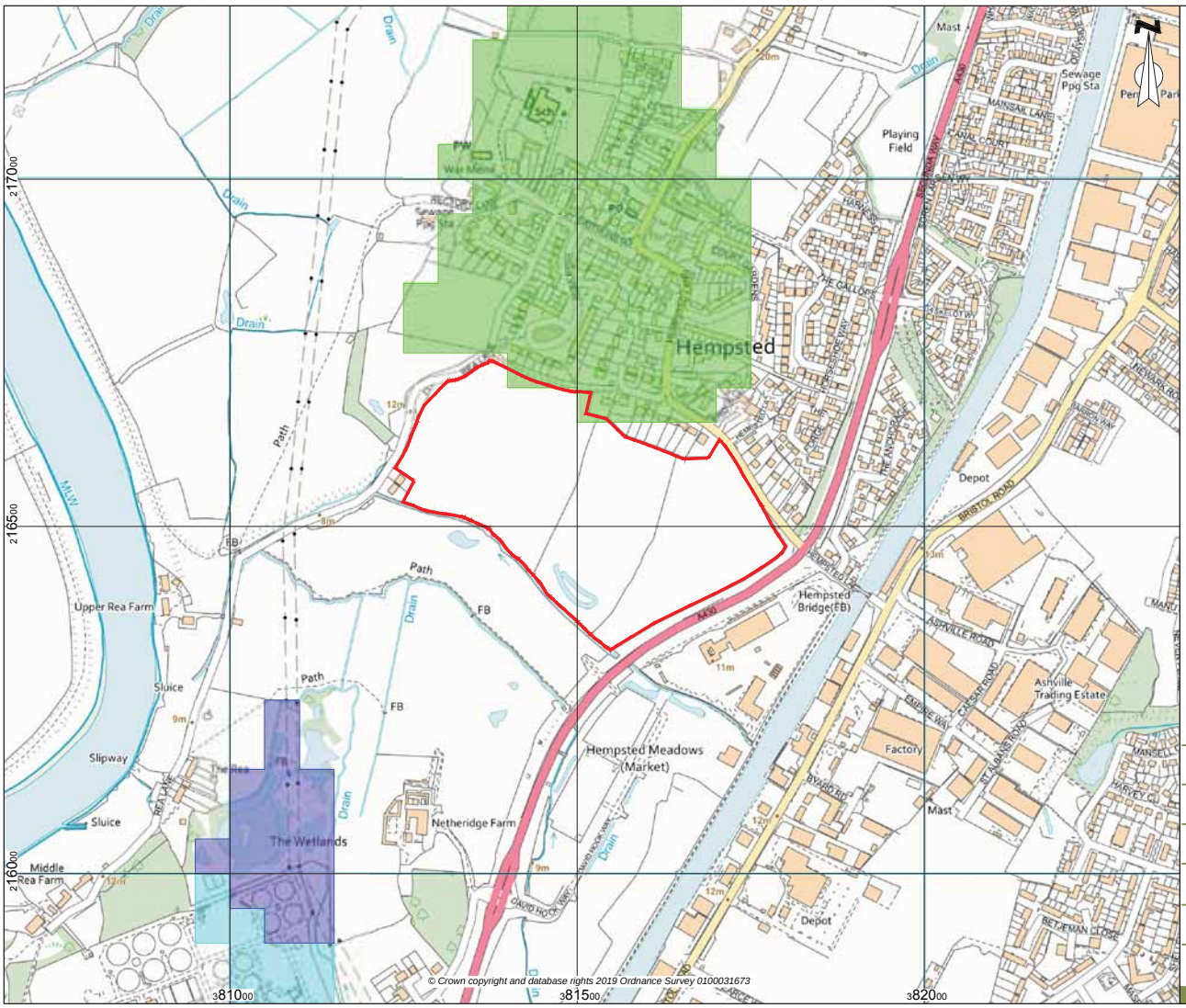
CHECKED: EOC

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: Surface Water Features

DRAWING NO: CRM.1132.021.HY.D.002



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

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SCALE: 1:5,000 @ A3

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DRAWN: MG

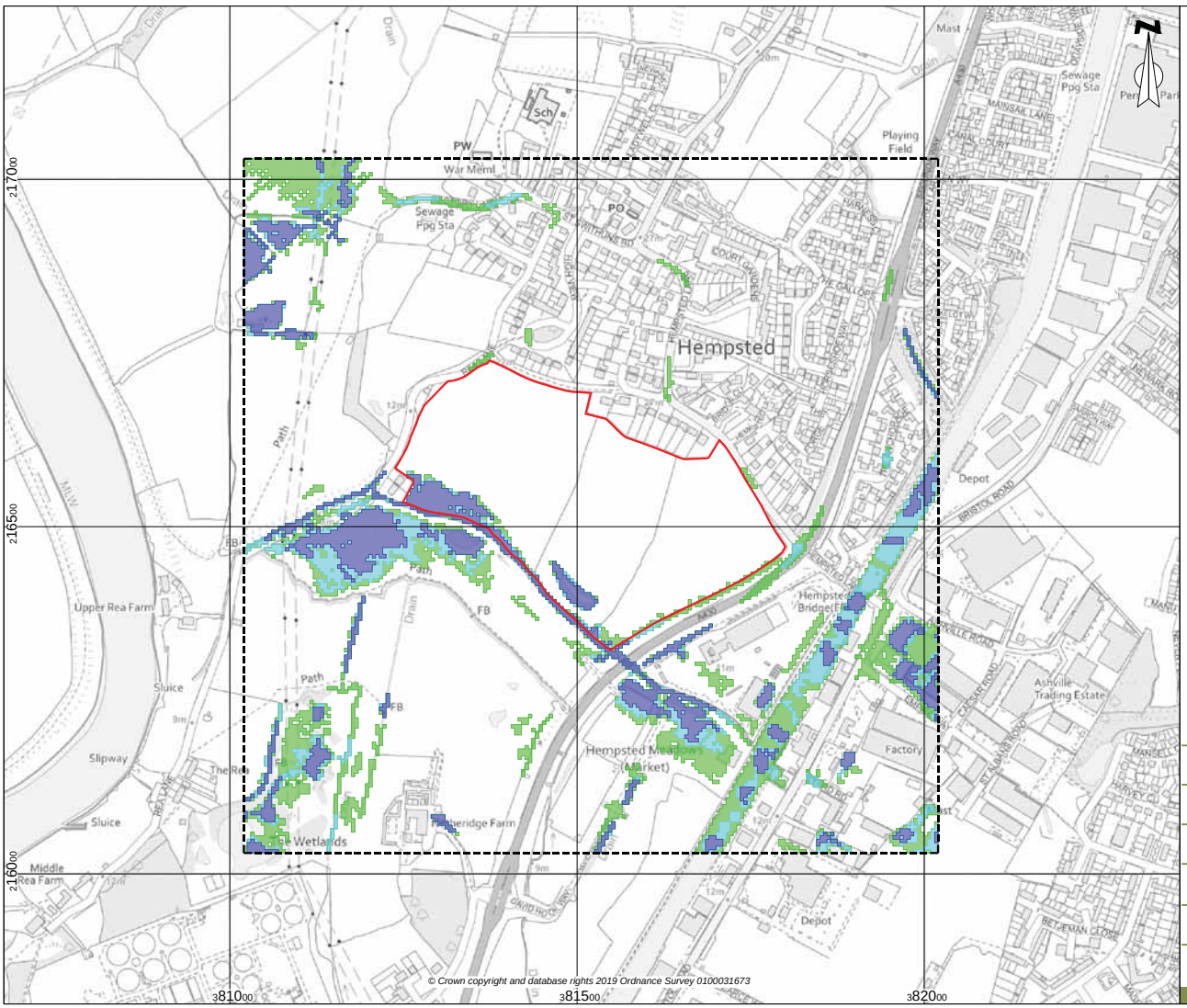
CHECKED: EOC

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: BGS Groundwater Susceptibility

DRAWING NO: CRM.1132.021.HY.D.003



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

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SCALE: 1:5,000@A3

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DRAWN: MG

CHECKED: EO'C

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: JBA Surface Water Features

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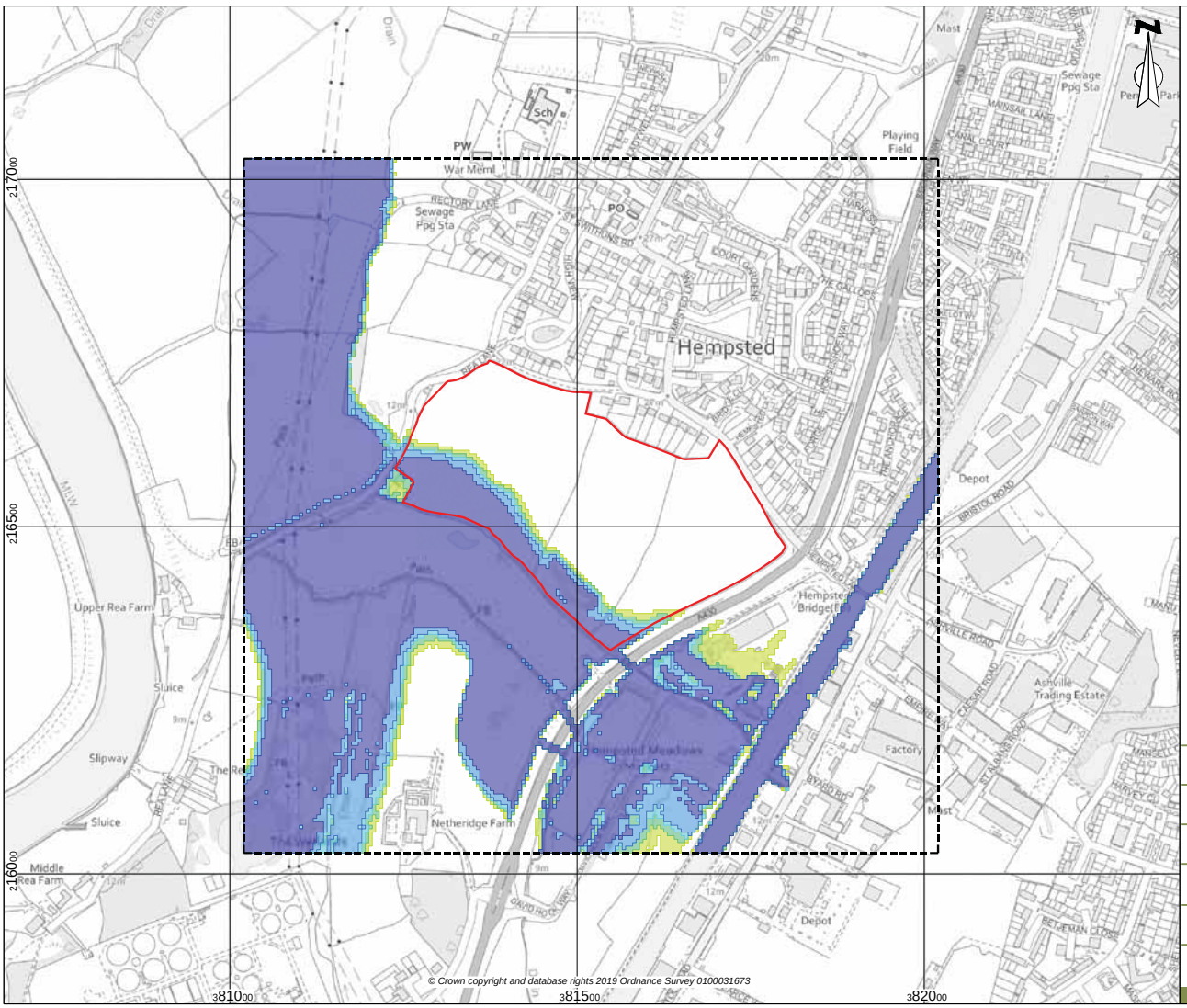

Key

- Site Boundary
- Search Extent
- 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 REF: CRM.1132.021

DRAWN: MG

CHECKED: EO'C

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: JBA Flooding from Rivers

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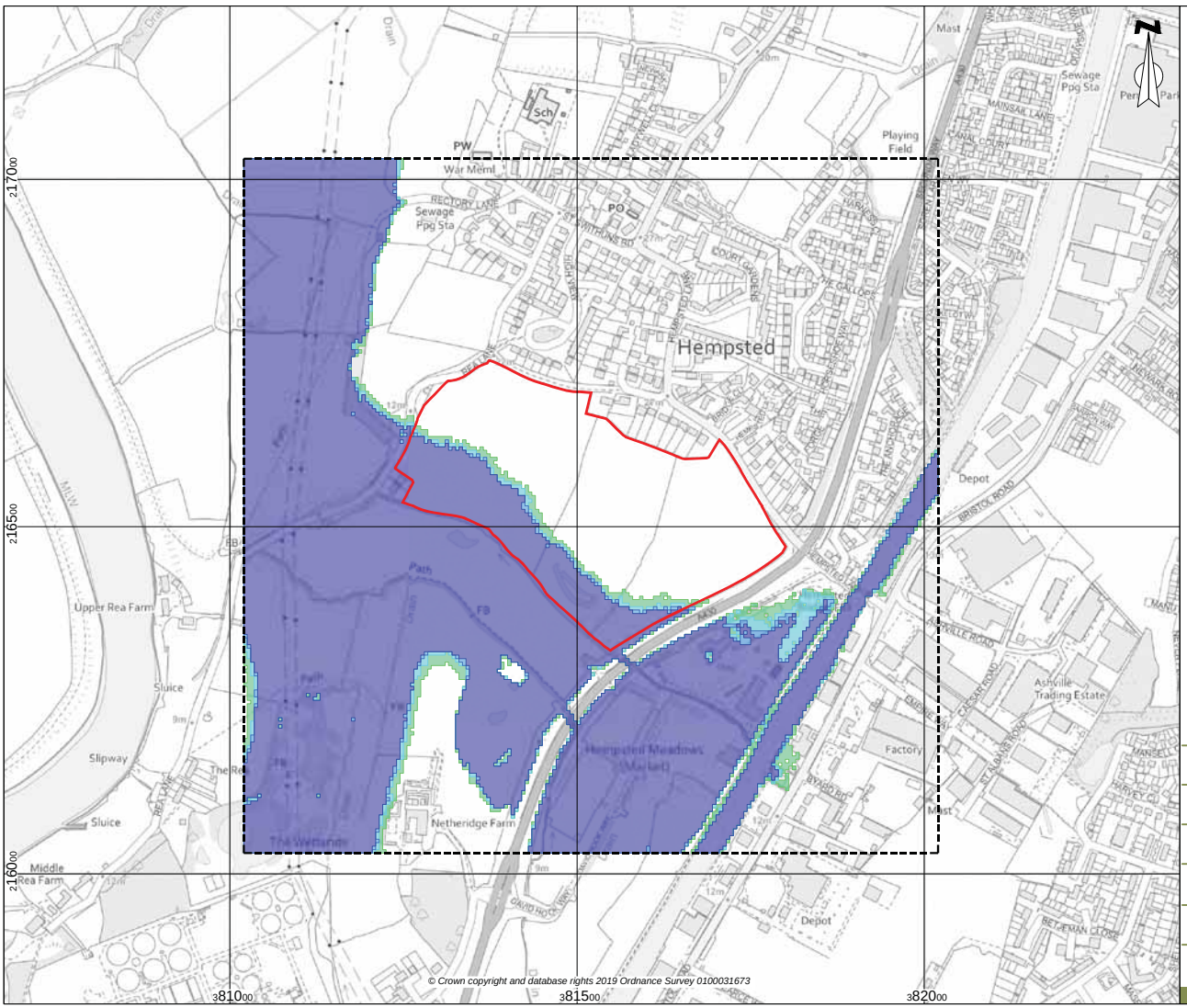

Key

- Site Boundary
- Search Extent
- 1 in 75 Year Coastal Flooding
- 1 in 100 Year Coastal Flooding
- 1 in 200 Year Coastal Flooding
- 1 in 1000 Year Coastal Flooding

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CLIENT: Gladman Developments Ltd

SCALE: 1:5,000@A3

PROJECT REF: CRM.1132.021

DRAWN: MG

CHECKED: EO'C

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: JBA Coastal Flooding

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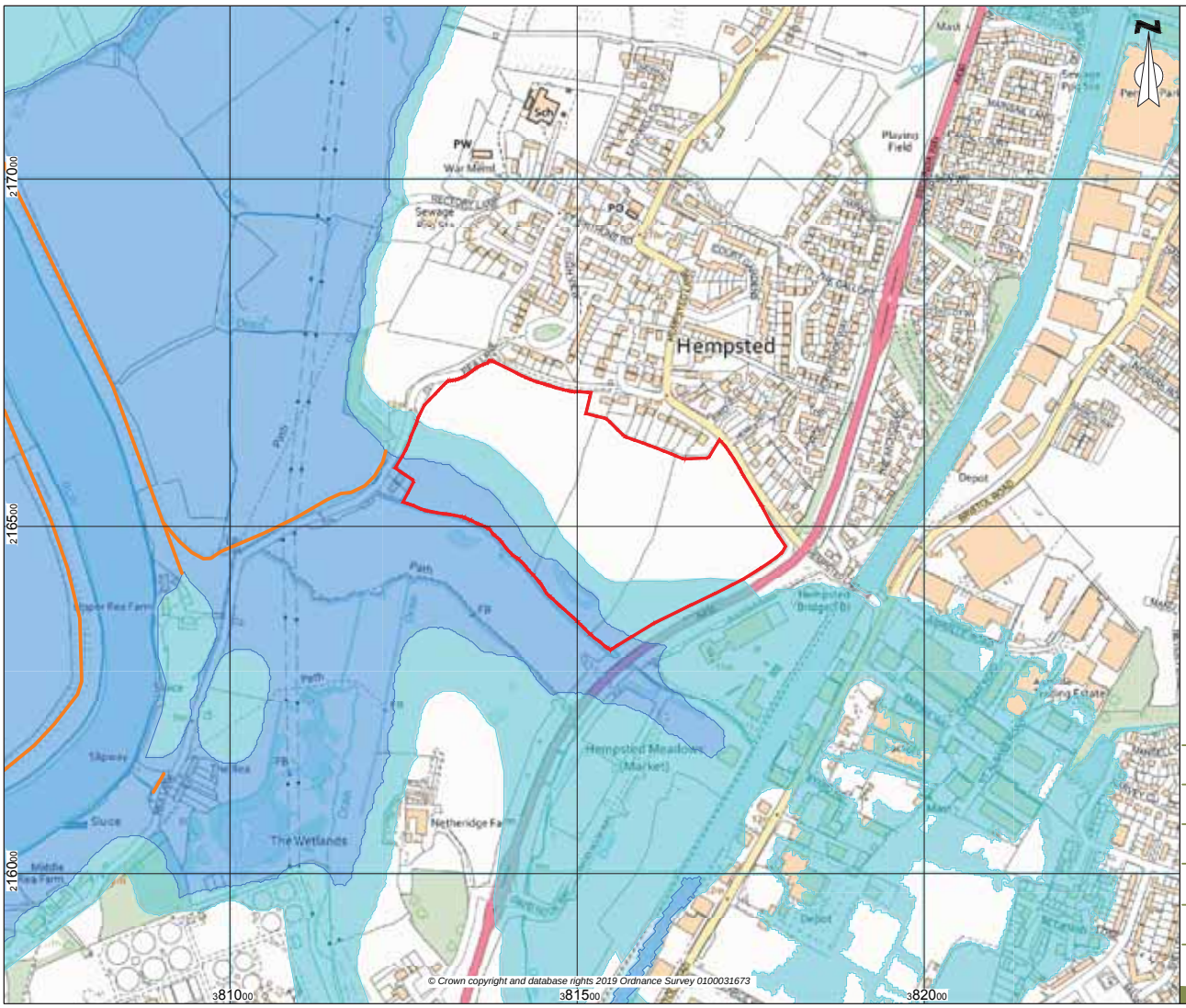

Key

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

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CLIENT: Glad an Develop ents Ltd

SCALE: 1:5,000 A3

PRO ECT REF: CRM.1132.021

DRAWN: MG

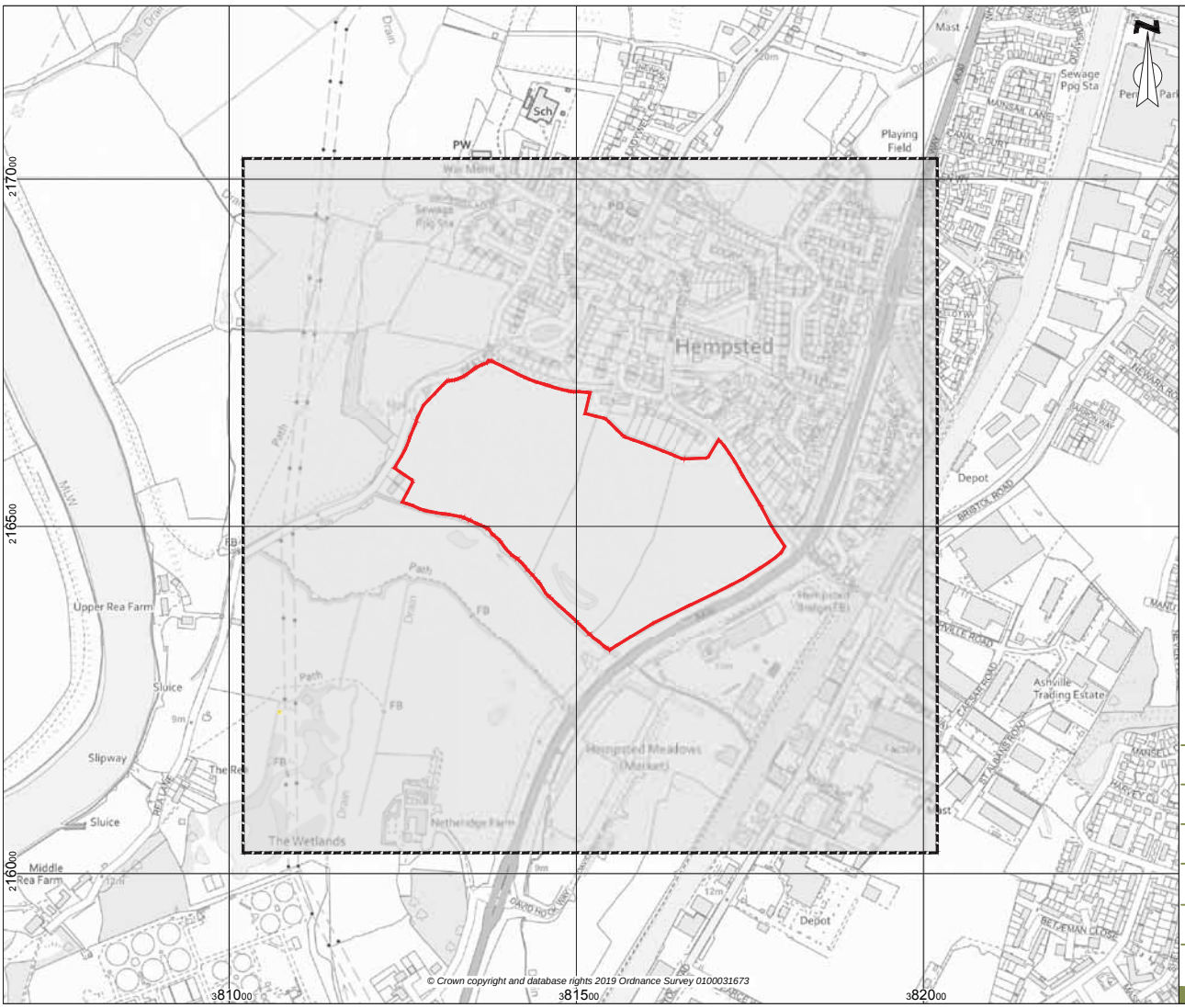
CHECKED: EO C

DATE: Sept 2019

PRO ECT: He psted Lane, Gloucester

TITLE: Environ ent A ency Flood Zones

DRAWING NO: CRM.1132.021.HY.D.005



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CLIENT: Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

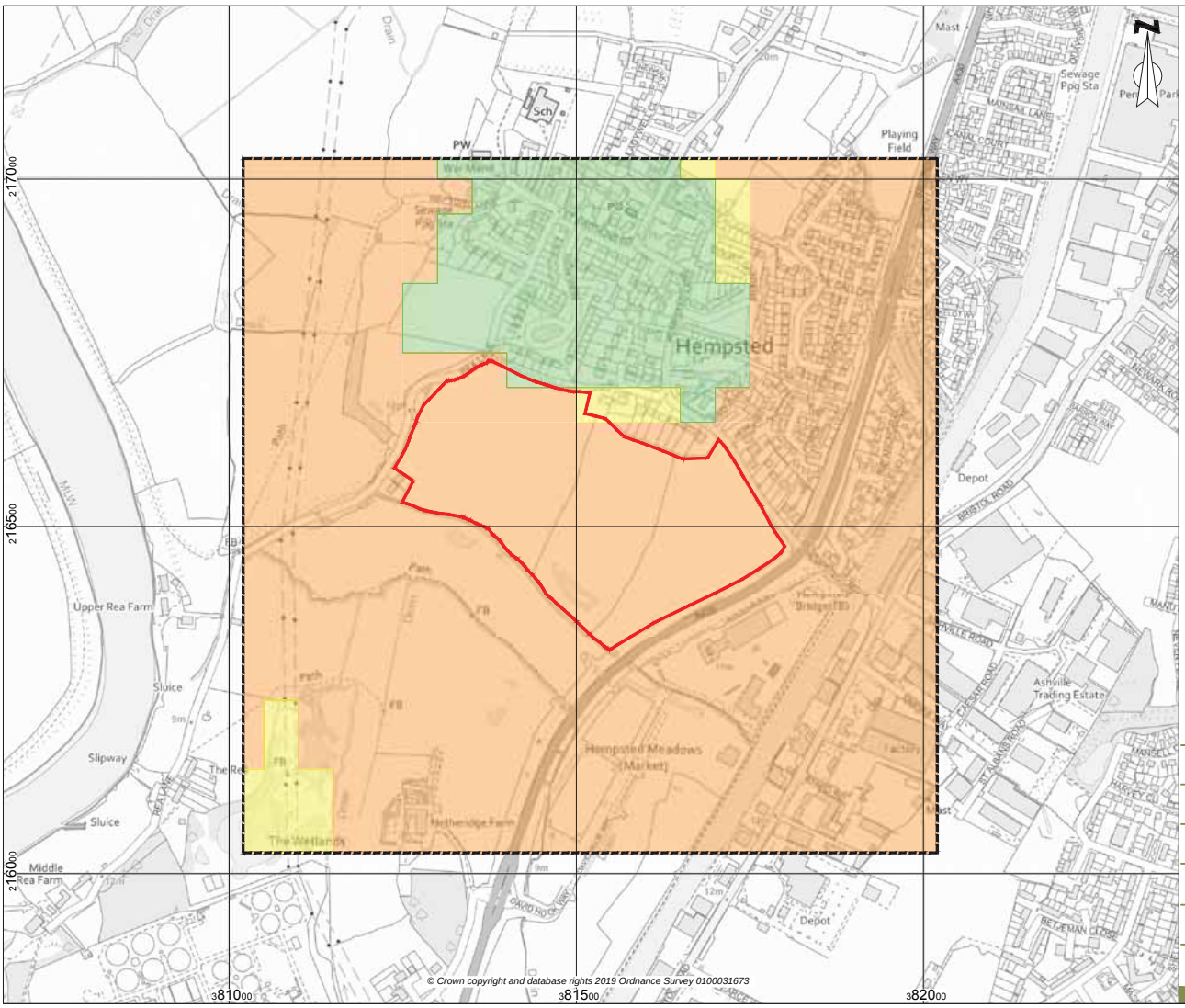
CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Ground□ater Flood Ris□ Map

DRAWING NO: CRM.1132.021.HY.D.006



Key

- Site Boundary
- Searc□ E□tent
- Hi□□Potential
- Moderate Potential
- Lo□ Potential

Notes:

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

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SCALE: 1:5,000□ A3

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CHECKED: EO□C

DATE: Sept 2019

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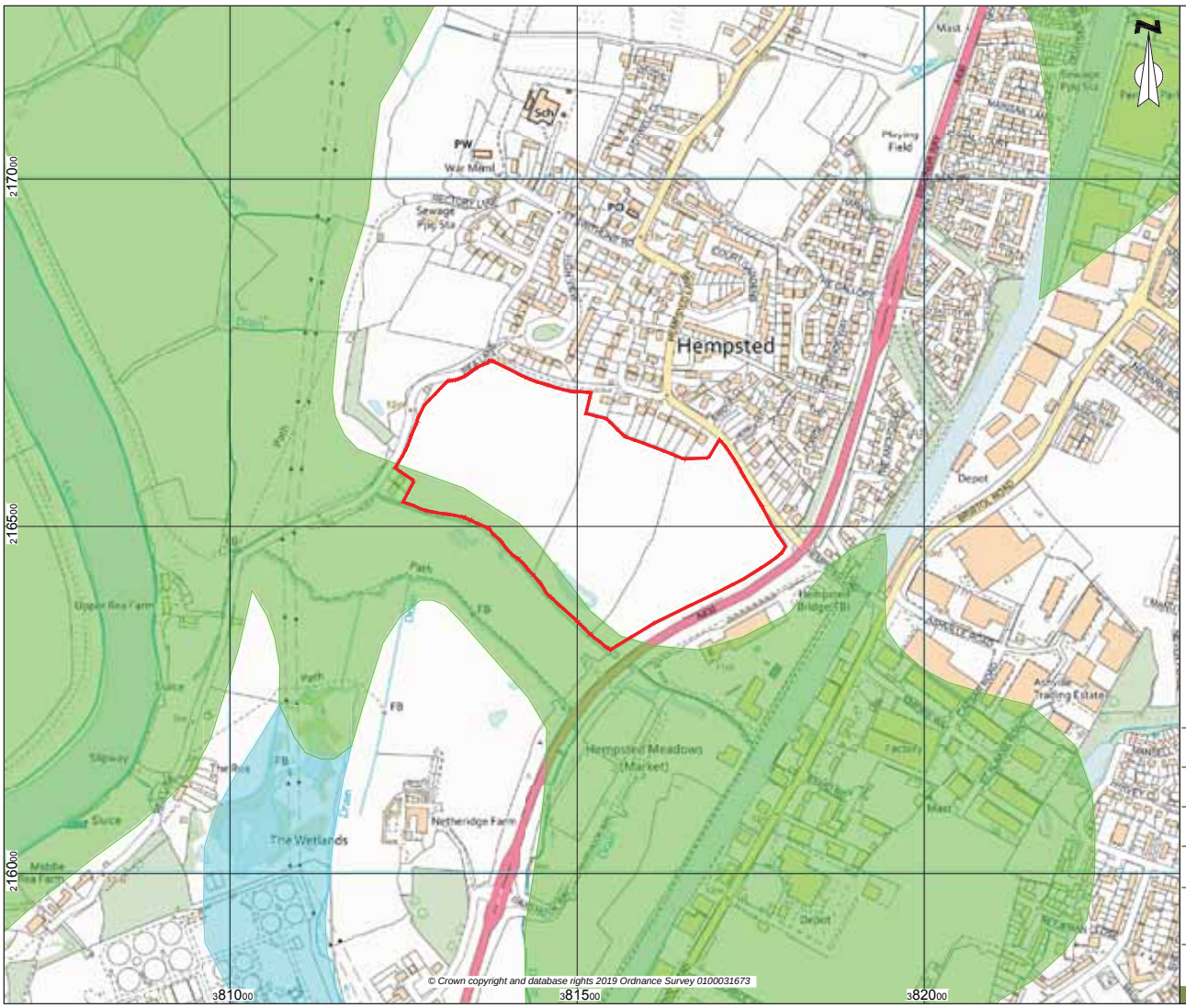

Key

- Site Boundary
- Geolo□ical Indicators o□ Floodin□ *from Coastal Flooding*
- Geolo□ical Indicators o□ Floodin□ *from Inland Flooding*

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CLIENT: Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Geolo□ical Indicators o□ Floodin□ (□ased on □eolo□ical deposits)

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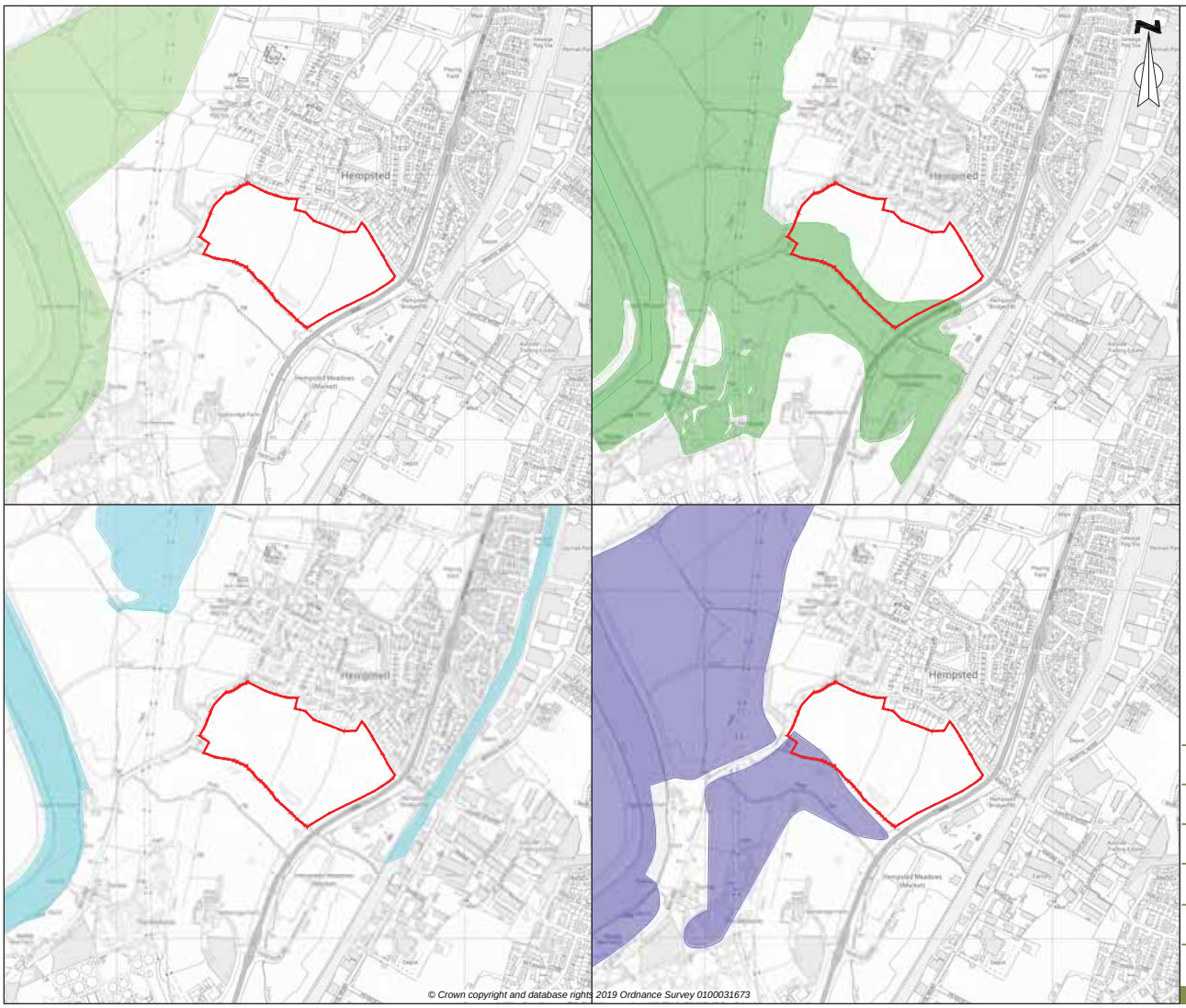

Key

- Site Boundary
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- Historic Flood Zone (Date o□lood 05/12/2000 - 20/12/2000)
- Historic Flood Zone (Date o□lood 29/10/2000 - 12/11/2000)
- Historic Flood Zone (Date o□lood 25/02/1990 - 28/02/1990)

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

CLIENT: Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

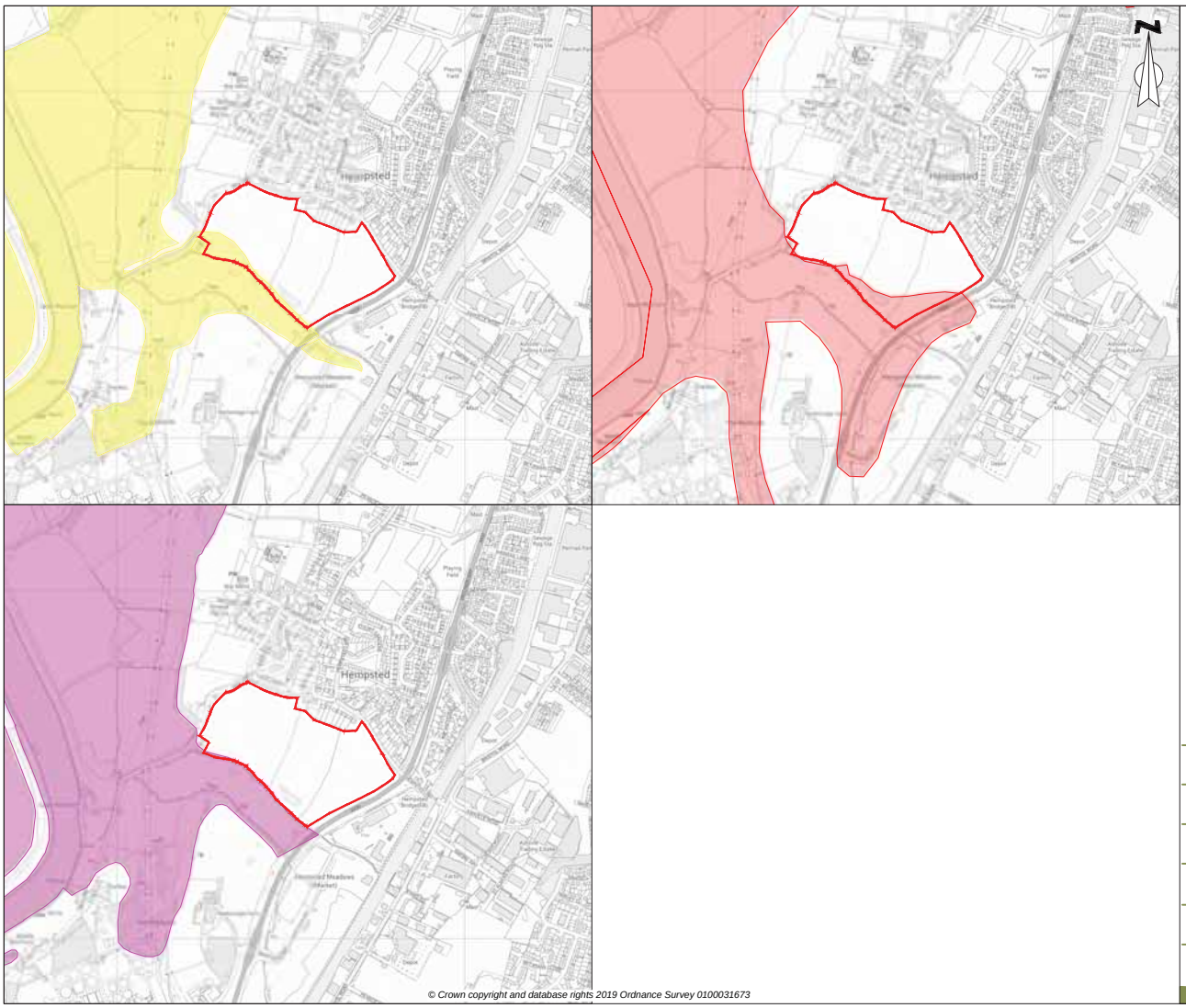
CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Historic Flood Zones

DRAWING NO: CRM.1132.021.HY.D.009.1



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- Historic Flood Zone (Date of flood 01/03/1947 - 01/03/1947)
- Historic Flood Zone (Date of flood 01/01/1939 - 01/01/1939)

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SCALE: 1:5,000 @ A3

PROJECT REF: CRM.1132.021

DRAWN: MG

CHECKED: EOC

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: Historic Flood Zones

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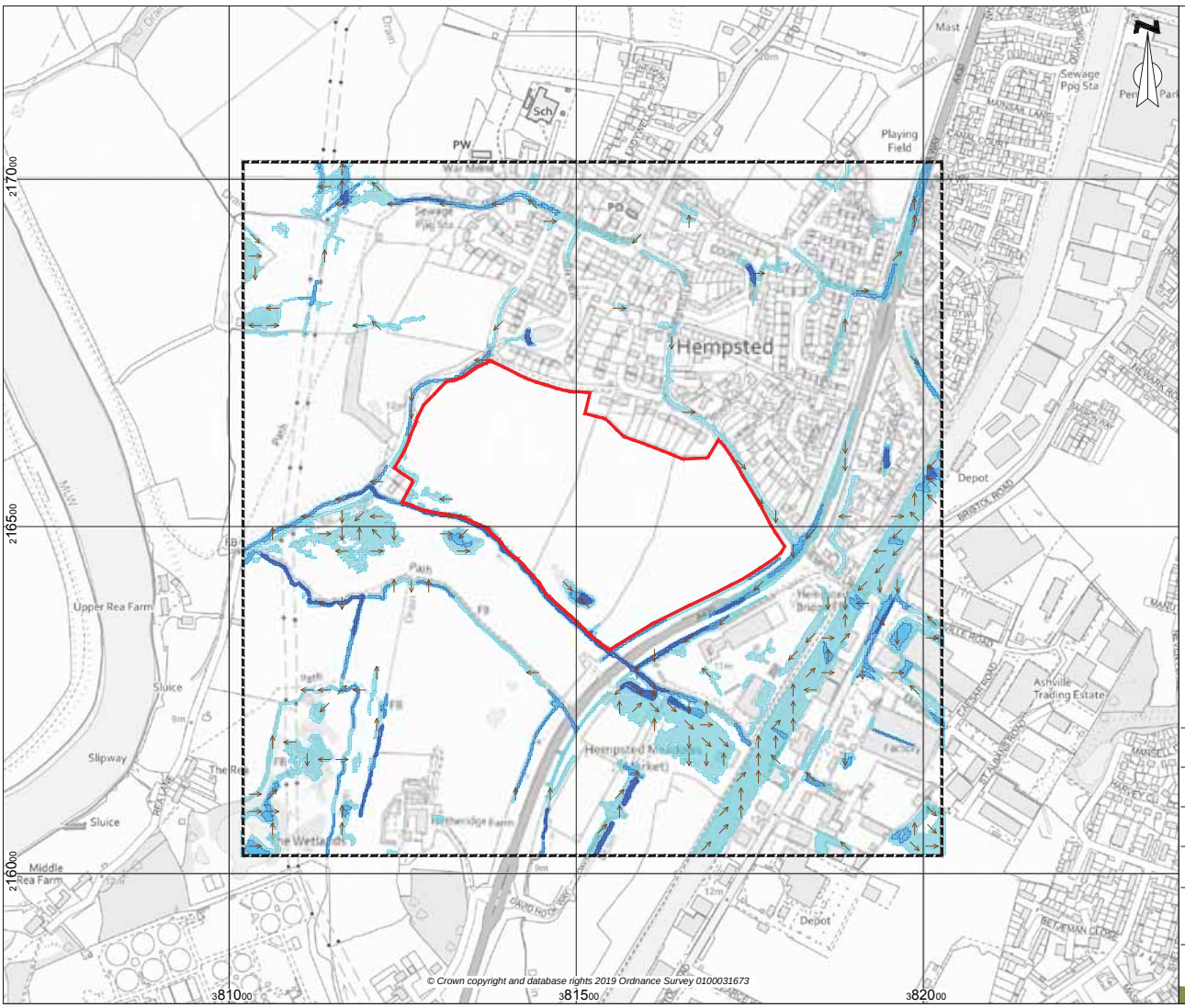

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CLIENT:
Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

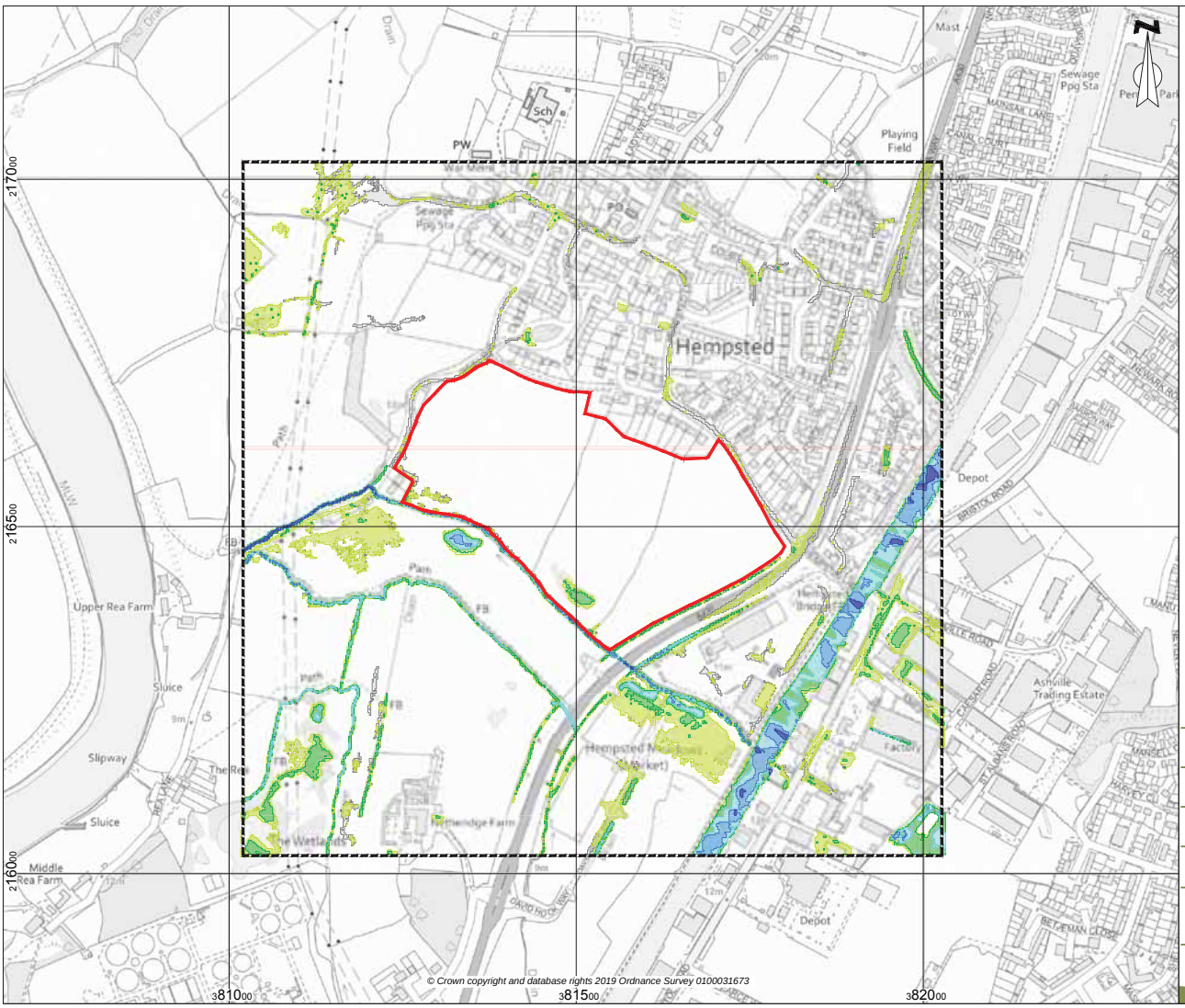
CHECKED: EO□C

DATE: Sept 2019

PRO□ECT:
He□psted Lane, Gloucester

TITLE:
Environ□ent A□ency Sur□ace Water Flo□ Pat□s

DRAWING NO:
CRM.1132.021.HY.D.010.1



Key

- Site Boundary
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- Dept□ □reater t□an 1.20 (□)
- Dept□ 0.90 - 1.20 (□)
- Dept□ 0.60 - 0.90 (□)
- Dept□ 0.30 - 0.60 (□)
- Dept□ 0.15 - 0.30 (□)
- Dept□ 0.0 - 0.15 (□)

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SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Environ□ent A□ency 1 in 1000 Year Sur□ace Water Dept□

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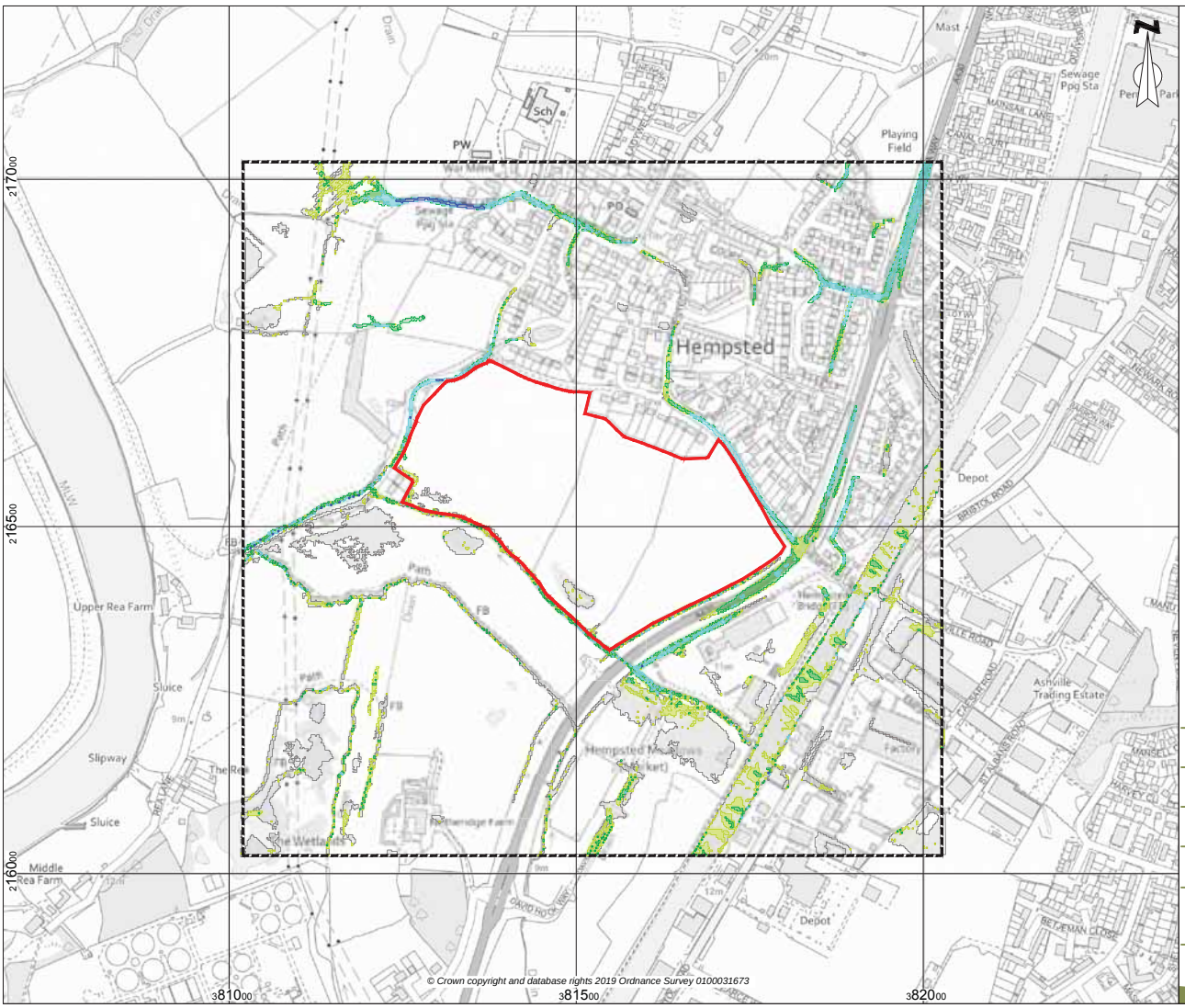

Key

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- Velocity 1.00 - 2.00 (□/s)
- Velocity 0.50 - 1.00 (□/s)
- Velocity 0.25 - 0.50 (□/s)
- Velocity 0.00 - 0.25 (□/s)

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CLIENT: Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Environ□ent A□ency 1 in 1000 Year Sur□ace Water Velocity

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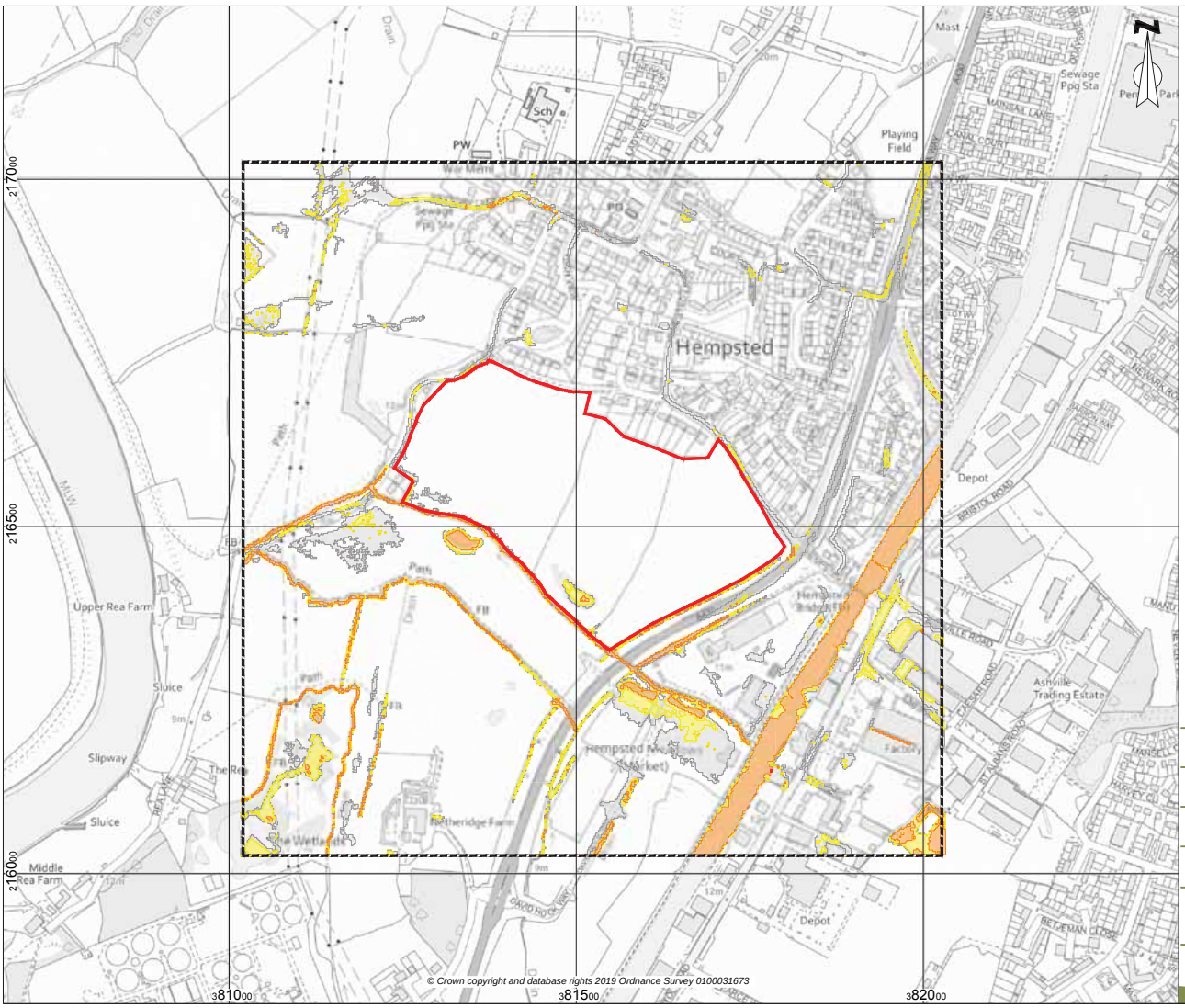

Key

- 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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CLIENT: Gladman Developments Ltd

SCALE: 1:5,000 @ A3

PROJECT REF: CRM.1132.021

DRAWN: MG

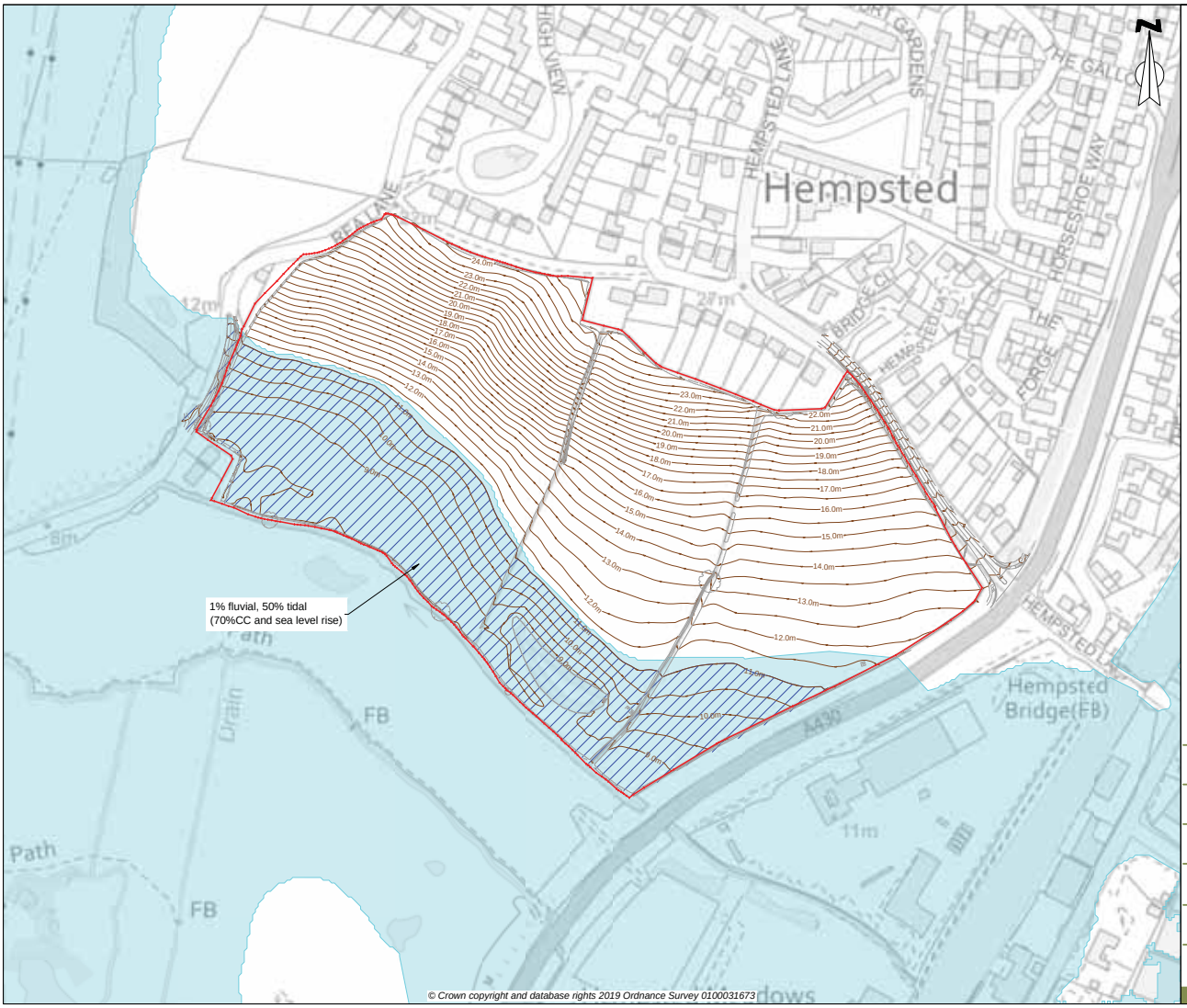
CHECKED: EOC

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: Environment Agency Surface Water 1000 Year Hazard Rating

DRAWING NO: CRM.1132.021.HY.D.010.4



Key

- Site Boundary
- 1% Fluvial, 50% Tidal (70%CC and sea level rise)
- EA Flood Zone 2

Notes:

Flood extent modelled on topographical survey.

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

CLIENT: Gladman Developments Ltd

SCALE: 1:5,000@A3

PROJECT REF: CRM.1132.021

DRAWN: MG

CHECKED: EO'C

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: Modelled Flood Extent

DRAWING NO: CRM.1132.021.HY.D.011

Contact Details:

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

tel: 0114 321 5151
www: enzygo.com

Hempsted Lane, Gloucester

Project:	NPPF: Flood Risk Assessment
For:	Gladman Developments Ltd
Status:	Final
Date:	December 2019

[redacted]

Enzygo Limited Registered in England No. 6525159
Registered Office Stag House Chipping Wotton-Under-Edge Gloucestershire GL12 7AD

Contents

Tables & Figures

Drawings

Appendices

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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 west of Hempsted Lane, Gloucester.

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 12.22-hectare (ha) Site comprises three agricultural (arable) land parcels, divided by hedgerows.
- The Site slopes in a southerly direction and is underlain by clayey soils and geology with low infiltration potential.
- A watercourse conveys flow north-west along the south-west boundary.
- The risk of flooding is assessed as follows:
    - The risk of fluvial/tidal flooding is assessed as negligible within the northern extent of the Site, but medium to high within the southern extent. There is also a residual risk of flooding from onsite drains.
    - The risk of surface water flooding is assessed as negligible for most of the Site, with an area of low risk associated with ponded areas within the western extent.
    - The risk of flooding from sewers is assessed as negligible for most of the Site but low along the reach of the onsite public surface water sewer.
    - 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 (including surface water attenuation) outside the mapped extent of fluvial flooding.
    - Provide an easement free from development along either side of the onsite and bounding watercourses. This easement would provide access for inspection and maintenance purposes.
    - Undertake maintenance activities to keep the watercourses clear from debris and overgrown vegetation to maintain the conveyance of the channels.
    - Set finished floor levels above external levels.
    - Set the surface water outfall from the proposed development at an appropriate height above the bed level of the receiving watercourse or provide a swale outfall from the detention basin to mitigate the risk of the outfall surcharging.
    - Adoption of a surface water management strategy.
    - Provide a development free easement either side of onsite public surface water sewer assets, or re-direct around the Site boundary.
- The proposed residential development is classified as more vulnerable. More vulnerable uses are considered acceptable in terms of flood risk in Flood Zone 1. Subject to the implementation of the above mitigation measures, the Sequential Test would be passed, and the Exception Test would not be required.

The FRA has considered the potential impact of the development on surface water runoff rates, given the increase in impermeable areas post-development. 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 an appropriately sized detention basin with an outfall to the bounding watercourse.

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 west of Hempsted Lane, Gloucester (the 'Site').

1.1.2 The proposal is for up to 245 dwellings, public open space, landscaping, sustainable drainage system (SuDS) within the 12.22ha Site, with vehicular access point from Hempsted Lane. All matters reserved except for means of access.

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 FRA[1] 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 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 development would remain safe throughout its lifetime, that the development would not

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

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 change[4] 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 policies within the Gloucester, Cheltenham and Tewkesbury Joint Core Strategy 2011-2031 Council Local Plan:

- Policy SD3: Sustainable Design and Construction - All development will be expected to be adaptable to climate change in respect of the design, layout, siting, orientation and function of both buildings and associated external spaces. Proposals must demonstrate that development is designed to use water efficiently, will not adversely affect water quality, and will not hinder the ability of a water body to meet the requirements of the Water Framework Directive.
- Policy INF2: Flood Risk Management - Development proposals must avoid areas at risk of flooding, in accordance with a risk-based sequential approach. Proposals must not increase the level of risk to the safety of occupiers of a site, the local community or the wider environment either on the site or elsewhere. For sites of a strategic scale, the cumulative impact of the proposed development on flood risk in relation to existing settlements, communities or allocated sites must be assessed and effectively mitigated.

Report Structure

1.4.3 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 179: Gloucester, Cheltenham & Stroud).
- Detailed topographic survey (Appendix 1).
- Environment Agency online mapping (Flood Map for Planning[5], Long Term Flood Risk Assessment for Locations in England[6], Catchment Data Explorer[7] and Main River Map[8]).
- River Basin District (RBD) Maps[9] (Severn RBD) together with guidance on climate change allowances[10].
- National River Flow Archive[11].
- Gloucestershire County Council Strategic Flood Risk Assessment (SFRA) and associated mapping[12] (Appendix 2).
- Gloucester, Cheltenham and Tewkesbury Joint Core Strategy 2011-2031.
- British Hydrological Society Chronology of British Hydrological Events[13].
- National Soils Resources Institute (NSRI): Soilscapes online mapping[14].
- British Geological Survey [BGS] online mapping: Geology of Britain Viewer[15].
- Landmark's Promap: Flood Data package: Additional flood mapping.
- Geosmart 1 in 100-year groundwater flood risk map.
- Severn Trent Water sewer asset plans (Appendix 3).
- DEFRA's Magic Map[16] 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.gloucestershire.gov.uk/planning-and-environment/flood-risk-management/flood-planning-information/
[13] http://www.cbhe.hydrology.org.uk/search.php
[14] http://www.landis.org.uk/soilscapes/
[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 Advice[17] and the NPPF/PPG ID: 7 was consulted and reviewed.

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

Gloucestershire County Council

2.2.5 Gloucestershire 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.

2.2.6 Gloucestershire County Council as the LLFA was consulted on flood risk issues at this Site. Correspondence with the LLFA is included in Appendix 5.

Severn Trent Water

2.2.7 Drainage and sewerage services in the UK are provided by a number of water and sewerage companies. Severn Trent Water 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.

2.3 Site Walkover

2.3.1 Enzygo staff carried out a walkover of the Site during September 2019. Observations made were used to inform the Site description.

[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 west of Hempsted Lane, Gloucester, GL2 5DB.

3.1.2 The Site is centred on National Grid Reference (NGR) 381526, 216546.

3.1.3 The 12.22ha Site location is shown in Drawing 001 and in more detail in Drawing 002.

3.2 Land Use

3.2.1 The land use comprises three agricultural (arable) land parcels, divided by hedgerows (Figures 3.1 and 3.2).

3.2.2 The Site is bounded by Hempsted Lane with residential dwelling beyond to the north-east, A430 with a commercial development beyond to the south-east, an unnamed watercourse with agricultural land beyond to the south-west, Rea Lane with agricultural land beyond to the west, and residential dwelling to the north.

3.2.3 The Site is currently accessed via gated access off Hempsted and Rea Lane.

Figure 3.1: Photographs of the Site

View north across the Site from the south-east corner.

View east across the Site from the western boundary.

Figure 3.2: Aerial Photograph of the Site

Image © 2019 Digital Globe.

3.3 Topographic Information

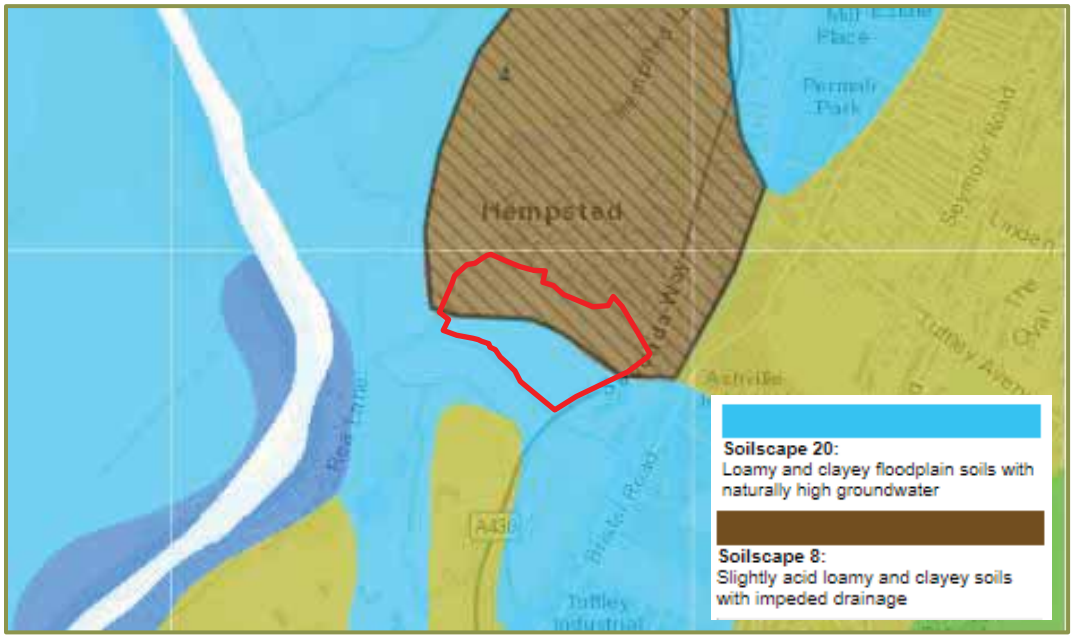
3.3.1 A detailed topographic survey was carried out during August 2019 and a copy is included as (Appendix 1). The Site falls in southerly direction from 25.84 metres Above Ordnance Datum (m AOD) along the northern boundary, to 8.41m AOD in the south-west corner. The fall of 17.43m over 300m gives a gradient of 1:17.

3.4 Soils and Geology

Soils Mapping

3.4.1 The Soilscapes online soils map viewer shows that the northern extent of the Site is underlain by loamy and clayey soils. The southern extent is underlain by loamy and clayey soils with high groundwater (Figure 3.3). The soils mapping is indicative and there may be localised variation in soil type.

Figure 3.3: Soils Mapping

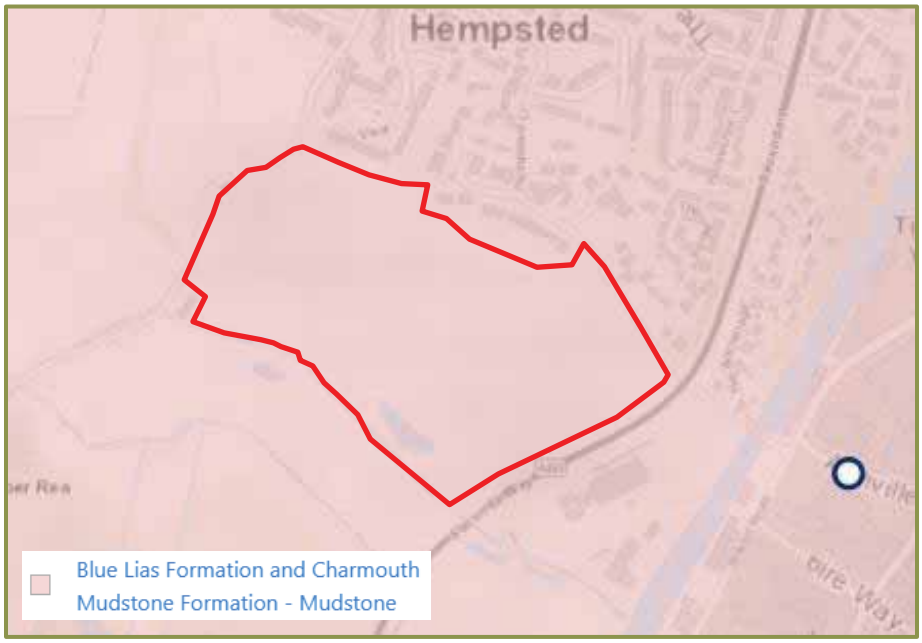


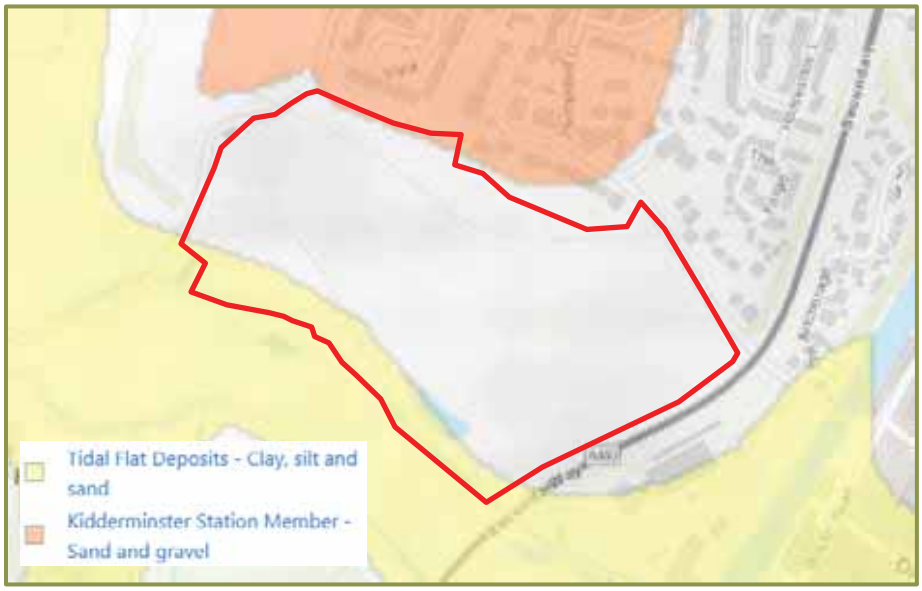
Soils Data © Cranfield University (NSRI) and for the Controller of HMSO [2019].

Geology Mapping

The Geology of Britain online map viewer (Figure 3.4) shows the bedrock beneath the Site is Blue Lias formation - mudstone. There are no superficial deposits beneath most of the Site. There are tidal flat deposits (Clay silt and sand) within the southernmost extent and Kidderminster Station member (Sand and gravel). The geology mapping is indicative and there may be localised variation in the superficial deposits.

Figure 3.4: Geology Mapping (continues over page)





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

BGS Borehole Logs

3.4.2 The Geology of Britain online map viewer shows there are no unrestricted historical boreholes located within the Site boundary or its immediate vicinity.

Soakaway Testing

3.4.3 Soakaway testing was undertaken during September 2019 and was undertaken in accordance with DG 365 'Soakaway Design' methodology guidance. A copy of the Soakaway Test Report is included in Appendix 6.

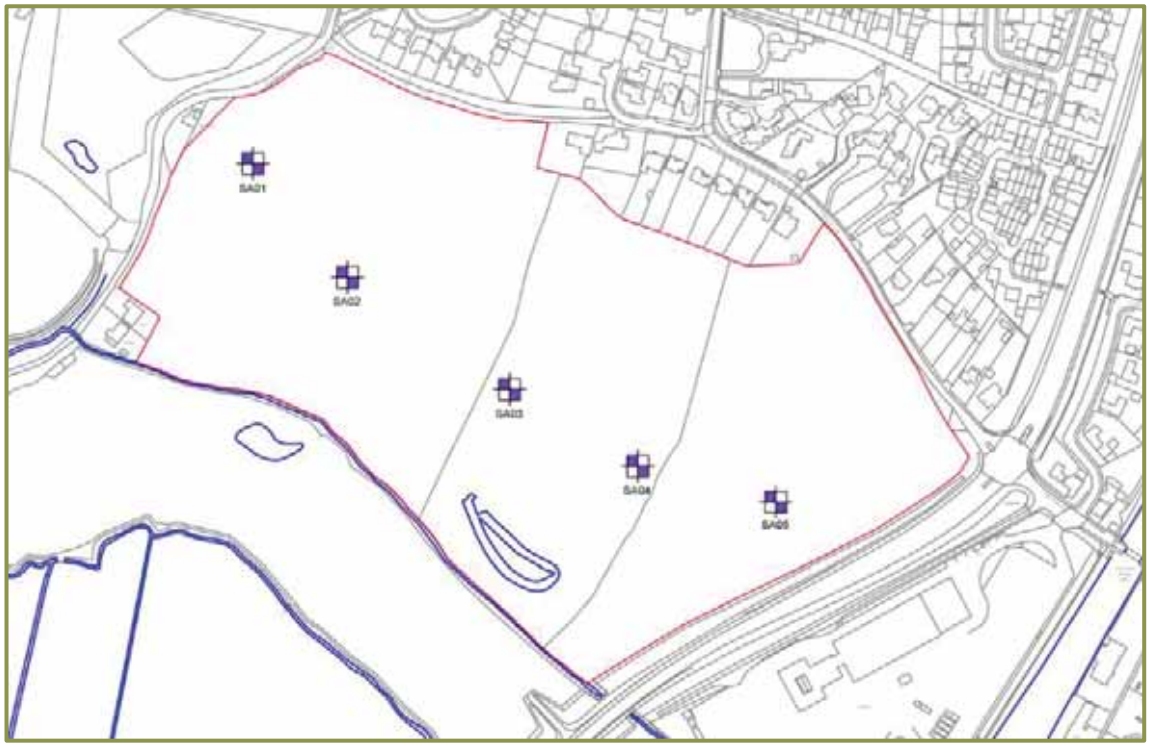
3.4.4 A total of five soakaway test pits were established through the southern extent of the Site (Figure 3.5). The positioning of the test pits was based around the flood risk constraints (i.e. sequential development of the Site, limiting built development outside the mapped extent of fluvial flooding [see Section 4 and 5]) and the proposed surface water drainage strategy (detention basin positioned at the topography low to achieve a gravity connection [see Section 6]).

3.4.5 The test pits were excavated to depths between 2.5m and 2.7m below existing ground level (mbgl). A summary of the trial pit logs is summarised in Table 3.1. The soakaway logs confirm the soils and geology as depicted by the soils and geology mapping, albeit trial pits were not positioned above the Tidal Flat Deposits or Kidderminster Station Member.

Table 3.1: Soakaway Log Summary

Strata	Summary Description	Depth (m bgl)
Made Ground (topsoil)	Brown slightly gravelly clayey sandy topsoil	0.00 - 0.40
Superficial	Firm orange brown clayey SILT	0.25 - 0.70
	Firm to stiff consistency orange brown mottled blue grey silty sandy gravelly CLAY	0.60 - 1.20
Bedrock	Firm to stiff consistency orange brown mottled blue grey laminated sandy gravelly CLAY	0.60 - 2.70
	Stiff consistency dark blue grey mottled orange brown laminated silty CLAY	1.30 - 2.50
Groundwater	Groundwater was not encountered	

Figure 3.5: Trial Pit Location Plan



3.5 Hydrogeology

Infiltration potential

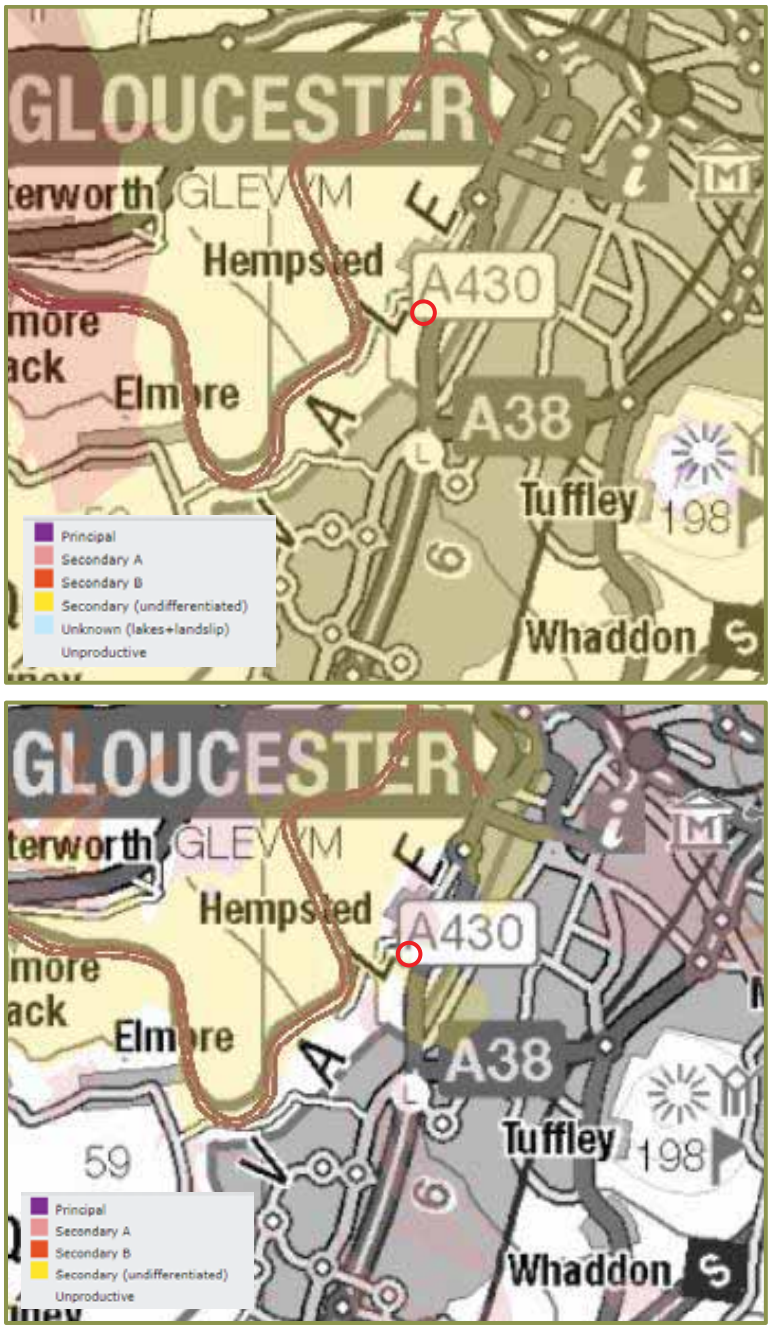
3.5.1 Soakaway testing (Appendix 6) demonstrated low infiltration potential. Groundwater ingress was not encountered in any of the soakaway trial pits.

Defra Magic Map

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

3.5.3 The Site is not located above a Principal Aquifer. The Site is however located above a Secondary Undifferentiated bedrock Aquifer (Figure 3.6).

Figure 3.6: Aquifer Designation Map



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

3.6 Catchment Hydrology

OS Mapping

i. River Severn

3.6.1 The fluvially dominated River Severn conveys flows south, approximately 365m to the west of the Site at its closest point. The River Severn is a 'main river', which is a watercourse where flood risk work is carried out by the Environment Agency.

ii. Hempsted Brook

3.6.2 An unnamed watercourse ('Hempsted Brook') conveys flows north-west, along the south-west boundary (Figure 3.7). Hempsted Brook is a tributary of the River Severn, with the confluence located approximately 375m to the south-west of the Site. OS Mapping identifies a sluice at the downstream reach of the unnamed watercourse, before it converges with the River Severn. Hempsted Brook is an 'ordinary watercourse', which is a watercourse where flood risk work is carried out by the local drainage authority/riparian landowner.

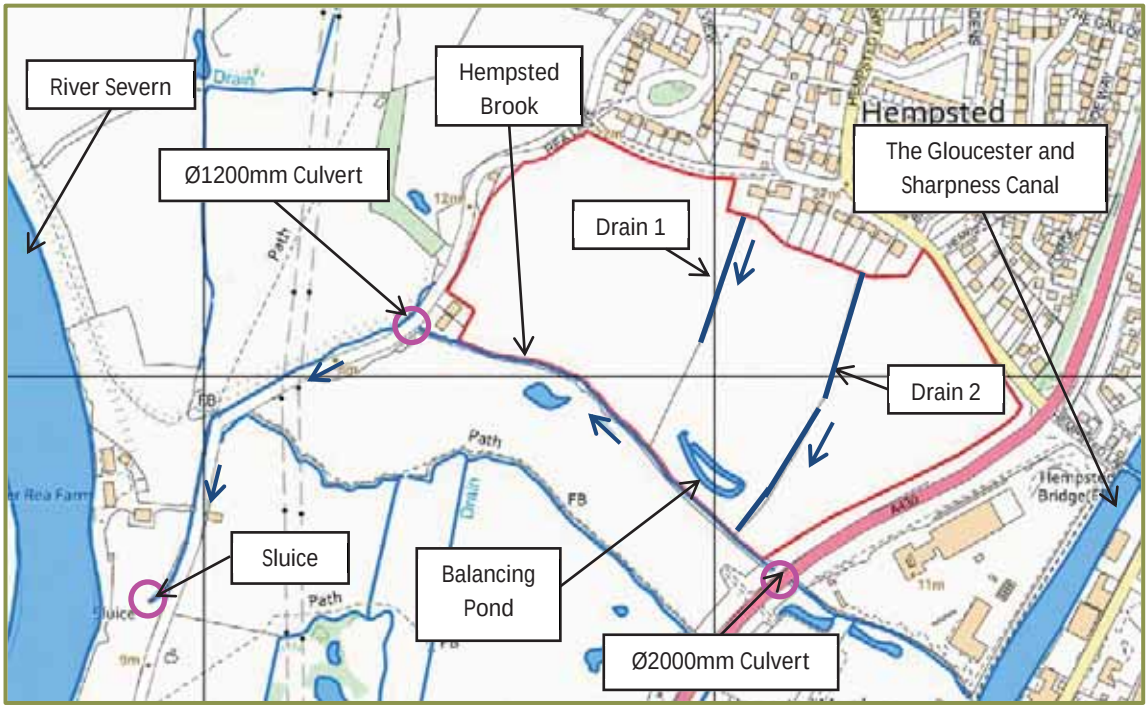
iii. River Severn

3.6.3 The Gloucester and Sharpness Canal is orientated north to south, approximately 120m to the east of the Site at its closest point. The canal is under the authority of the Canal and River Trust.

iv. Balancing Pond

3.6.4 There is a pond located within the southern extent of the Site, which is a Severn Trent Water offline balancing pond.

Figure 3.7: Map of Watercourses



Topographic Survey

i. Drains 1 and 2

3.6.5 The topographic survey (Appendix 1) identifies two drains ('Drain 1' and 'Drain 2') orientated north to south through the Site, along the field boundaries.

3.6.6 The bed levels of Drain 1 indicate that flow would be conveyed south. Mid-way through the Site boundary, the drain is shown to enter into a Ø150mm culvert inlet. The landowner confirmed that this ditch has been filled in at this point and does not have onward connectivity.

3.6.7 The bed levels of Drain 2 indicate that flow would be conveyed south, with an outfall to Hempsted Brook to the south.

ii. Balancing Pond

3.6.8 The topographic survey (Appendix 1) shows a Ø400mm and Ø225mm inlet/outlet from the public surface water sewer network, which conveys flows south-west through the eastern extent of the Site (Appendix 3).

Site Walkover Observations

i. Hempsted Brook

3.6.9 Hempsted Brook was observed to be conveying approximately 300mm depth of flow, north-west along the southern boundary.

3.6.10 The channel profile is approximately; 3m width (left to right bank), 1m bed width, 1m depth and 1:3 side slope. The channel was overgrown with vegetation, which is considered normal for the time of year when the walkover was undertaken (Figure 3.8)

3.6.11 The Hempsted Brook enters the Site at the south-east corner from an approximate Ø2000mm culvert from beneath the A430 to the east (Figure 3.9). The watercourse exists the Site at the western corner via a Ø1200m culvert beneath Rea Lane (Figure 3.10).

Figure 3.8: Hempsted Brook

Figure 3.9: Ø2000mm A430 Culvert Outfall

Figure 3.10: Ø1200m Rea Lane Culvert Inlet

ii. Drains 1 and 2

3.6.12 The channel profiles were approximately; 3m width (left to right bank), 1m bed width, 0.5m depth and 1:3 side slope. The ditches were overgrown with vegetation, which is considered normal for the time of year when the walkover was undertaken.

iii. Balancing Pond

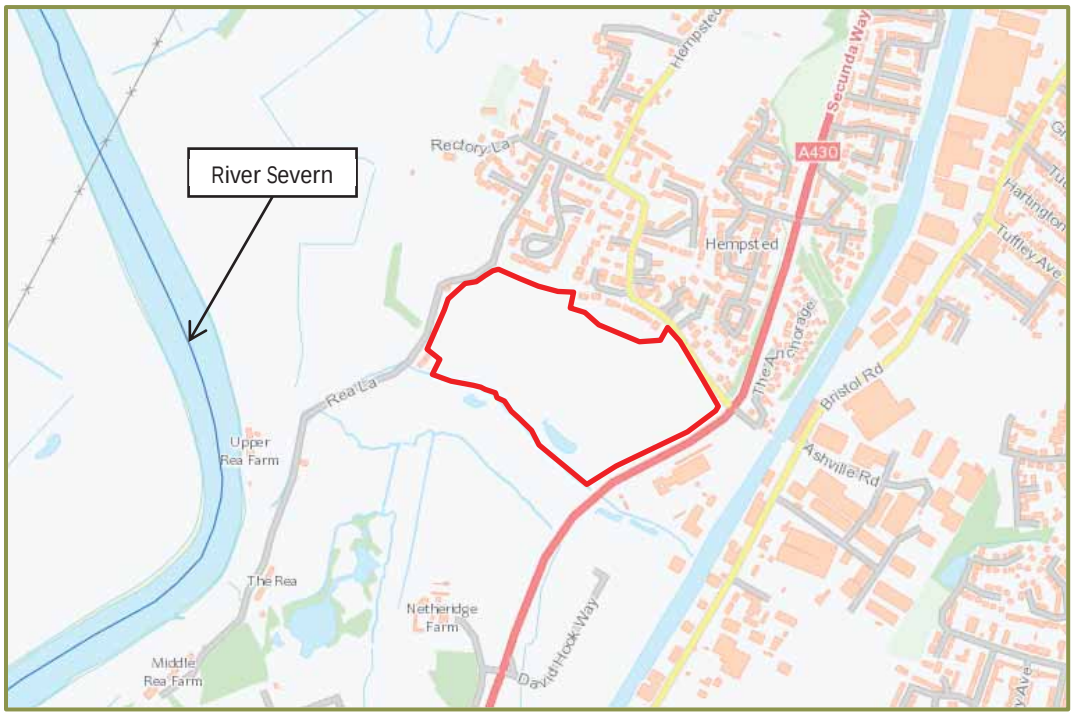
3.6.13 The onsite balancing pond was observed to wet and is not impounded. The balancing pond is assumed to serve the residential development to the north and is shown as being an offline feature on the Severn Trent Water Asset Plans (Appendix 3).

Figure 3.11: Balancing Pond

Main River Map

3.6.14 The Environment Agency online main river map (Figure 3.12) identifies the River Severn, which conveys flows south, approximately 375m to the -west of the Site at its closest point.

Figure 3.12: Main River Map

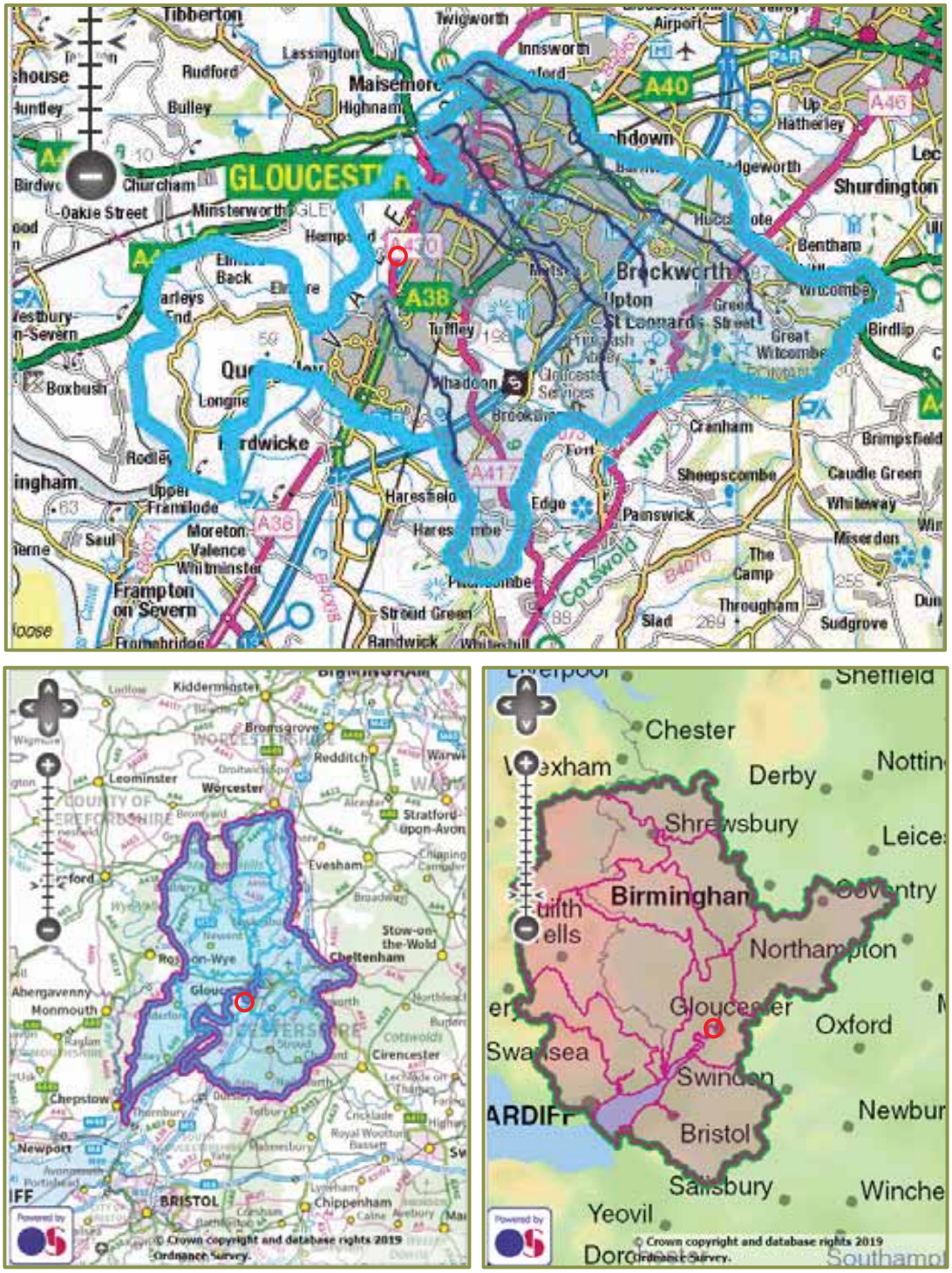


Contains Environment Agency information © Environment Agency and database right [2019].

Environment Agency Catchment Data Explorer Mapping

3.6.15 The Site resides within the Gloucester Trib Operational Catchment (Figure 3.13), which is within the Severn Vale Management Catchment and Severn River Basin District.

Figure 3.13: Catchment Data Explorer



Top: Gloucester Trib Operational Catchment. Bottom Left: Severn Vale Management Catchment. Bottom Right: Severn River Basin District. Contains Environment Agency information © Environment Agency and database right [2019].

3.7 Sewerage Assets

3.7.1 Severn Trent Water asset plans show that there is a public surface water sewer conveying flow south-west through the eastern extent of the Site, with an outfall to Hempsted Brook to the south of the onsite balancing pond (Figure 3.14).

Figure 3.14: Sewer Asset Plans

Contain Severn Trent Water information © Crown Copyright and database right [2019].

3.8 Designated Sites

3.8.1 The DEFRA Magic Map (England and Wales) shows there are no designated sites in or close to the Site including downstream (from a flood risk and drainage perspective).

4.0 Flood Risk Assessment

4.1 Potential Sources of Flooding

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

Table 4.1: Potential Risk Posed by Flooding Sources

Flooding Source	Potential Flood Risk at Application Site (Yes/No)	Potential Source	Data Sources
Fluvial	Yes	River Severn, Hempsted Brook and Drains 1 and 2.	Environment Agency flood mapping (Drawing 005), Modelled Flood Levels (Appendix 4), JBA Flooding from Rivers (Drawing 004.2) and SFRA mapping.
Tidal	Yes	River Severn.	Environment Agency flood mapping (Drawing 005), Modelled Flood Levels (Appendix 4), JBA Coastal Flooding (Drawing 004.3) and SFRA mapping.
Groundwater	Yes	Secondary Undifferentiated Aquifer (Bedrock).	BGS mapping (Drawing 003) and Geosmart Groundwater (Drawing 006).
Surface Water	Yes	Poor permeability and Site topography.	JBA Surface Water Flooding (Drawing 004.1) and Environment Agency Complex mapping (Drawings 010.1-010.4).
Sewer	Yes	Public surface water Sewer.	Severn Trent Water Asset plans (Appendix 3) and topographic survey (Appendix 1).
Infrastructure Failure	Yes	Balancing pond, canal and reservoir failure.	Environment Agency online flood mapping and OS mapping.

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 online flood map (Drawing 005) shows the northern and central extents of the Site are located within Flood Zone 1; which is land outside the 1 in 1000-year probability of fluvial (river) flooding (0.1% Annual Exceedance Probability [AEP]), at 'low' risk. The southern extent of the Site, adjacent to Hempsted Brook, is within Flood Zones 2 and 3. 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. Flood Zone 3 is land within the 1 in 100-year (>1% AEP) risk of fluvial flooding, at 'high' risk. The Environment Agency flood mapping does

not differentiate between Flood Zones 3a and 3b ('functional floodplain' - 5% AEP / 1 in 20-year event).

Modelled Flood Levels

4.2.3 The Environment Agency provided modelled levels for nodes along the River Severn, closest to the Site. The levels were taken from a 1D ISIS model (Tidal Severn model 2007) for the Severn Estuary. The correspondence states the watercourse is fluvially dominated in the vicinity of the Site. (Appendix 4).

4.2.4 The modelled flood levels were provided for a range of return periods and nodes for both fluvial and tidal events. Node MC128 was the nearest and most representative node for the Site (Figure 4.1). A summary of the modelled flood levels for node MC128 are included in Table 4.2.

Figure 4.1: Node Locations

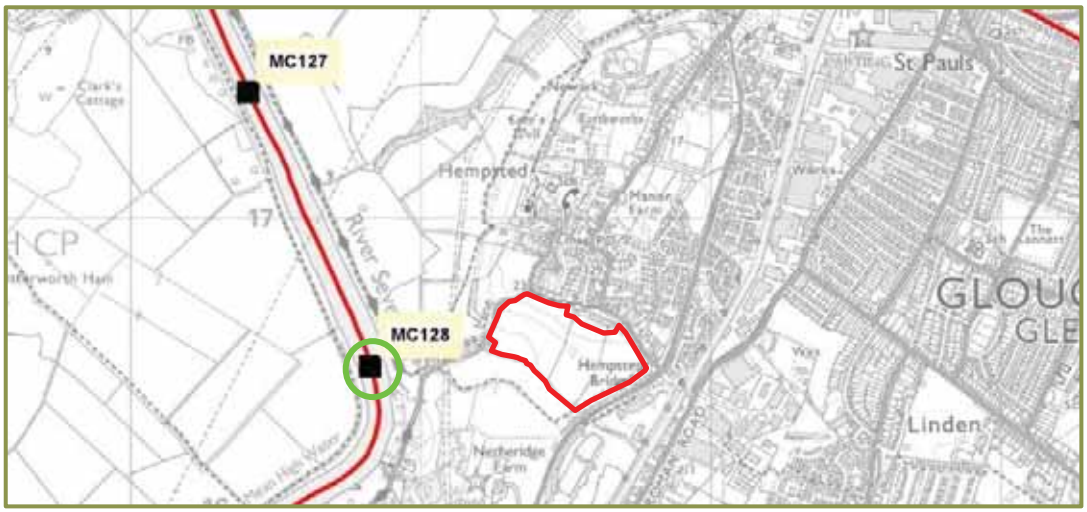


Table 4.2: Modelled Flood Levels

	Maximum Water Levels				
Node Label	**5yr fluvial, 75yr tidal**	**5yr fluvial, 100yr tidal**	**5yr fluvial, 200yr tidal**	**5yr fluvial, 200yr tidal (+20% climate change)**	**5yr fluvial, 1000yr tidal**
MC128	10.29	10.30	10.33	10.61	10.40

	Maximum Water Levels				
Node Label	**75yr fluvial, 2yr tidal**	**100yr fluvial, 2yr tidal**	**100yr fluvial, 2yr tidal (+20% climate change)**	**200yr fluvial, 2yr tidal**	**1000yr fluvial, 2yr tidal**
MC128	10.41	10.43	10.70	10.49	10.91

4.2.5 The Tidal Severn model 2007 does not include levels for updated climate change allowances for the Severn River Basin District (Higher Central 35%, Upper End 70%). As such, Enzygo Ltd undertook a model re-run exercise to obtain the revised climate change flood levels.

4.2.6 Enzygo Ltd have recently undertaken a modelling exercise for a nearby Site for Gladman Developments Ltd, to determine climate change flood levels. The modelling outputs are relevant to this Site.

4.2.7 Fluvial inputs to the 'Tidal Severn model 2007' are derived from the 'River Severn fluvial model'. As such, a re-run of the tidal model also required a re-run of the Severn fluvial model.

4.2.8 In order to update the primary fluvial inputs to the Severn Tidal model, output hydrographs were taken from the Severn fluvial model re-run. Fluvial inputs were amended for updated climate change scenarios (+35% and +70%CC) for the 1 in 100-year and 5-year fluvial events in order to maintain the joint probability as shown in Table 4.1. A 5-year fluvial event has been used to represent the fluvial input during extreme tidal events. No changes to the fluvial inputs were made for the 100-year and 1000-year fluvial (non-climate change) inputs, a methodology which has previously been agreed with the Environment Agency (Appendix 4).

4.2.9 The 1 in 100-year and 5-year climate change fluvial inflow hydrographs, in the Severn tidal model, were replaced with an output hydrograph from the Severn fluvial model re-run, representative of the updated climate change allowances. As a conservative approach, the tidal model was only updated to include fluvial inputs for the +70% climate change increase.

4.2.10 Peak flood levels and hydrographs for a range of flood events (both tidally and fluvially dominated) were extracted for Node MC 128 and are presented in Table 4.3 and Figure 4.2.

4.2.11 Modelled peak levels and hydrographs confirm the Environment Agency statement that flood levels are fluvially dominated at the MC 128 node location. A comparison of non-climate change modelled levels presented in Table 4.3 with supplied levels from the Environment Agency (Table 4.2) shows a very close match, therefore increasing confidence in the derived climate change flood levels (Table 4.2).

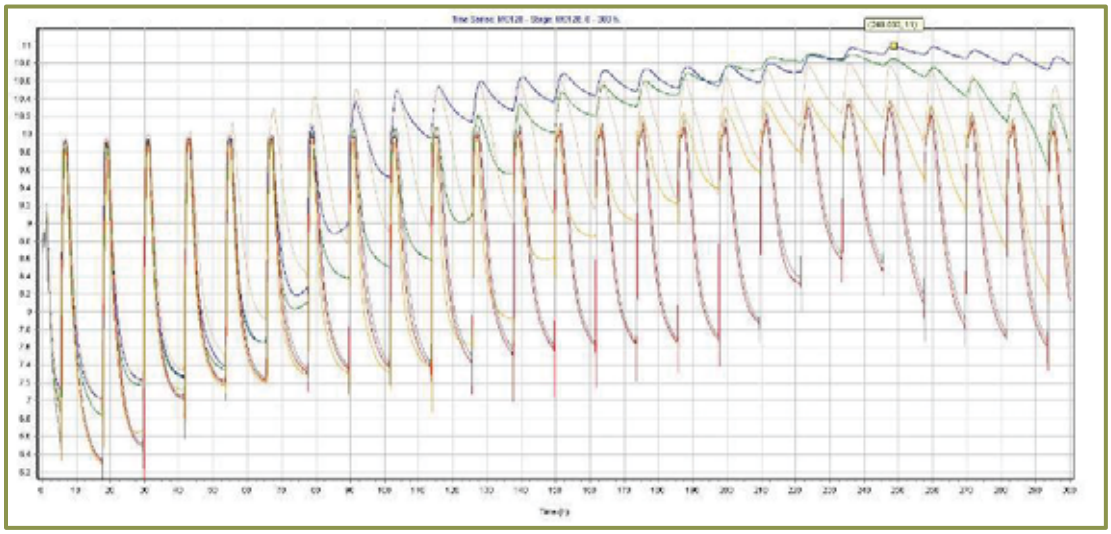
Table 4.2: Modelled Flood Levels

	Annual Exceedance Probability - Maximum Water Levels (m AOD)					
Node Label	**5yr fluvial, 1000yr tidal**	**5yr fluvial, 200yr tidal**	**1000yr fluvial, 2yr tidal**	**5yr fluvial, 200yr tidal (70%CC fluvial and sea level rise)**	**100yr fluvial, 2yr tidal**	**100yr fluvial, 2yr tidal (70%CC and sea level rise)**
MC128	10.40	10.34	10.91	10.80	10.40	11.00

4.2.12 Table 4.3 and Figure 4.2 show that peak flood levels for extreme fluvial events are greater than peak levels from extreme tidal events. Table 4.3 shows that when a +70% climate change allowance is applied to the fluvial 1 in 100-year event, the peak flood level is 11.00mAOD, which is 0.09m (90mm) higher than the 1 in 1000-year present day level (10.91mAOD). The 1 in 100-year (+70% climate change) modelling level therefore represents the greatest fluvial flood risk to the Site during the proposed lifetime of development.

4.2.13 The modelled flood level of 11.00 mAOD (representing the 100yr fluvial, 2yr tidal (70%CC and sea level rise event) was contoured and mapped against the topographic survey (Appendix 1) to produce a flood outline within the Site (Figure 4.3).

Figure 4.2: Modelled Hydrographs for all Scenarios at Node MC128



Blue: 1 in 100-year fluvial +2-year tide (70%CC fluvial and sea level rise). Orange: 1 in 100-year fluvial +2-year tide. Brown: 1 in 5-year fluvial and 200-year tide (70%CC fluvial and sea level rise). Green: 1 in 1000-year fluvial and 2-year tide. Red: 5-year fluvial and 200-year tide. Grey: 5-year fluvial and 1000-year tide.

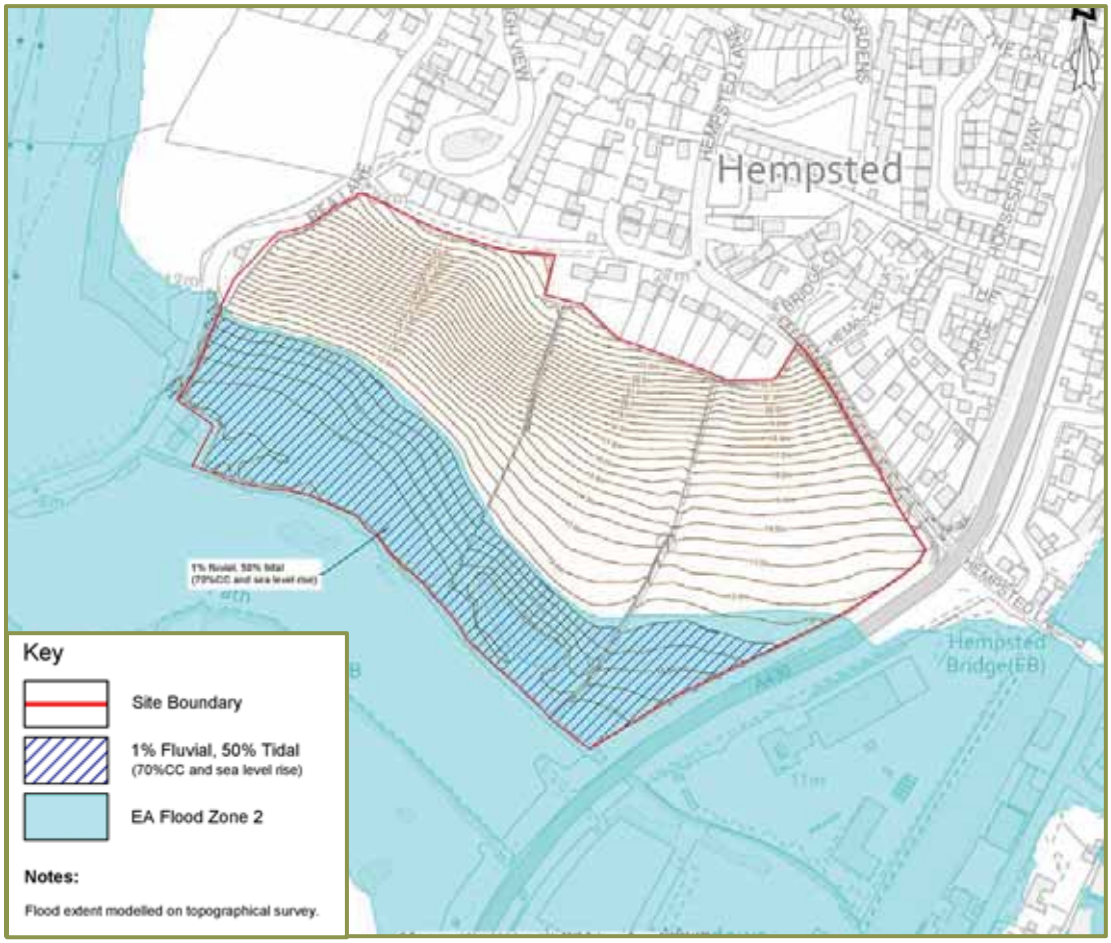
4.2.14 When the 11.00mAOD flood outline is compared to Environment Agency Flood Zone 2, it has a lesser extent (Figure 4.3). This is despite the 1 in 100-year +70%CC event being 0.09m higher than the 1 in 1000-year fluvial event, which is representative of Flood Zone 2. As such, Flood Zone 2, as shown in Figure 4.3, is representative of a flood level greater than the 1 in 100-year +70%CC flood event.

4.2.15 Where significant historical flood events have occurred, the outlines are often used in place of model results to inform Flood Zone 2. It is assumed that Flood Zone 2 within the Site is a composite outline representing the 1/2/1947 and 5/12/2000 to 20/12/2000 historical flood events (Drawing 009.1 and 009.2).

4.2.16 Whilst the 1 in 100-year +70%CC event model re-run provides the greatest flood level, the Environment Agency Flood Zone 2 has a greater flood outline (Figure 4.3). As a conservative approach, the Environment Agency Flood Zone 2 flood outline has been carried forward within this FRA.

4.2.17 It is assumed that Hempsted Brook along the southern boundary of the Site has not been modelled. The fluvial flood risk from this watercourse is likely to be represented by surface water flood mapping (Drawing 010.1), which shows floodwater being largely contained within channel. The fluvial flood risk on Site would be dominated by the River Severn backing up along the unnamed watercourse. Therefore, fluvial flood risk from the unnamed watercourse will be secondary to that described for the River Severn.

Figure 4.3: Modelled Flood Outline Vs Environment Agency Flood Zone 2



JBA Flooding from Rivers

4.2.18 The JBA mapping (Drawing 004.2) shows that the northern and central extents of the Site are located outside the mapped extent of fluvial flooding. The southern extent of the Site, adjacent to Hempsted Brook, is within the mapped extent of fluvial flooding associated with the 1 in 20-year, 75-yar, 100-year, 200-year and 1000-year events.

SFRA Mapping

4.2.19 SFRA mapping (Appendix 2) shows that the northern and central extents of the Site are located outside the mapped extent of fluvial flooding. The southern extent of the Site, adjacent to Hempsted Brook, is within the mapped extent of Flood Zones 2, 3a, 3a+CC and 3b.

Flood History

4.2.20 The SFRA mapping and Drawings 009.1-009.2 shows there have been historic fluvial flood events which have inundated the southern extent of the Site during the February 1990 and December 2000 flood events.

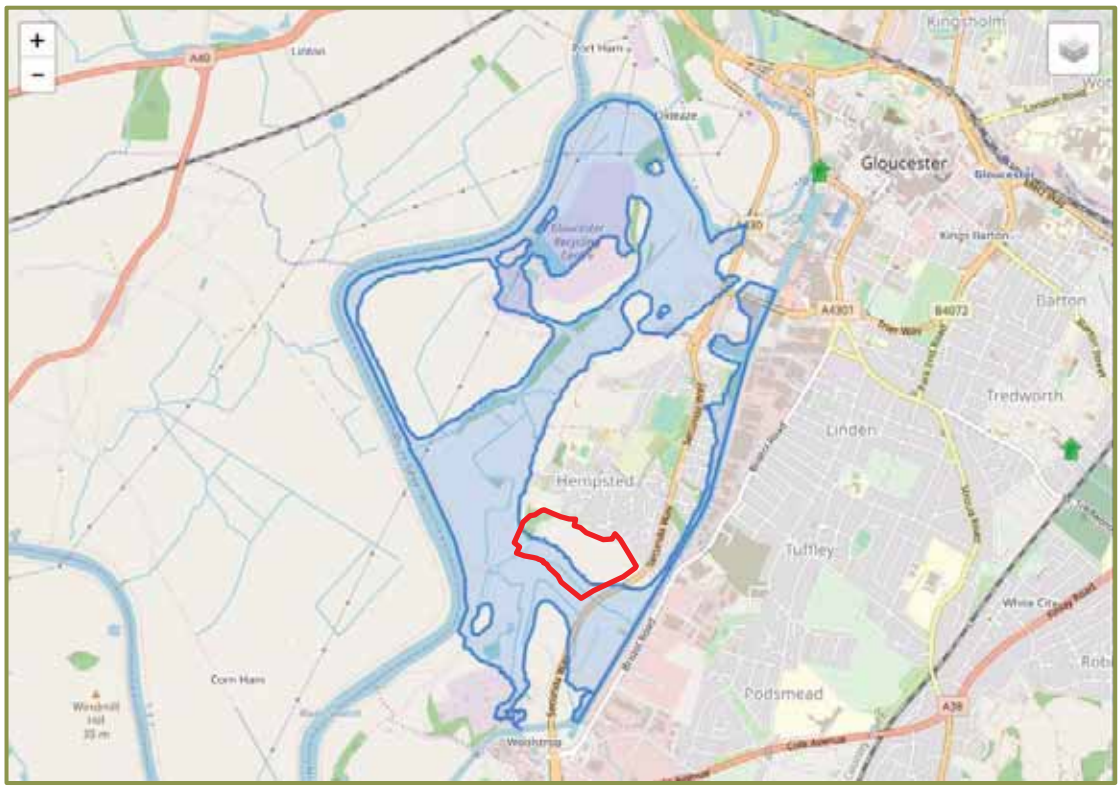
Flood Defences

4.2.21 Environment Agency online flood mapping shows that the Site does not benefit from flood defences.

Flood Warning Service

4.2.22 River Levels UK mapping shows the Site is located within an area which receives flood warnings. The southern extent of the Site is within the mapped coverage from the '*River Severn at Hempsted flood warning area'*.

Figure 4.4: Flood Warning Areas



Flood Risk Summary

4.2.23 Drains 1 and 2 are orientated north to south through the Site, with outfalls to Hempsted Brook.

4.2.24 The risk of fluvial flooding is assessed as negligible within the northern extent of the Site, but medium to high within the southern extent. There is also a residual risk of flooding from onsite drains.

4.2.25 Mitigation measures against fluvial flooding are discussed in Section 5.

4.3 Tidal Flooding

4.3.1 The risk of tidal flooding is moderate to high in the south of the Site from the River Severn.

4.3.2 Although the River Seven is tidal in this location, correspondence with the Environment Agency and modelled flood levels (Figure 4.2) confirm that flooding is fluvially dominated. Therefore, any tidal flood risk would be mitigated by the fluvial flood risk mitigation measures.

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 most of the Site is located outside the mapped extent of groundwater flooding.

4.4.2 There is a negligible area along the northern boundary where there is limited potential for groundwater flooding to occur. The risk of flooding is likely to be associated with the underlying Kidderminster Station member (Sand and gravel) superficial deposits. The superficial deposits are overlain by loamy and clayey soils; therefore, it is unlikely that groundwater would rise to the surface.

4.4.3 The BGS mapping is coarse and should be superseded by the Geosmart groundwater flood risk map.

Geosmart Groundwater Flood Risk Map

4.4.4 The Geosmart 1 in 100-year groundwater flood risk map (Drawing 006) shows that the Site is at negligible risk of groundwater flooding and falls within Risk Class 4 (Table 4.4).

4.4.5 Mapped classes combine understanding of likelihood, model and data uncertainty, and possible severity. Likelihood is ranked according to whether we expect groundwater flooding at a site due to extreme elevated groundwater levels with an annual probability of occurrence greater than 1%, considering model and data uncertainty. Severity relates to expectations of the amount of property damage or other harm that groundwater flooding at that location might cause (Table 4.4).

Table 4.4: 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.

Risk Class	Probability of Groundwater Flooding	Effect
2: Moderate	Annual probability greater than 1%.	Significant possibility of damage to property or harm to other sensitive receptors at or near this location. flooding is likely to be in the form of shallow pools or streams. Surface water flooding and failure of drainage systems may be worsened when groundwater levels are high.
1: High	Annual probability greater than 1%.	Groundwater flooding will occur which could lead to damage to property or harm to other sensitive receptors at or near this location. Flooding may result in damage to property, road or rail closures and, in exceptional cases, may pose a risk to life. Surface water flooding and failure of drainage systems may be worsened when groundwater levels are high.

Flood Risk

4.4.6 The risk of groundwater flooding is assessed as negligible.

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 that most of the Site is located outside the mapped extent of surface water flooding.

4.5.3 There is a surface water flow pathway orientated south-east to north-west along the reach of Hempsted Brook. The surface water flooding is associated with the 1 in 75-year, 200-year and 1000-year events and is likely to be representative of fluvial flooding. The flow pathway is mostly confined to channel along its reach but appears to back-up at the downstream (western) extent of the Site. It is likely that the flood mapping does not take into consideration the conveyance capacity of the Ø1200mm culvert beneath Rea Lane.

4.5.4 There is an area of ponding associated with the balancing pond in the southern extent of the Site. The surface water flooding is associated with the 1 in 75-year, 200-year and 1000-year events.

4.5.5 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

4.5.6 The Environment Agency Complex Surface Water Flood Mapping (Drawings 010.1 to 010.4) shows that most of the Site is located outside the mapped extent of surface water flooding.

4.5.7 There is a surface water flow pathway orientated south-east to north-west along the reach of Hempsted Brook. The surface water flooding is associated with the 1 in 30-year, 100-year and 1000-year events. The flow pathway is mostly confined to channel along its reach. The pathway has a depth up to 1.20m, a velocity of up to 02.0m/s and a hazard rating up to 'significant' (1.25-2.00). The flow pathway is likely to be representative of fluvial flooding and will be mitigated through the fluvial mitigation measures.

4.5.8 There is an area of ponding associated with the balancing pond in the southern extent of the Site. The ponding is associated with the 1 in 30-year, 100-year and 1000-year events. The ponded area has a depth up to 0.60m, velocity up to 0.50m/s and a hazard rating up to 'significant' (1.25-2.00). The balancing pond is managed by Severn Trent Water; therefore, the risk of flooding is mitigated through inspection and maintenance.

4.5.9 There are small areas of ponding within the western extent of the Site. The ponding is associated with the 1 in 1000-year events, t\he ponded area has a depth up to 0.30m, velocity up to 0.25m/s and a hazard rating up to 'low' (0.50-0.75). The risk of surface water ponding is likely to be associated with topographic low points.

Flood Risk Summary

4.5.10 The risk of surface water flooding is assessed as negligible for most of the Site, with an area of low risk associated with ponded areas within the western extent.

4.5.11 Mitigation measures against 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 Adoption[18] 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).

COMMERCIALDW Drainage and Water Enquiry

4.6.3 There is a public surface water sewer conveying flow south-west through the eastern extent of the Site, with an outfall to Hempsted Brook to the south of the onsite balancing pond. From a review COMMERCIALDW Drainage and Water Enquiry (Appendix 3), there are no recorded sewer flooding incidents located within the Site boundary.

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

Flood Risk Summary

4.6.4 The risk of flooding from sewers is assessed as negligible for most of the Site but low along the reach of the onsite public surface water sewer.

4.6.5 Mitigation measures against sewer flooding is discussed in section 5.

4.7 Flooding from Infrastructure Failure

Balancing Pond

4.7.1 There is a balancing pond located within the southern extent of the Site. The pond is not impounded and is maintained by Severn Trent Water. The risk of flooding from pond failure is assessed as negligible.

Canal

4.7.2 The Gloucester and Sharpness Canal is orientated north to south, approximately 120m to the east of the Site. Utilising LiDAR data it was found the canal is approximately 3m lower than the level of the Site. Therefore, the risk of flooding from canal failure is assessed as negligible.

Reservoir

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

5.0 Flood Risk Mitigation Measures

5.1 Introduction

5.1.1 The following sources of flooding were identified:

- Fluvial/tidal flooding (River Severn backing-up along Hempsted Brook and residual flooding from Drains 1 and 2).
- Surface water flooding (surface water ponding in the western extent)
- Sewer Flooding (public surface eater sewer within the eastern extent).

5.2 Mitigation Measures

Fluvial/Tidal Flooding

- Sequentially develop the Site, limiting the built development (including surface water attenuation) outside the mapped extent of fluvial flooding.
- Provide a 4m easement free from development along either side of the onsite and bounding watercourses. This easement would provide access for inspection and maintenance purposes, including vehicle access.
- Undertake maintenance activities to keep the watercourses clear from debris and overgrown vegetation to maintain the conveyance of the channels.
- Set finished floor levels a minimum of +150mm above external levels.
- Set the surface water outfall from the proposed development at an appropriate height (i.e. above the 1 in 100-year + 70% CC modelled flood level [11.0m AOD]) or provide a swale outfall from the detention basin to mitigate the risk of the outfall surcharging.

Surface Water Flooding

- Adoption of a surface water management strategy.
- Set finished floor levels as per above.

Sewer Flooding

- Provide a development free easement (3m either side) of onsite public surface water sewer assets, or re-direct around the Site boundary.

5.3 Summary of Flood Risk

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

Table 5.1: Probability and Consequences of All Sources of Flooding

Flooding Source	Potential Source	Probability	Consequence & Impact Without Mitigation	Consequence & Impact with Mitigation
Fluvial	River Severn, Hempsted Brook and Drains 1 and 2.	Negligible within the northern and middle extents but high within the southern extent.	Negligible within the northern and middle extents but high within the southern extent.	Low
Tidal	River Severn.	Negligible within the northern and middle extents but high within the southern extent.	Negligible within the northern and middle extents but high within the southern extent.	Low
Groundwater	Secondary Undifferentiated Aquifer (Bedrock).	Negligible	Negligible	Negligible
Surface Water	Poor permeability and Site topography.	Negligible for most of the Site, low for surface water ponding in the western extent.	Negligible for most of the Site, low for surface water ponding in the western extent.	Negligible
Sewer	Public surface water Sewer.	Negligible for most of the Site but low for the reach along the surface water sewer within the eastern extent.	Negligible for most of the Site but low for the reach along the surface water sewer within the eastern extent.	Negligible
Infrastructure Failure	Balancing pond, canal and reservoir failure.	Negligible	Negligible	Negligible

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

5.4 Flood Guidance and Sequential Test

5.4.1 The proposal is for a residential development. Table 2 of PPG ID: 7 (not included in this report) classifies the proposed use as 'more vulnerable'. More vulnerable uses are considered acceptable in terms of flood risk in Flood Zone 1. Subject to the implementation of the above mitigation measures, the Sequential Test would be passed, and the Exception Test would not be required.

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 12.22ha Site is comprised of three agricultural (arable) land parcels, divided by hedgerows.

6.2.2 The Site is underlain by soils and geology with low infiltration potential. It is likely that drainage is predominantly via overland flow, following the topography of the Site to the topographic low points (Hempsted Brook), with a small amount of infiltration to bedrock, and throughflow to watercourse.

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 The proposal is for residential development. An allowance of 55% impermeable area (inclusive of 10% for urban creep) was applied to the 6.4ha developable area. The existing and proposed impermeable areas are shown in Table 6.1. The proposed development will increase the impermeable surfaces and so increase the amount of runoff.

Table 6.1: Impermeable Area

Area	Existing Buildings and Hardstanding	Proposed Buildings and Hardstanding	Difference
Area (ha)	0.00	3.52	+3.52
Percentage of Total Site Area (%)	0	28.8	+28.8

6.4 Greenfield Runoff Rates

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

6.4.2 The runoff rates were calculated using HR Wallingford software utilising the FEH method.

6.4.3 The following parameters were used in the runoff calculations:

- Developable Area: 6.3ha.
- Average Annual Rainfall (SAAR): 655mm/year;
- BFIHOST: 0.4860
- Region No.: 4

6.4.4 Table 6.2 shows the calculated greenfield runoff rates. Drainage Calculations are included in Appendix 7.

Table 6.2: Greenfield Runoff Rates

Annual Probability (Return Period, years)	Greenfield Runoff (l/s)
QBAR	17.3
100% (1)	14.5
3.33% (30)	34.4
1% (100)	44.4
1% Plus Climate Change	65.9

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.*

6.4.5 The LLFA stated in their correspondence that discharge rates equivalent to QBAR greenfield or equivalent would be acceptable. Therefore, the QBAR runoff rate has been utilised to inform the drainage calculations in the remainder of the report.

6.5 Sustainable Drainage Options (SuDS)

Feasibility of SuDS

6.5.1 Soakaway testing was undertaken during September 2019. A copy of the Infiltration Test Report is included in Appendix 6. Findings show that infiltration-based SuDS would not feasible due to low infiltration.

Choice of SuDS Options

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

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

Table 6.3: SuDS Options

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

Note: *SuDS appropriate to the development are highlighted green.*

6.5.4 A hierarchy of SuDS techniques is identified[19]:

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

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

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

SuDS Maintenance

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

6.5.7 Maintenance of the SuDS features would be in line with the SuDS Manual (CIRIA C753, 2015), as detailed in Figure 6.1. The maintenance would be undertaken by a private maintenance company.

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

6.5.8 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.

6.5.9 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 6.1: 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 2000[20] 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:** Hempsted Brook conveys flow north-west along the south-west boundary.
3. **A sewer:** There is a public surface water sewer conveying flow south-west through the eastern extent of the Site, with an outfall to Hempsted Brook.

6.6.2 The potential route to discharge from the existing Site will be by outfall to Hempsted 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 an onsite detention basin, positioned to achieve a gravity fed connection to the Hempsted Brook.

6.6.6 An indicative drainage layout is 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: 3.52ha;
- Cv (proportion of rainfall forming surface water runoff): 75% summer, 84% winter;
- Infiltration losses: 0.00m/hour;
- With outfall at QBAR (Table 6.2).
- The attenuation volume for the 1 in 100-year event (plus climate change) is 3,762m^3.

6.6.9 Drainage calculations are included in Appendix 7. The calculated runoff rates and attenuation volumes will be reviewed at detailed design stage.

[20] Office of the Deputy Prime Minister, The Building Regulations 2000.

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 QBAR 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) towards the unnamed watercourse, 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.

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 12.22ha Site on land west of Hempsted Lane, Gloucester.

7.2 Flood Risk

7.2.1 The risk of fluvial/tidal flooding is assessed as negligible within the northern extent of the Site, but medium to high within the southern extent. There is also a residual risk of flooding from onsite drains.

7.2.2 The risk of surface water flooding is assessed as negligible for most of the Site, with an area of low risk associated with ponded areas within the western extent.

7.2.3 The risk of flooding from sewers is assessed as negligible for most of the Site but low along the reach of the onsite public surface water sewer.

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 (including surface water attenuation) outside the mapped extent of fluvial flooding.
- Provide an easement free from development along either side of the onsite and bounding watercourses. This easement would provide access for inspection and maintenance purposes.
- Undertake maintenance activities to keep the watercourses clear from debris and overgrown vegetation to maintain the conveyance of the channels.
- Set finished floor levels above external levels.
- Set the surface water outfall from the proposed development at an appropriate height above the bed level of the receiving watercourse or provide a swale outfall from the detention basin to mitigate the risk of the outfall surcharging.
- Adoption of a surface water management strategy.
- Provide a development free easement either side of onsite public surface water sewer assets, or re-direct around the Site boundary.

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 Zone 1. Subject to the implementation of the above mitigation measures, the Sequential Test would be passed, and the Exception Test would not be required.

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 a detention basin designed to maintain runoff at pre-development rates, with an outfall to the watercourse.

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.

DRAWINGS

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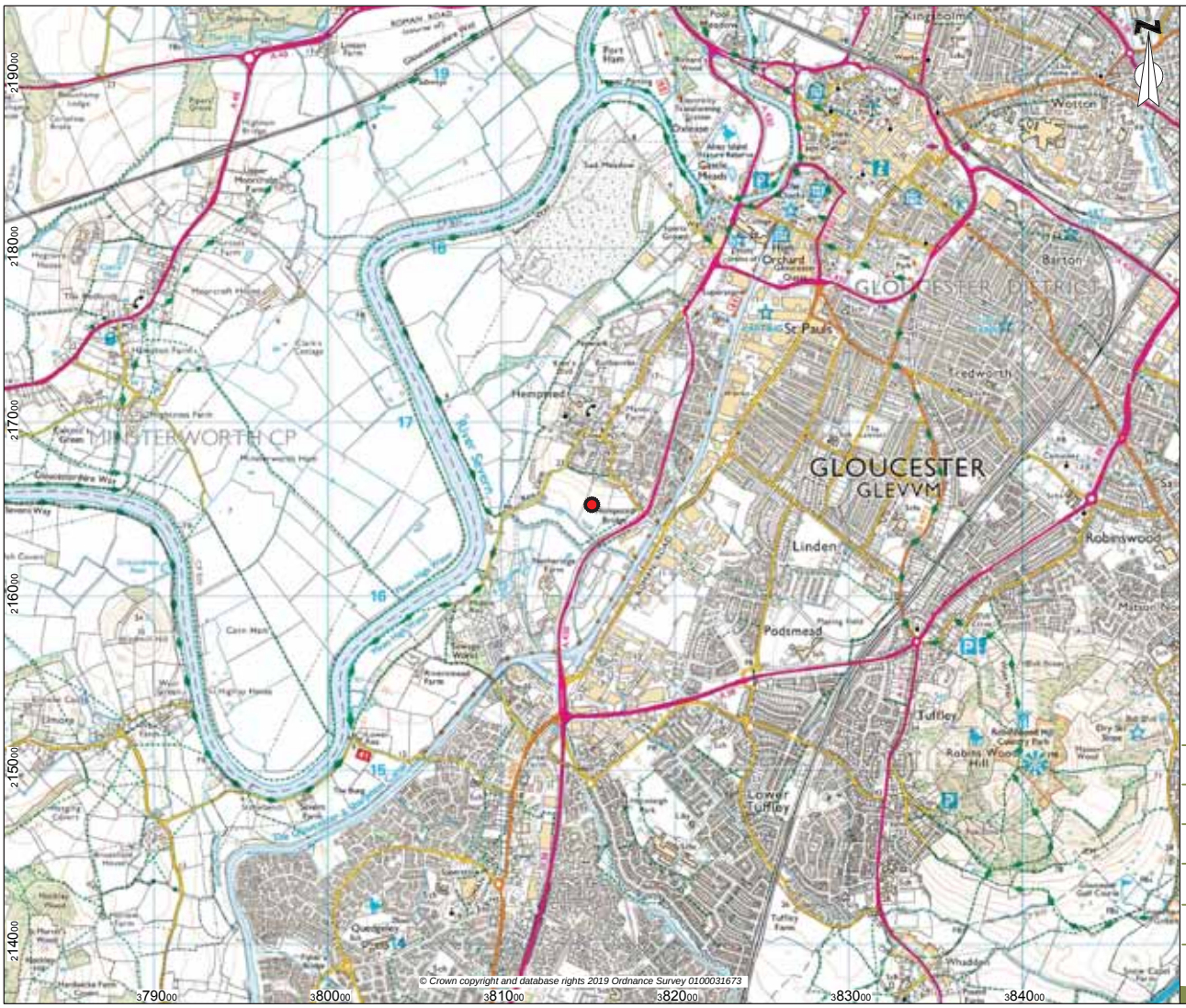


Key

Site Location
(SO 8152 1653)

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

CLIENT:
Glad□an Develop□ents Ltd

SCALE:
1:20,000□ A3

PRO□ECT REF:
CRM.1132.021

DRAWN:
MG

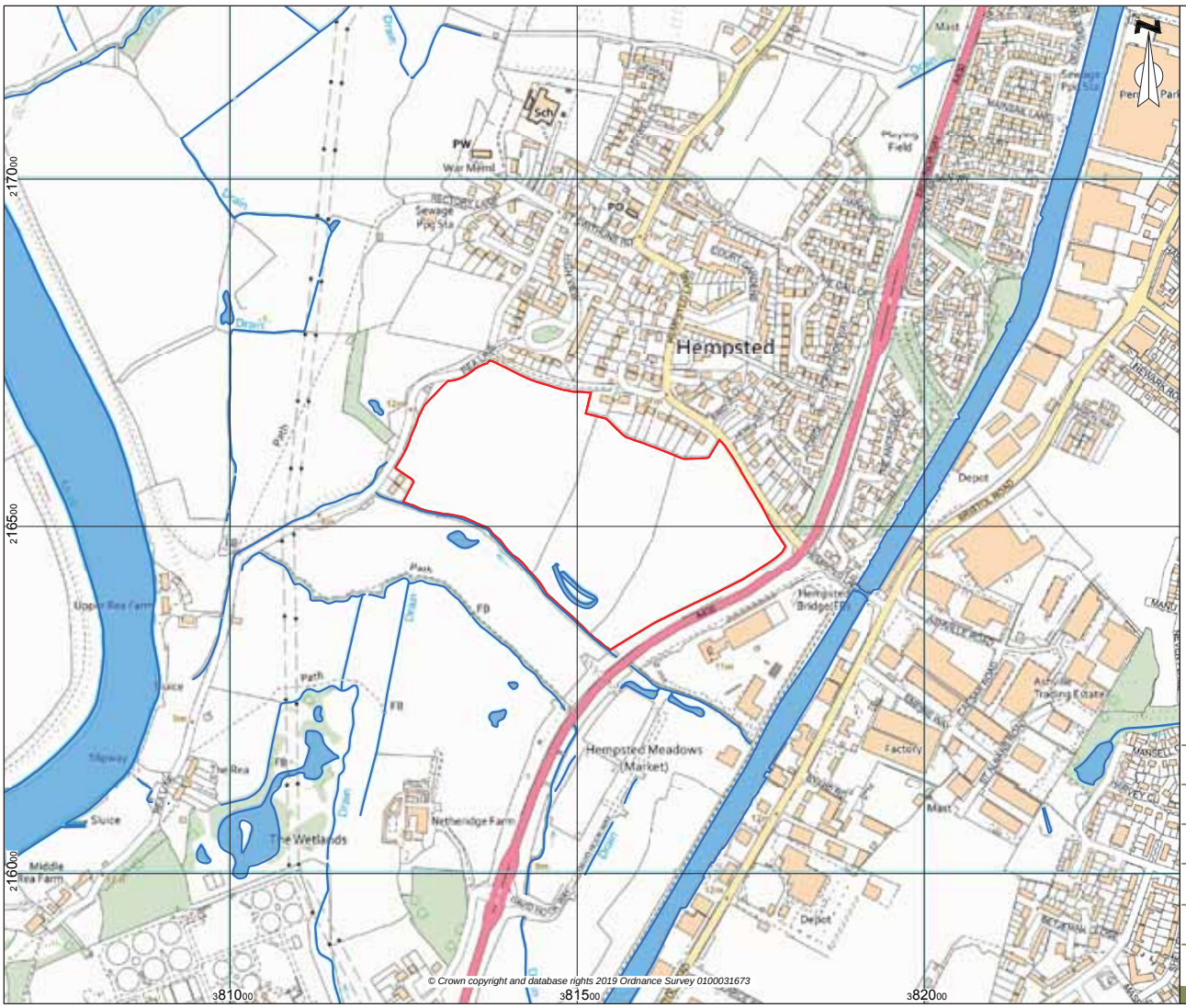
CHECKED:
EO□C

DATE:
Sept 2019

PRO□ECT:
He□psted Lane, Gloucester

TITLE:
Site Location Plan

DRAWING NO:
CRM.1132.021.HY.D.001



Key

Site Boundary

Surface Water Features

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

CLIENT: Gladman Developments Ltd

SCALE: 1:5,000 @ A3

PROJECT REF: CRM.1132.021

DRAWN: MG

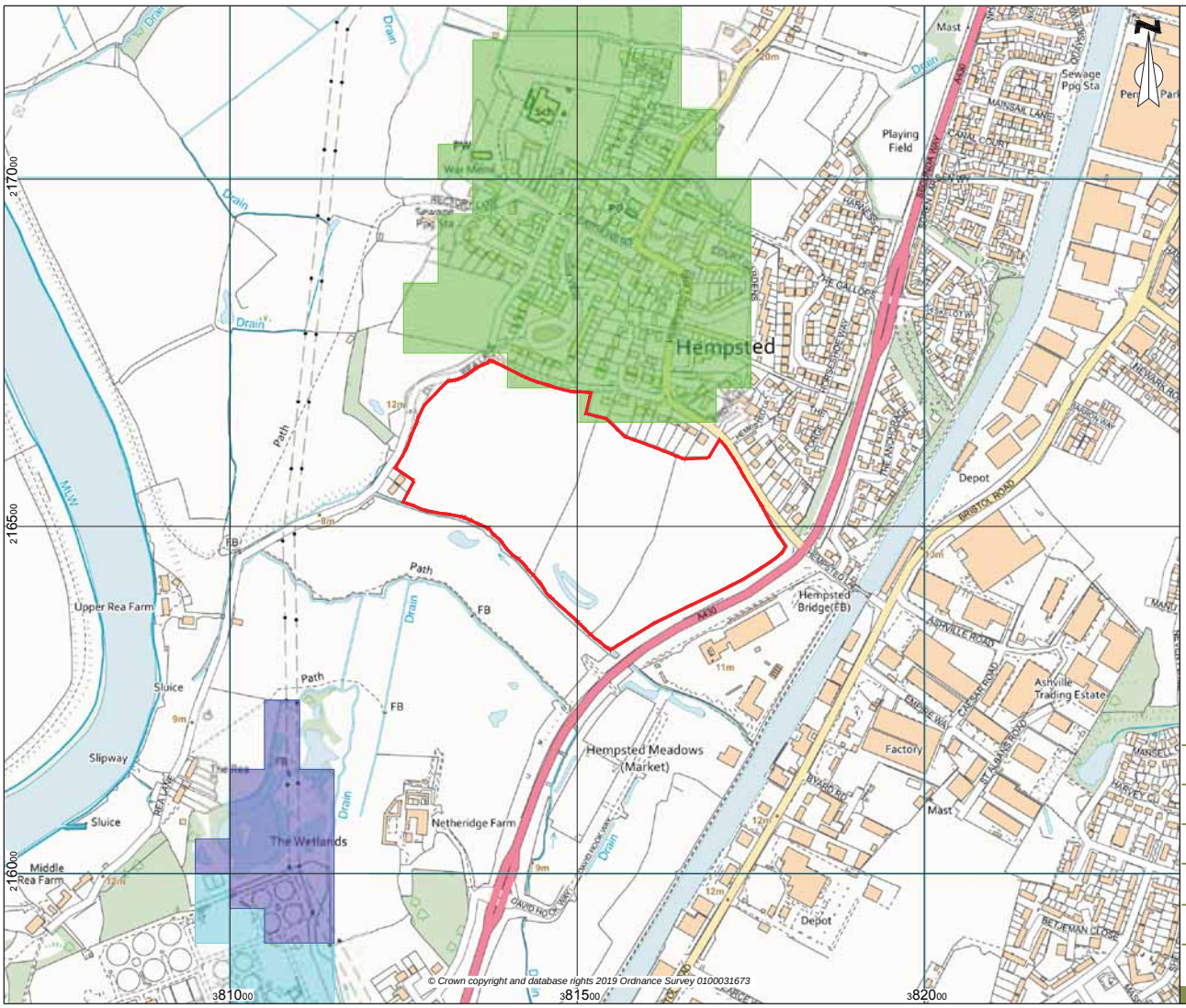
CHECKED: EOC

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: Surface Water Features

DRAWING NO: CRM.1132.021.HY.D.002



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

CLIENT: Gladman Developments Ltd

SCALE: 1:5,000 @ A3

PROJECT REF: CRM.1132.021

DRAWN: MG

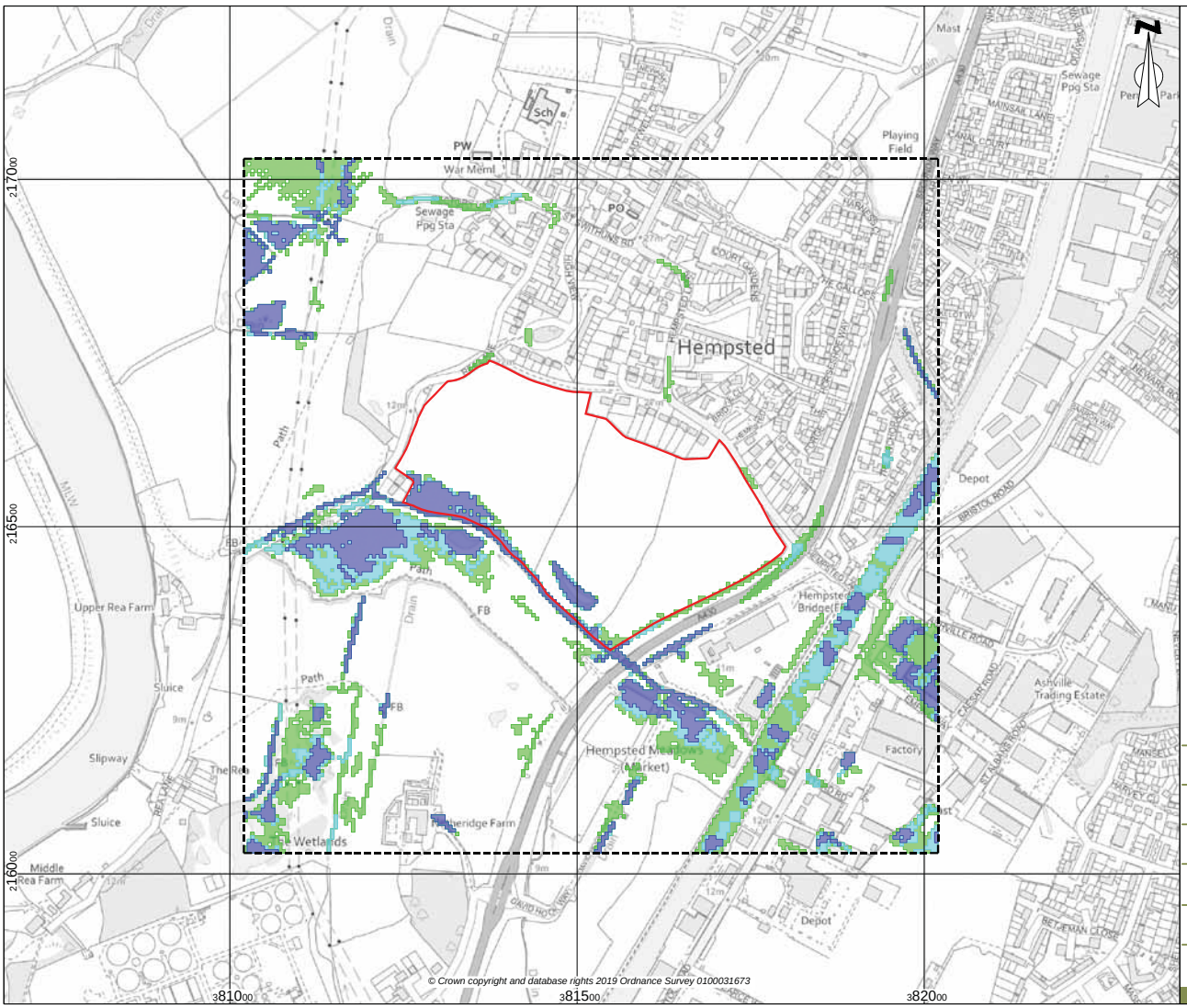
CHECKED: EOC

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: BGS Groundwater Susceptibility

DRAWING NO: CRM.1132.021.HY.D.003



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CLIENT: Gladman Developments Ltd

SCALE: 1:5,000@A3

PROJECT REF: CRM.1132.021

DRAWN: MG

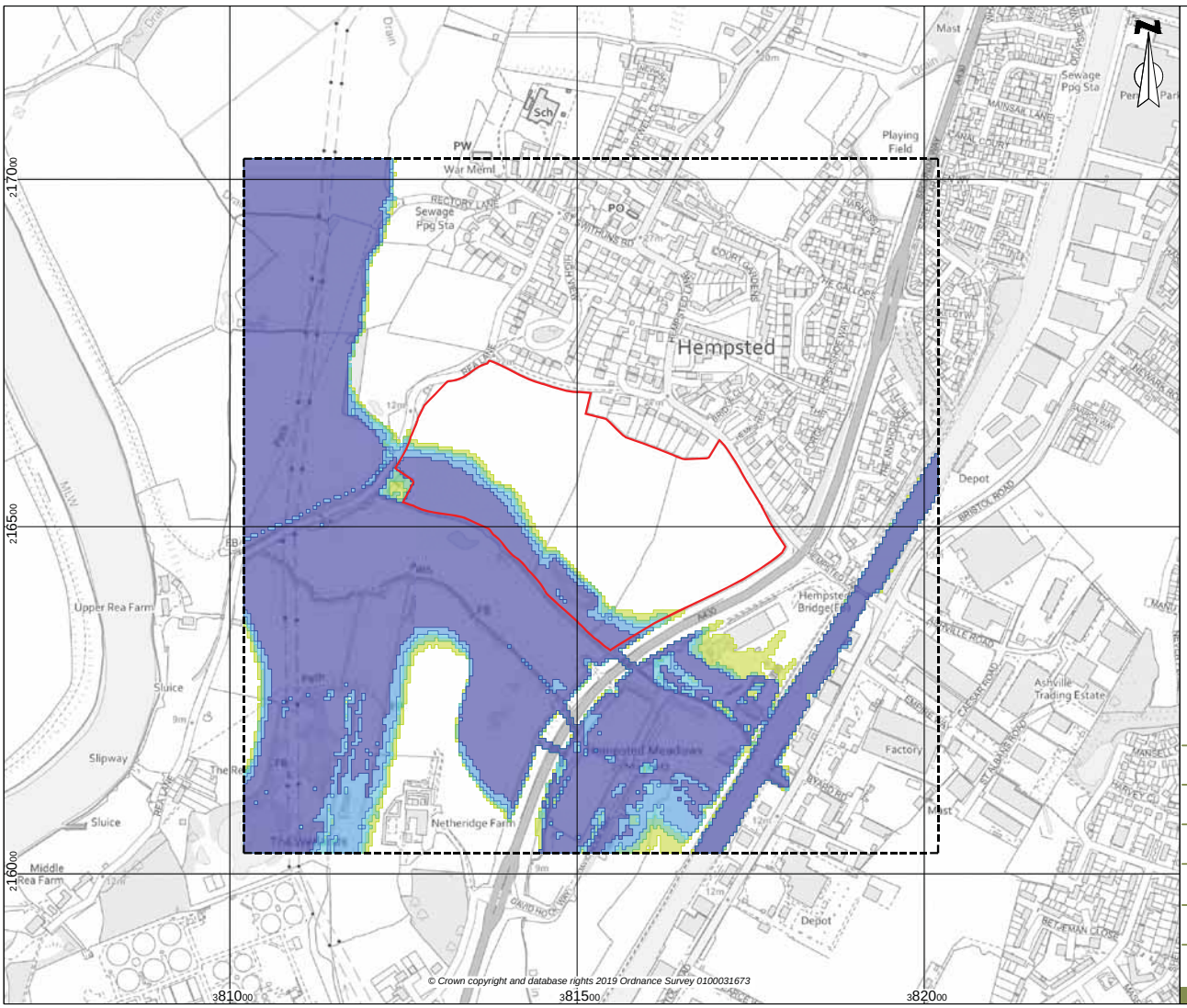
CHECKED: EO'C

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: JBA Surface Water Features

DRAWING NO: CRM.1132.021.HY.D.004.1



Key

- Site Boundary
- Search Extent
- 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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SCALE: 1:5,000@A3

PROJECT REF: CRM.1132.021

DRAWN: MG

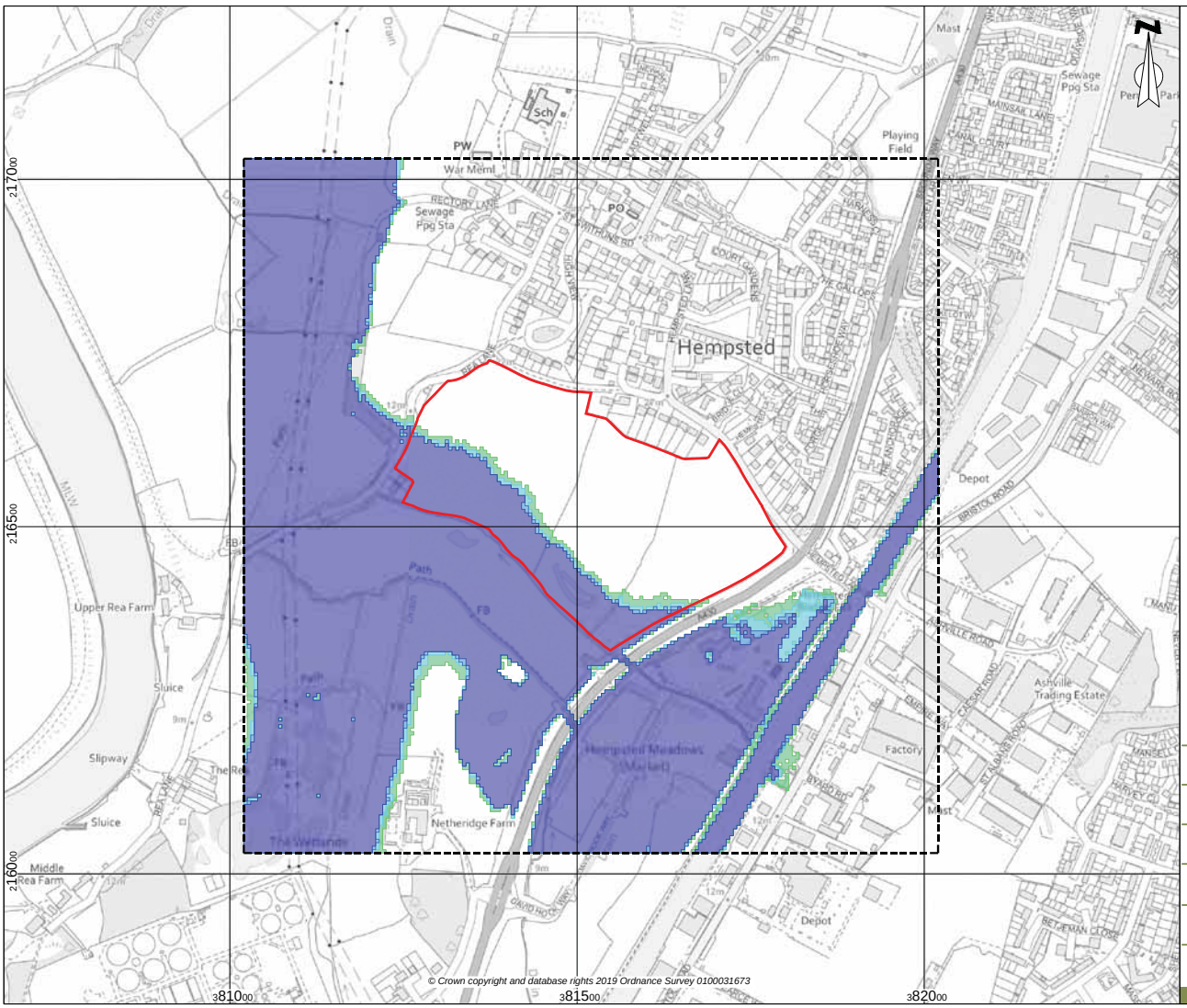
CHECKED: EO'C

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: JBA Flooding from Rivers

DRAWING NO: CRM.1132.021.HY.D.004.2



Key

- Site Boundary
- Search Extent
- 1 in 75 Year Coastal Flooding
- 1 in 100 Year Coastal Flooding
- 1 in 200 Year Coastal Flooding
- 1 in 1000 Year Coastal Flooding

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

CLIENT: Gladman Developments Ltd

SCALE: 1:5,000@A3

PROJECT REF: CRM.1132.021

DRAWN: MG

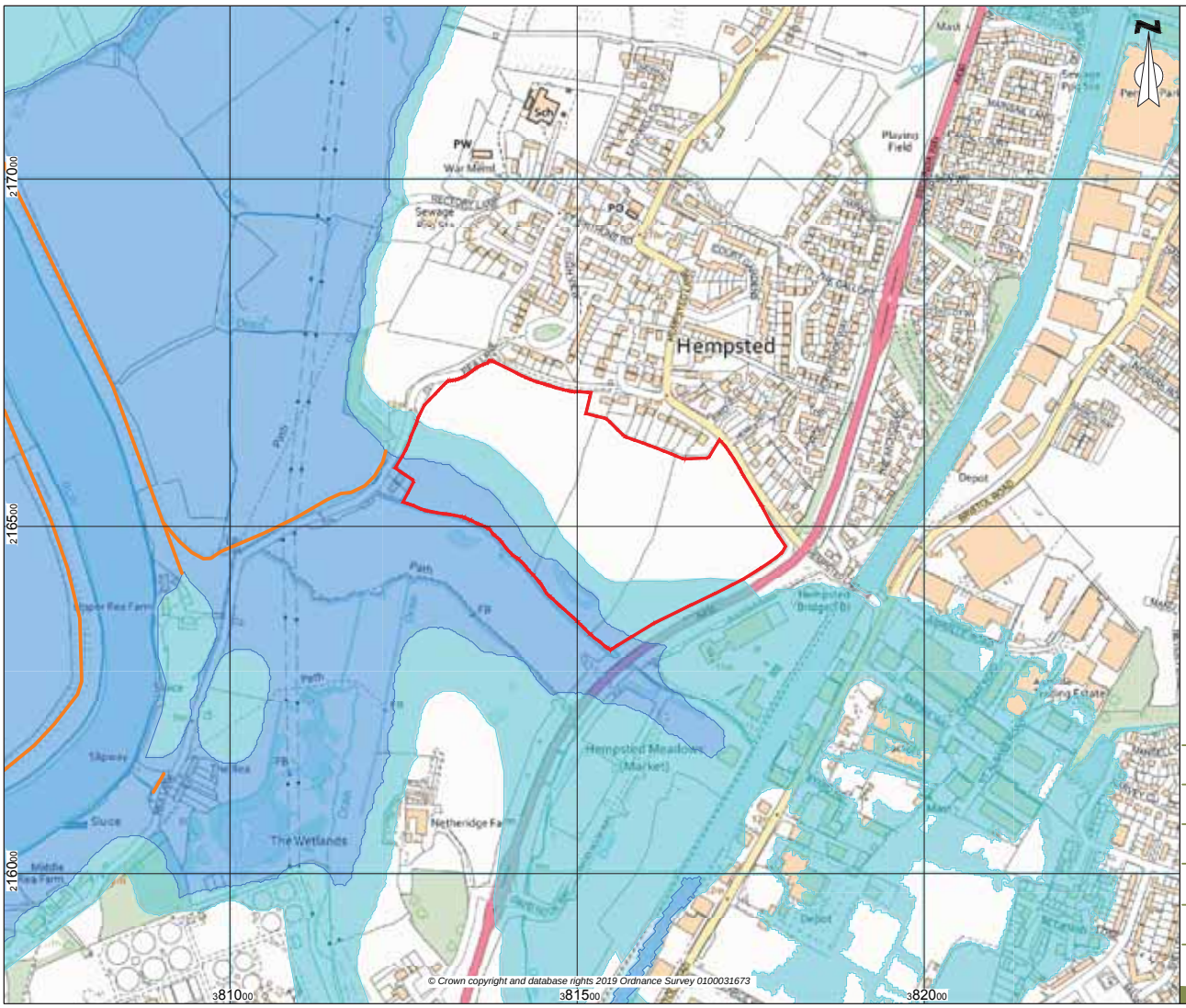
CHECKED: EO'C

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: JBA Coastal Flooding

DRAWING NO: CRM.1132.021.HY.D.004.3



Key

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

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CLIENT: Glad an Develop ents Ltd

SCALE: 1:5,000 A3

PRO ECT REF: CRM.1132.021

DRAWN: MG

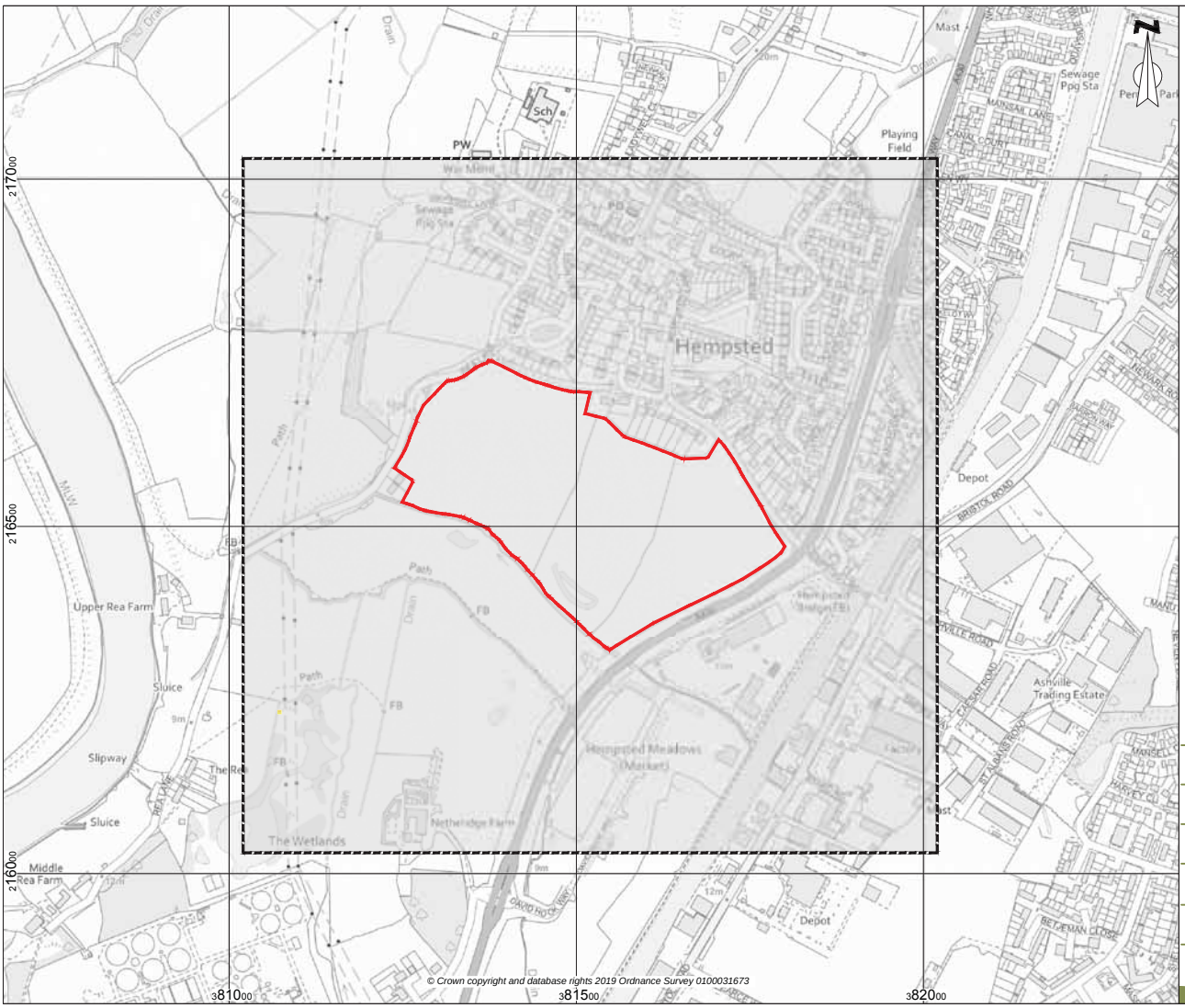
CHECKED: EO C

DATE: Sept 2019

PRO ECT: He psted Lane, Gloucester

TITLE: Environ ent A ency Flood Zones

DRAWING NO: CRM.1132.021.HY.D.005



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CLIENT: Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

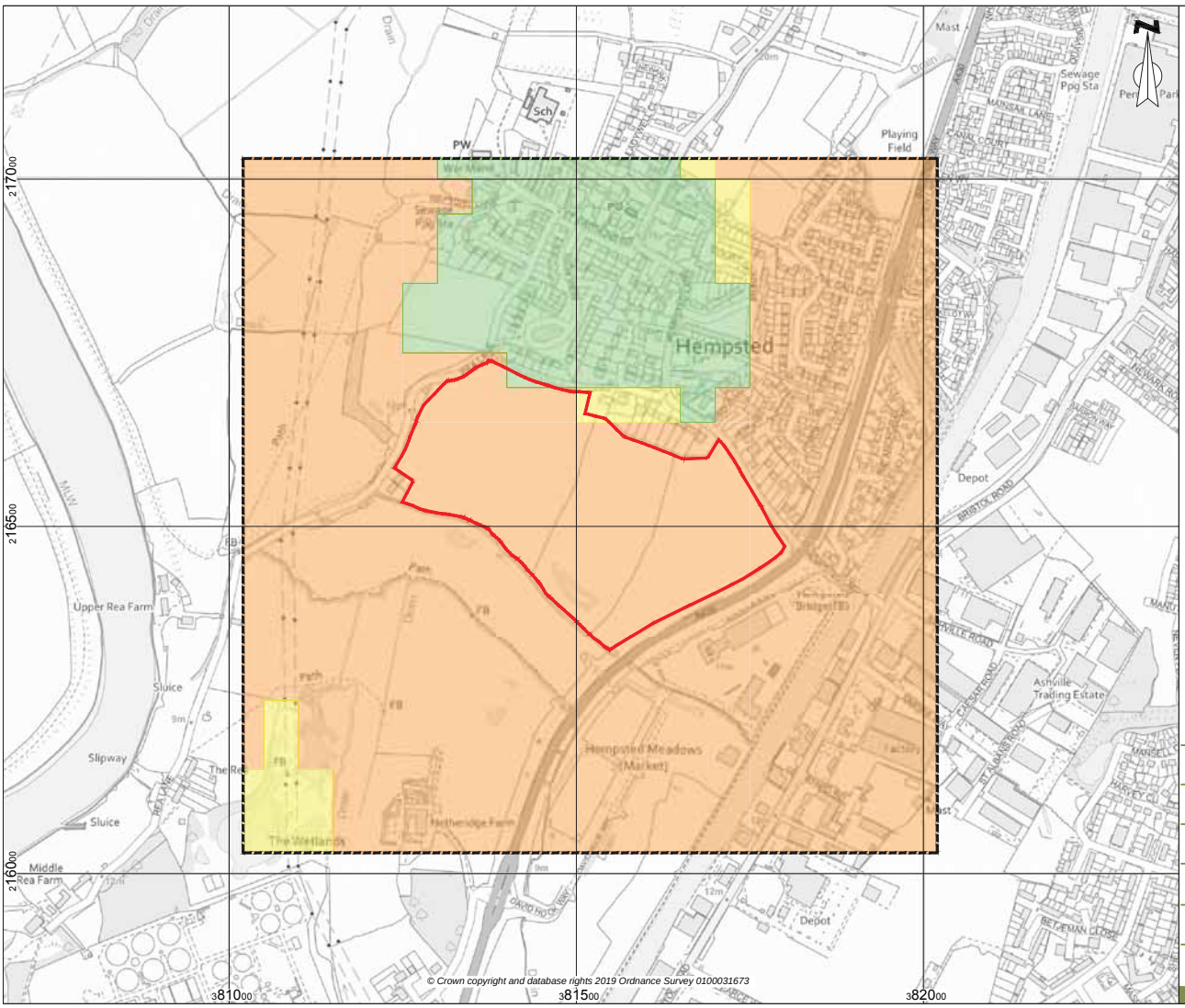
CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Ground□ater Flood Ris□ Map

DRAWING NO: CRM.1132.021.HY.D.006



Key

- Site Boundary
- Searc□ E□tent
- Hi□□Potential
- Moderate Potential
- Lo□ Potential

Notes:

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

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PRO□ECT REF: CRM.1132.021

DRAWN: MG

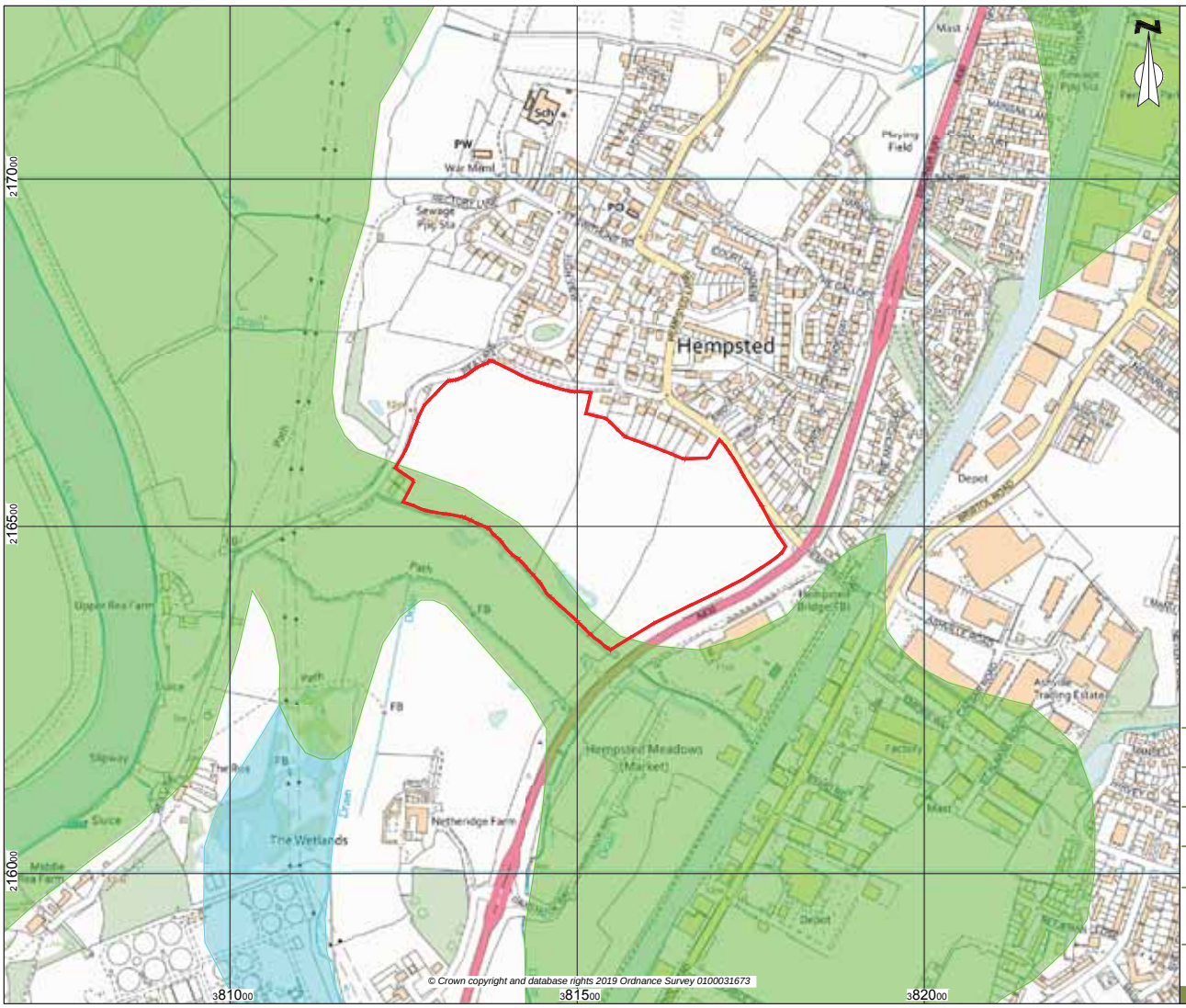
CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: SuDS In□iltration Potential Map

DRAWING NO: CRM.1132.021.HY.D.007



Key

- Site Boundary
- Geolo□ical Indicators o□ Floodin□ *from Coastal Flooding*
- Geolo□ical Indicators o□ Floodin□ *from Inland Flooding*

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SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Geolo□ical Indicators o□ Floodin□ (□ased on □eolo□ical deposits)

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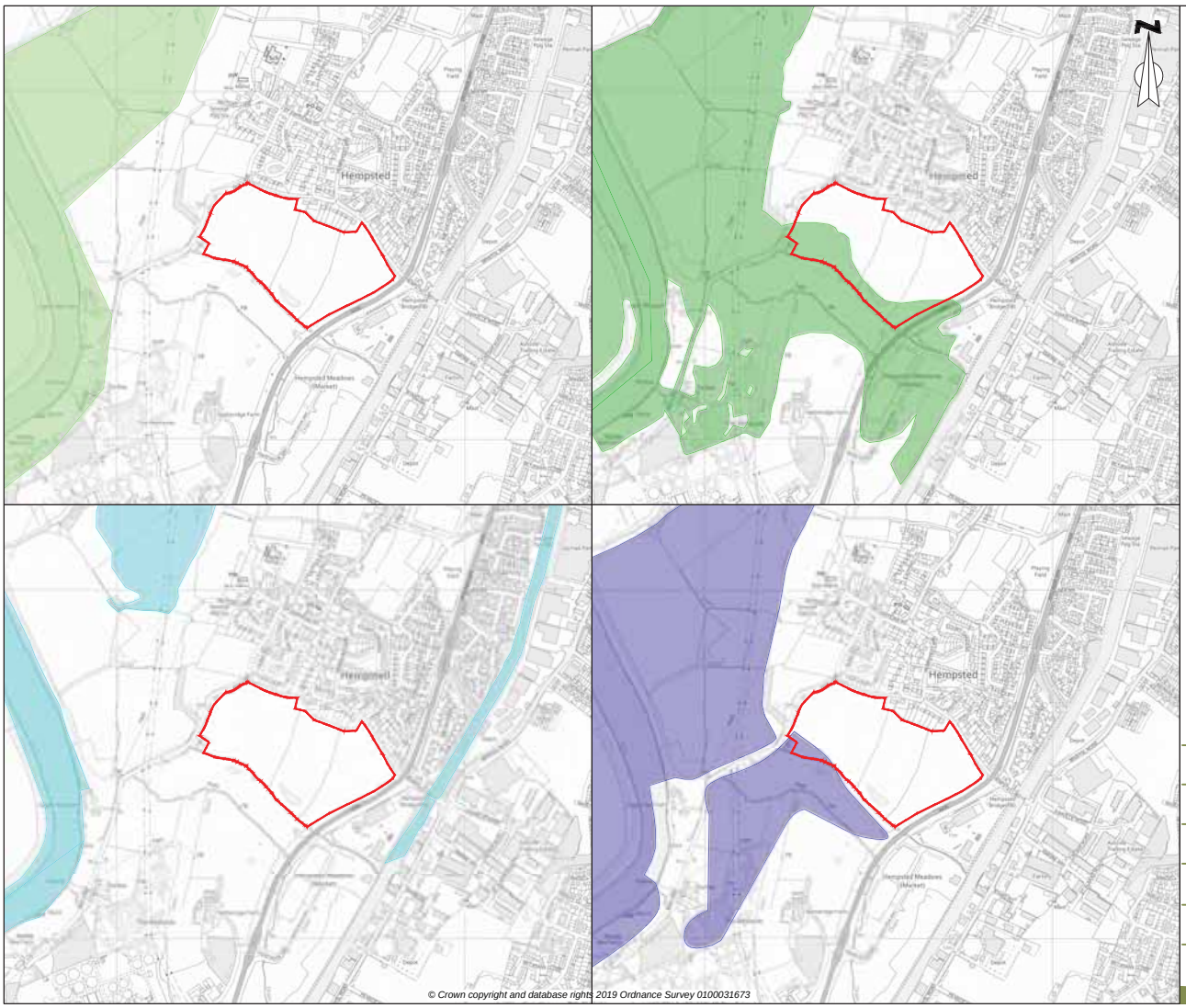

Key

- Site Boundary
- Historic Flood Zone (Date o□lood 20/07/2007 - 31/07/2007)
- Historic Flood Zone (Date o□lood 05/12/2000 - 20/12/2000)
- Historic Flood Zone (Date o□lood 29/10/2000 - 12/11/2000)
- Historic Flood Zone (Date o□lood 25/02/1990 - 28/02/1990)

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CLIENT: Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

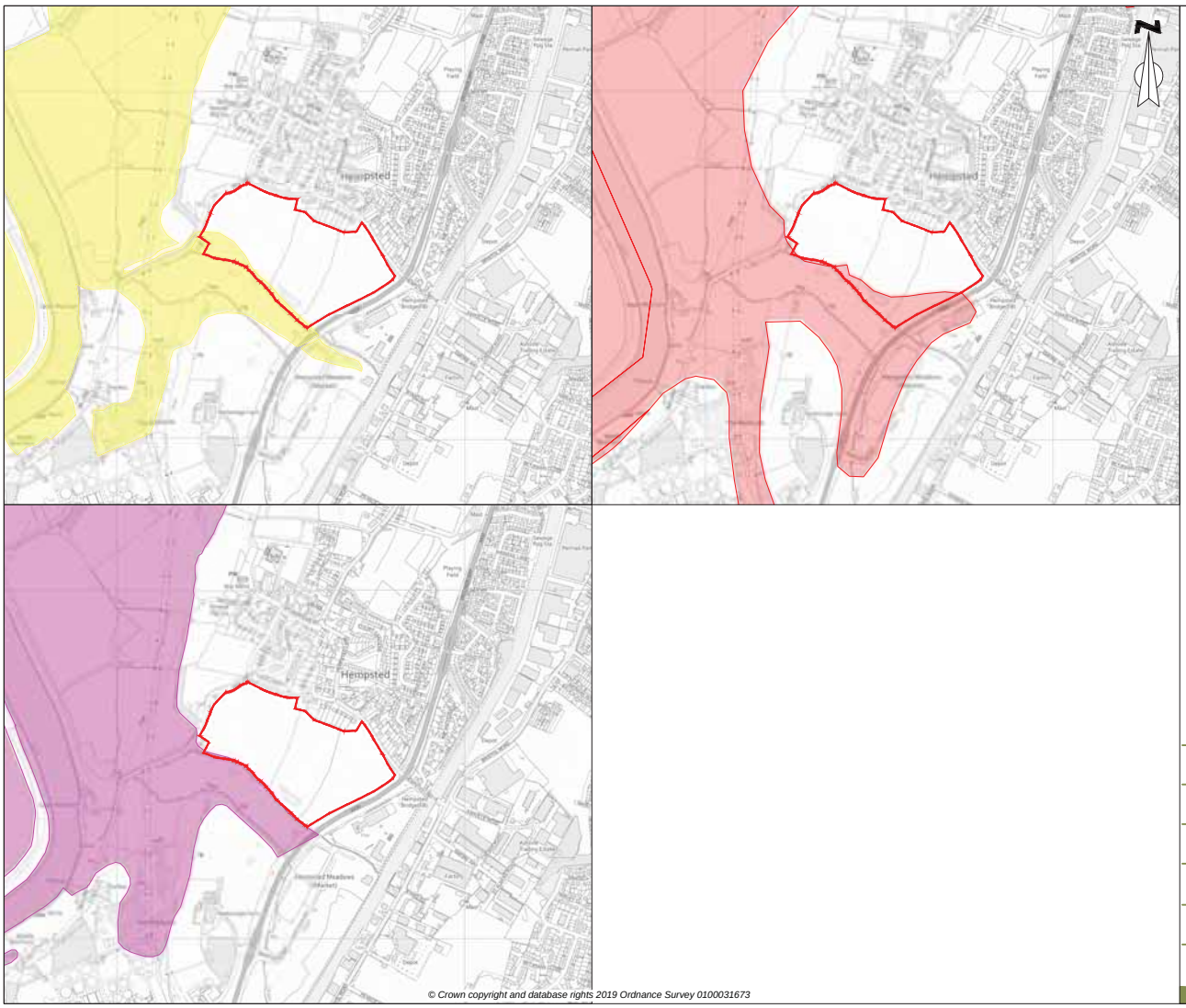
CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Historic Flood Zones

DRAWING NO: CRM.1132.021.HY.D.009.1



Key

- Site Boundary
- Historic Flood Zone (Date of flood 01/01/1990 - 01/01/1990)
- Historic Flood Zone (Date of flood 01/03/1947 - 01/03/1947)
- Historic Flood Zone (Date of flood 01/01/1939 - 01/01/1939)

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SCALE: 1:5,000 @ A3

PROJECT REF: CRM.1132.021

DRAWN: MG

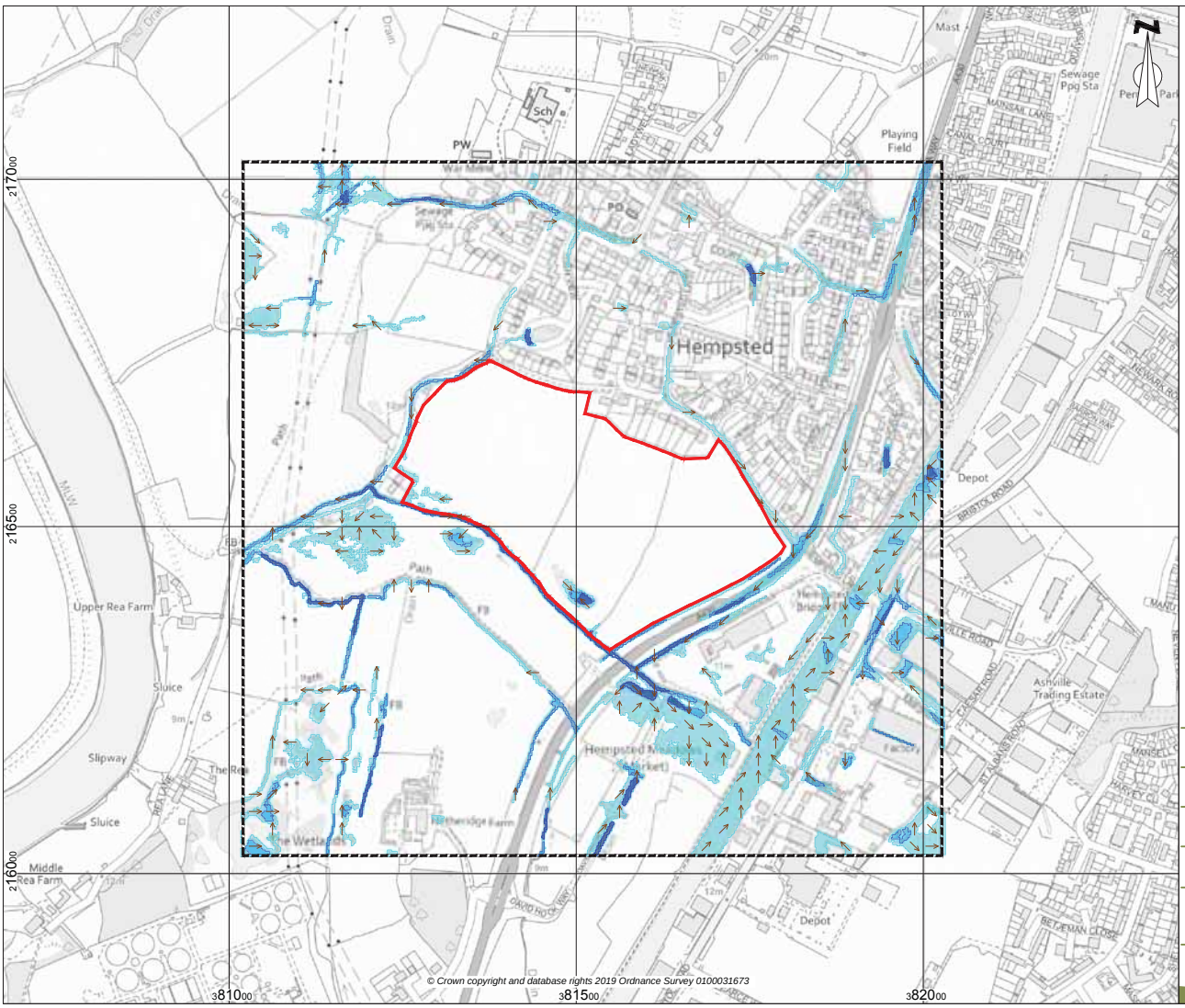
CHECKED: EOC

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: Historic Flood Zones

DRAWING NO: CRM.1132.021.HY.D.009.2



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CLIENT:
Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

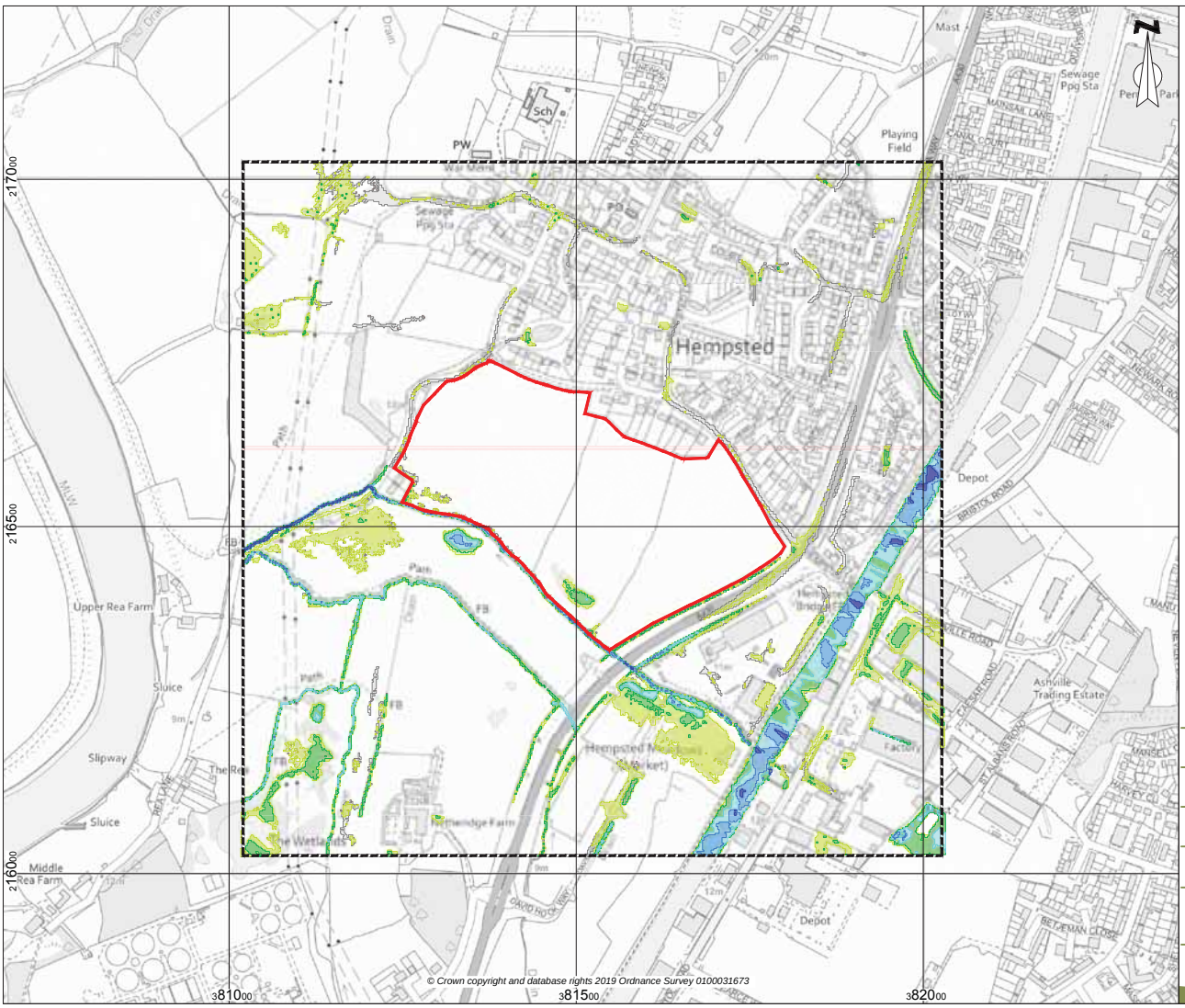
CHECKED: EO□C

DATE: Sept 2019

PRO□ECT:
He□psted Lane, Gloucester

TITLE:
Environ□ent A□ency Sur□ace Water Flo□ Pat□s

DRAWING NO:
CRM.1132.021.HY.D.010.1



Key

- Site Boundary
- Searc□ E□tent
- Dept□ □reater t□an 1.20 (□)
- Dept□ 0.90 - 1.20 (□)
- Dept□ 0.60 - 0.90 (□)
- Dept□ 0.30 - 0.60 (□)
- Dept□ 0.15 - 0.30 (□)
- Dept□ 0.0 - 0.15 (□)

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CLIENT: Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

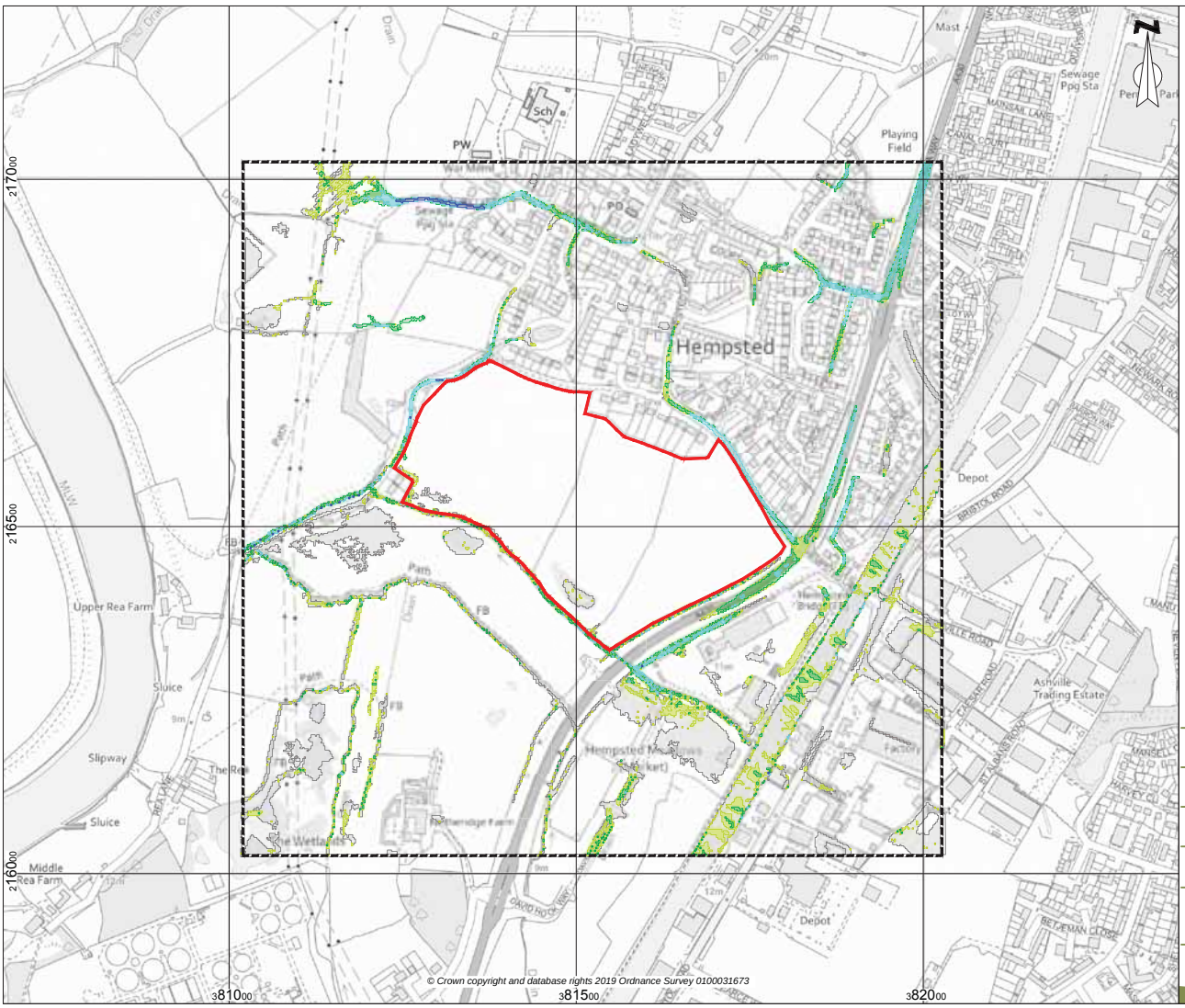
CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Environ□ent A□ency 1 in 1000 Year Sur□ace Water Dept□

DRAWING NO: CRM.1132.021.HY.D.010.2



Key

- Site Boundary
- Searc□ E□tent
- Velocity 2.00 or □reater (□/s)
- Velocity 1.00 - 2.00 (□/s)
- Velocity 0.50 - 1.00 (□/s)
- Velocity 0.25 - 0.50 (□/s)
- Velocity 0.00 - 0.25 (□/s)

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CLIENT: Glad□an Develop□ents Ltd

SCALE: 1:5,000□ A3

PRO□ECT REF: CRM.1132.021

DRAWN: MG

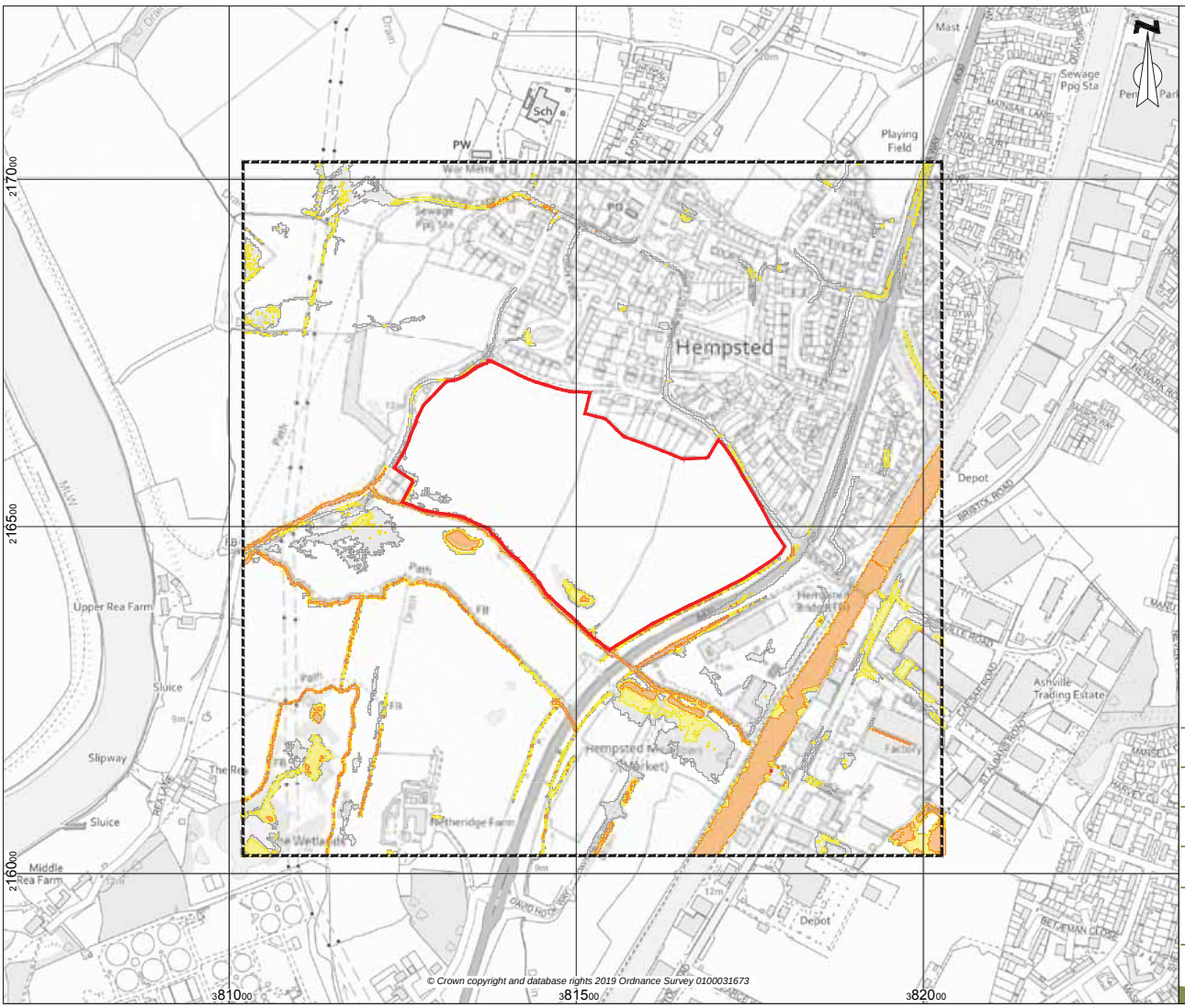
CHECKED: EO□C

DATE: Sept 2019

PRO□ECT: He□psted Lane, Gloucester

TITLE: Environ□ent A□ency 1 in 1000 Year Sur□ace Water Velocity

DRAWING NO: CRM.1132.021.HY.D.010.3



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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CLIENT: Gladman Developments Ltd

SCALE: 1:5,000 @ A3

PROJECT REF: CRM.1132.021

DRAWN: MG

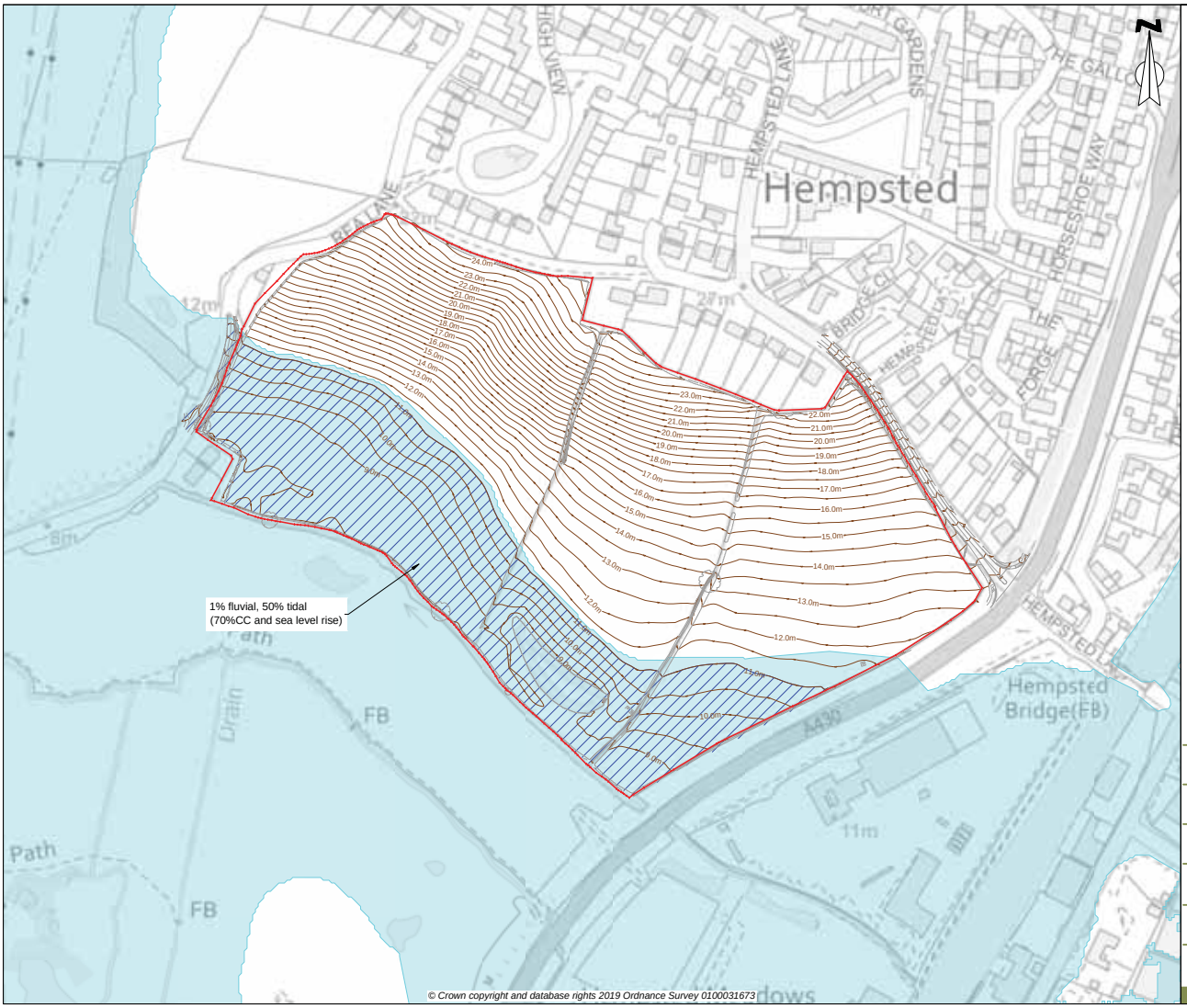
CHECKED: EOC

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: Environment Agency Surface Water 1000 Year Hazard Rating

DRAWING NO: CRM.1132.021.HY.D.010.4



Key

- Site Boundary
- 1% Fluvial, 50% Tidal (70%CC and sea level rise)
- EA Flood Zone 2

Notes:

Flood extent modelled on topographical survey.

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CLIENT: Gladman Developments Ltd

SCALE: 1:5,000@A3

PROJECT REF: CRM.1132.021

DRAWN: MG

CHECKED: EO'C

DATE: Sept 2019

PROJECT: Hempsted Lane, Gloucester

TITLE: Modelled Flood Extent

DRAWING NO: CRM.1132.021.HY.D.011