now part of

Wisloe Green

Flood Risk & Surface Water Site Appraisal

On behalf of **The Ernest Cook Trust and Gloucestershire County Council**

Project Ref: 44396/4001 | Rev: A | Date: October 2019

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For and on behalf of Peter Brett Associates LLP				

Revision	Date	Description	Prepared		Reviewed	Approved
A	11/10/2019	First Issue	KT	LD	AJ	RES

This report has been prepared by Peter Brett Associates LLP (‘PBA’) on behalf of its client to whom this report is addressed (‘Client’) in connection with the project described in this report and takes into account the Client's particular instructions and requirements. This report was prepared in accordance with the professional services appointment under which PBA was appointed by its Client. This report is not intended for and should not be relied on by any third party (i.e. parties other than the Client). PBA accepts no duty or responsibility (including in negligence) to any party other than the Client and disclaims all liability of any nature whatsoever to any such party in respect of this report.

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Appendices

1 Introduction

1.1 General

1.1.1 This Flood Risk & Surface Water Site Appraisal has been prepared by Peter Brett Associates, now part of Stantec, (PBA) on behalf of our client, the Ernest Cook Trust (ECT) and Gloucestershire County Council (GCC), to provide initial high-level information relating to Flood Risk and Drainage on the proposed development site known as "Wisloe Green".

1.1.2 This Site Appraisal is a desk-based study with the purpose of outlining the available baseline information relating to flood risk and surface water management on site. This information will be used to initiate the design concept for managing flood risk and surface water as part of the proposed development.

1.1.3 Any future planning application would require a full Flood Risk Assessment and a more detailed assessment of the onsite surface water drainage strategy, including any relevant applications for connection.

1.2 Sources of information

1.2.1 The report has been prepared based on the following sources of information:

- Development proposals provided by ECT and GCC;
- Environment Agency (EA) published **'Open Data'** datasets available online, reproduced with OS mapping under licence to PBA (contains Ordnance Survey data © Crown copyright and database right [2017], contains Environment Agency information © Environment Agency and database right);
- The **Environment Agency (EA) Online Flood Maps** for Planning [1] and **Long Term Flood Risk** [2] mapping;
- Stroud District Council Strategic Flood Risk Assessment level 1, dated September 2008;
- Stroud District Council Strategic Flood Risk Assessment level 2, dated March 2012;
- FEH13 rainfall data and point descriptors, extracted from the FEH online service;
- Gloucestershire SuDS Design and Maintenance Guide, dates November 2015;
- EA Product 4 (Reference 142924), dated 4th October 2019;
- Gloucestershire County Council consultation responses received 13th September 2019 and 26th September 2019.

[1] https://flood-map-for-planning.service.gov.uk/

[2] https://flood-warning-information.service.gov.uk/long-term-flood-risk/

2 Proposed Development Site

2.1 Site Description

2.1.1 The proposed development site (hereafter referred to as *'the site'*) is located in the district of Stroud and the county of Gloucestershire. The site is comprised of land between the A38 and M5 corridors and neighbours Slimbridge to the north west, Cambridge to the north and Draycott to the south.

2.1.2 The site is bound by the River Cam to the north, the M5 to the east, the railway line to the south, and the A38 to the west. The site is formed of four distinct parcels, as the A4135 bisects the site from west to east. Parcels 1, 2 and 3 being the land north of the A4135 and Parcel 4 the land to the south of the A4135.

2.1.3 The site is centred around the Ordnance Survey (OS) grid reference 375000m E 202853 m N and with an area of approximately 77.9ha.

2.1.4 A site location and key features plan are provided in **Appendix A**.

2.2 Existing Topography

2.2.1 A review of LiDAR data of the site has been undertaken and indicated that Parcels 1, 2 and 3 fall from the south east corner (approximately 26m AOD) towards the northern boundary (approximately 15m AOD).

2.2.2 Parcel 4 falls from the south west (approximately 27m AOD) towards the north west (approximately 20m AOD).

2.2.3 A full, 3D topographical site survey is recommended to support future assessments and design.

2.3 Hydrological Setting

2.3.1 There is an unnamed watercourse flowing north west through Parcel 4 of the site. This watercourse is a tributary of the Lighten Brook, which flows into Gilgal Brook and eventually the River Severn.

2.3.2 Adjacent to the northern boundary of Parcel 1 lies the River Cam which is designated as an EA "Main River" and flows north west to a confluence with the Gloucester and Sharpness Canal.

2.3.3 The Water Framework Directive (WFD) (Commission of the European Communities, 2000) (ref 13.2) establishes a framework for a European-wide approach to action in the field of water policy. The EA Catchment Data Explorer website[1] outlines water quality data relating to the WFD targets for 2027.

[1] https://environment.data.gov.uk/catchment-planning/

2.3.4 Based on the most recent water quality data recorded in 2016, both the Gilgal Brook and River Cam were classified as having a "*Moderate*" rating for the quality of the overall water body. A chemical water quality of "*Good*" was assigned to the river, however the ecological water quality was classified as "*Moderate*" and thus, the overall water body was classified to be of "*Moderate*" rating. Any surface water runoff associated with the proposed development should therefore seek to maintain the chemical water quality of the watercourse but improve the ecological water quality.

2.4 Existing Drainage Arrangements

On-Site Drainage

2.4.1 The site consists primarily of open agricultural land, such that surface water would either drain via natural infiltration into the ground or would drain via the existing surface water drainage measures within the site, such as field drains and ditches running alongside field boundaries.

Public Sewers

2.4.2 Severn Trent Water (STW) has been contacted in order to obtain copies of its sewerage infrastructure plans for the site and surrounding area. At the time of writing, PBA are yet to receive these.

2.5 On-site Flood Risk

2.5.1 The majority site is shown by the EA's '*Flood Map for Planning*' to lie within **Flood Zone 1 'Low probability'**. The north boundary of Parcel 1 lies within **Flood Zones 2 and 3**, with risk associated with flood extents of the River Cam in this area. The SFRA reviewed contains additional Flood Zone mapping which differentiates the Flood Zone 3 into Flood Zones 3a and 3b. Flood Zone 3b is the "functional floodplain" and should be kept clear of any development. The SFRA mapping indicates that all of the Flood Zone 3 extents are considered Flood Zone 3b.

2.5.2 It should be noted that as the watercourse crossing Parcel 4 is minor, it is likely that it has not been subject to hydraulic modelling by the EA, meaning the flood risk associated with it has not been confirmed.

2.5.3 The EA's *'Flood Risk from Surface Water'* mapping indicates that the majority of the site lies within an area of *"Very Low"* risk. There are some areas across the site with risk ranging from "*Low to High*". A review of OS mapping and LiDAR suggests that these are associated with the watercourse, field boundaries and low lying areas across the site.

2.5.4 The '*Flood Risk from Reservoirs Mapping*' present extents, depths and velocities of flooding for simulated, hypothetical 'credible worst case' dam breaches for reservoirs with a capacity of 25,000m^3 or greater. These reservoirs fall under the Reservoir Act 1975. The mapping indicates that the part of Parcel 1, including the northern boundary, of the site lies within the modelled extents of reservoir flooding.

2.5.5 Flood risk mapping is in included within **Appendix B**.

Historic Flooding

2.5.6 A review of EA datasets for the record of historic flooding and recorded flood outlines shows that no historic flooding extents within the site boundary. The dataset shows extents both upstream and downstream of the site along the River Cam as result of channel capacity exceedance.

2.6 Geology and Hydrogeology

2.6.1 The Geology of Britain viewer provided by the British Geological Survey (BGS)[1] indicates that the entire site is underlain by a bedrock of Blue Lia Formation and Charmouth Mudstone Formation (undifferentiated) – Mudstone. The majority of the site is underlain by superficial deposits of Cheltenham Sand and Gravel – Sand and Gravel, and partial underlain by Alluvium – Clay, Silt, Sand and Gravel.

2.6.2 The bedrock is designated as a secondary aquifer (undifferentiated) and the superficial deposits as a secondary aquifer.

2.7 Consultation

2.7.1 Requests for information have been sent to statutory consultees: GCC (as the Lead Local Flood Authority (LLFA)), Stroud District Council (SDC), Severn Trent Water, Lower Severn IDB and Environment Agency. At the time of the writing this site appraisal we are still awaiting a response from Severn Trent Water, Lower Severn IDB and SDC and have received responses from the other consultees. As part of future work stages, further liaison on with the statutory consultees would be required.

[1] http://mapapps.bgs.ac.uk/geologyofbritain/home.html

3 Surface Water Drainage Strategy

3.1 Development Proposals

3.1.1 This section will review potential surface water management for development proposals on site. The site is currently being proposed for allocation in the Local Plan to provide the opportunity for a new, self-contained mid-sized settlement comprising at least 1,500 new dwellings and 5ha of employment land by 2040.

3.1.2 It is understood that the development proposals will be influenced by the findings of this Site Appraisal and others provided by other technical disciplines.

3.2 Managing Surface Water

Drainage hierarchy

3.2.1 A preliminary discharge strategy has been devised based on publicly available information collected via a desk-study and consultation with the LLFA.

3.2.2 The NPPF recognises that flood risk and other environmental damaged can be managed by minimising changes in the volume and rate of surface water runoff from development sites and recommends that priority is given to the use of Sustainable Drainage Systems (SuDS) in new development.

3.2.3 As the intention of SuDS is to mimic the natural drainage regime of the undeveloped site, the NPPF PPG states the following (consistent with the Building Regulations H3 hierarchy and the SuDS Manual CIRIA C753):

The aim should be to discharge surface water runoff as high up the following hierarchy of drainage options as reasonably practical:

i. Into the ground (infiltration);

ii. To a surface water body;

iii. To a surface water sewer, highway drain or another drainage system;

iv. To a combined sewer.

3.2.4 The hierarchy is considered below:

Infiltration

3.2.5 Based on the drainage hierarchy, the preferred method for disposal of surface water from the new development is via infiltration.

3.2.6 A desktop review of the underlying geology onsite, using British Geological Society (BGS) mapping indicates that the infiltration potential on site is likely to be low. Therefore, infiltration has not been identified as a viable means of surface water discharge at this stage.

3.2.7 It is recommended that the infiltration potential on site is confirmed by targeted in-situ soakage testing in accordance with BRE Soakaway Design (DG 365). This will be required to support a future planning application.

Discharge to Watercourse

3.2.8 Where infiltration is not possible, the next preference in the drainage hierarchy is to discharge to a watercourse.

3.2.9 As stated previously, an unnamed watercourse flows through the centre of Parcel 4. Therefore, it is proposed that this parcel discharges to this watercourse.

3.2.10 As the site spans both banks of the watercourse, there should be no requirement for additional third party consent beyond Land Drainage Consent (applied to and granted by the LLFA) prior to construction. Some alterations to existing levels may be required during construction to permit discharge via gravity.

3.2.11 The remainder of the site falls towards the River Cam, therefore it is proposed that surface water for these areas is discharged to this watercourse. It should be noted that drainage from Parcels 2 and 3 will need to cross the A4135 in order to reach the River Cam (should development take place in these parcels) and this will likely be done with a short pipe crossing underneath the road which would require consent from the relevant authority.

3.2.12 Based on the available information, it is unclear whether the site's boundary reaches the banks of the River Cam. As such, it will be necessary to determine landownership adjacent to the River Cam and site boundary to determine whether third party consent will be required to construction an outfall to the river. This should be done prior to submission of any planning application (outline or full).

3.2.13 In addition, as the River Cam is a Main River, a Flood Risk Activity Permit (FRAP) will be also be required prior to construction (FRAPs are granted by the EA).

Discharge to Sewer

3.2.14 Should discharge via infiltration or watercourse not be deliverable, then discharge to a sewer would be the next option.

3.2.15 We are yet to receive public sewer asset plans from STW and thus have been unable to fully assess the feasibility of this option. However, it should be noted that consultation would be required with STW to determine possible connection points to the existing sewer network and the upgrades necessary to ensure that there is no detriment to the sewer network. If offsite upgrade works are required, STW will be responsible for any upgrading work required downstream of the identified connection point.

3.2.16 Nonetheless, as stated previously, further work will be required to fully determine the viability and deliverability of discharge via infiltration or to a watercourse on site. In accordance with the drainage hierarchy, priority should be given to investigating these options over discharge to a sewer.

3.3 Initial Consideration for a Surface Water Drainage Strategy

Discharge Rates

3.3.1 The existing site currently consists of agricultural greenfield land, and as such local planning policy dictates that the post-development runoff rates should be limited to match the existing present-day greenfield rates for all return periods up to and including the 100-year (1% AEP) event.

3.3.2 However, consultation with the LLFA indicates that, due to known downstream flood risk, it would be preferable to limit discharge rates from the site to match the existing present-day greenfield QBAR rate (approximately equivalent to the 2.3-year (43.5% AEP) event) for all return periods up to the 100-year event.

3.3.3 Currently, there is a discrepancy between GCC's "SuDS Design & Maintenance Guide" and industry best-practice CIRIA document C753 "The SuDS Manual" regarding whether the IH124 or FEH Statistical methods should be used to calculate greenfield runoff rates. Both documents were published in November 2015 so it is unclear which method would be preferred by the LLFA. Irrespective, greenfield runoff rates have been calculated using both methods to provide initial guidance.

3.3.4 The existing greenfield QBAR runoff rate has been calculated to be between **2.2 and 5.1 l/s/ha**, depending on the preferred calculation method.

3.3.5 The LLFA has been contacted to determine the preferred method prior to preparation of a planning application for the site.

Attenuation Volumes

3.3.6 Using the calculated peak discharge rates, it has been estimated that between **771 and 967m^3 of attenuation storage per hectare of impermeable development (m^3/ha)** will be required on site.

SuDS-led Surface Water Management

3.3.7 As stated previously, planning policy dictates that SuDS should be the preferred method for managing surface water.

3.3.8 The topography of the site lends itself to strategic attenuation features being located as close to the unnamed watercourse in Parcel 4 and River Cam in Parcel 1. These attenuation features are considered as "strategic" within a SuDS Management Train (a sequence of SuDS components throughout the site) as these will primarily be used to manage surface water runoff up to the 1 in 100 year storm event, plus an allowance for climate change.

3.3.9 Given the local landscape and hydrological setting, the strategic attenuation itself should comprise of either ponds or wetlands to reflect "wetter", marshy conditions. This will seek to incorporate them into the '*blue-green'* infrastructure strategy for the site, providing both amenity and biodiversity enhancement on site. The approximate land take for attenuation features will be subject to further design (and confirmation of a preferred greenfield runoff calculation method).

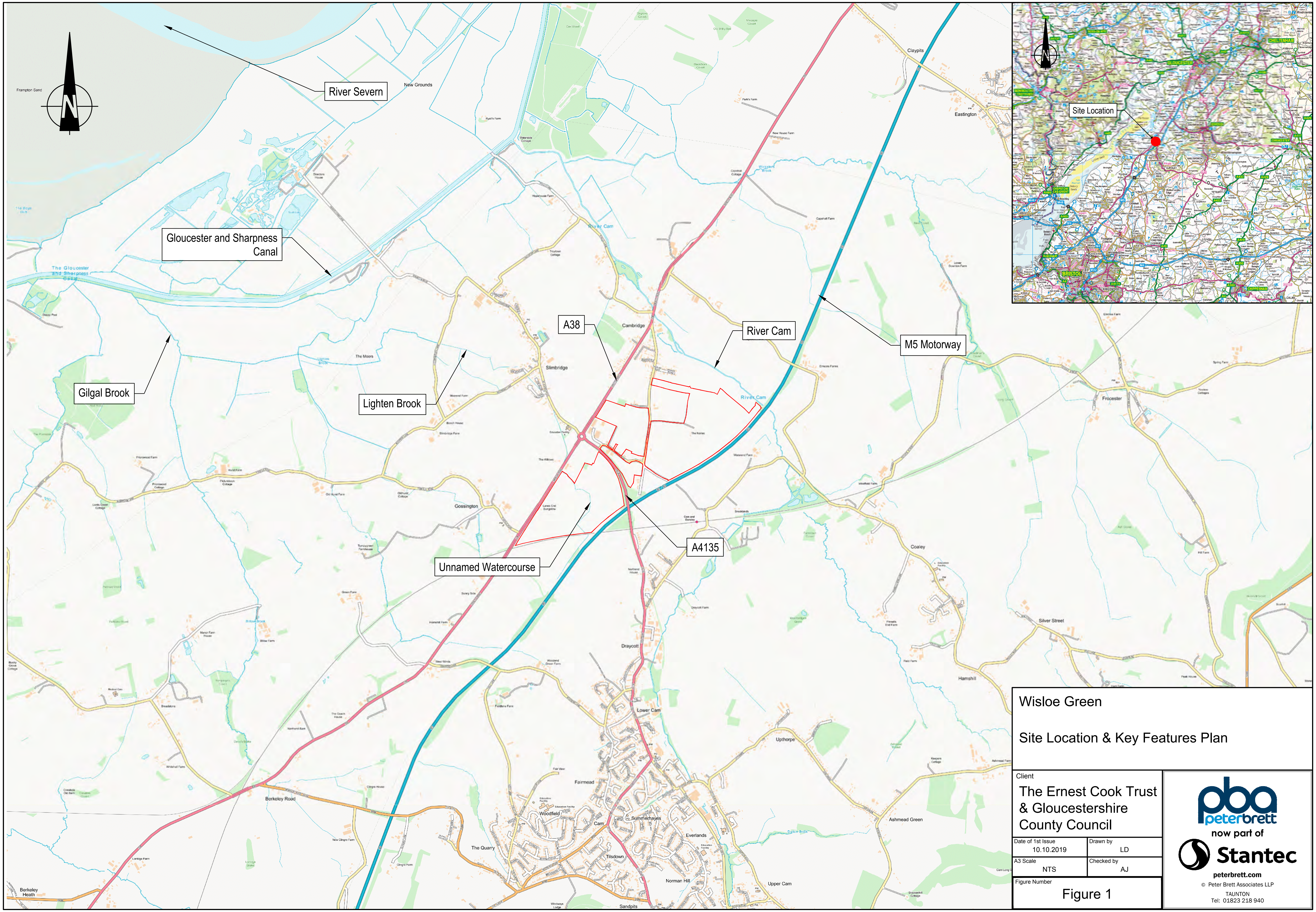
3.3.10 In accordance with the Management Train, locating "regional" attenuation throughout the site's parcels would provide better SuDS integration within the development and better mimic natural processes. The form of these features is heavily dependent on what type of component is proposed and where it is located within the development, however a few principles can be established. Swales can be designed to have "wetter", marshier conditions due to their linear and smaller scale, but it is recommended that "regional" basins are designed to accommodate drier conditions that these spaces are more accessible and usable to future occupants of the site.

3.3.11 Upstream of “regional” components, it is recommended that “source control” features are implemented. These typically include smaller scale SuDS features such as rain gardens, tree pits, bioretention and permeable pavements. Their principle aim is to treat runoff water quality at source, slow the flow of runoff through the system and provide ancillary ecological and landscape benefits. By treating water quality at source, most pollutants are removed, allowing components further down the Management Train to better provide amenity and biodiversity enhancement.

3.3.12 Calculations and initial surface water drainage strategy drawings are included within **Appendix C**.

Appendix A Baseline Information

Figure 1 – Site Location & Key Features Plan



Wisloe Green

Site Location & Key Features Plan

Client
The Ernest Cook Trust & Gloucestershire County Council

Date of 1st Issue	Drawn by
10.10.2019	LD
A3 Scale: NTS	Checked by: AJ

Figure Number
Figure 1

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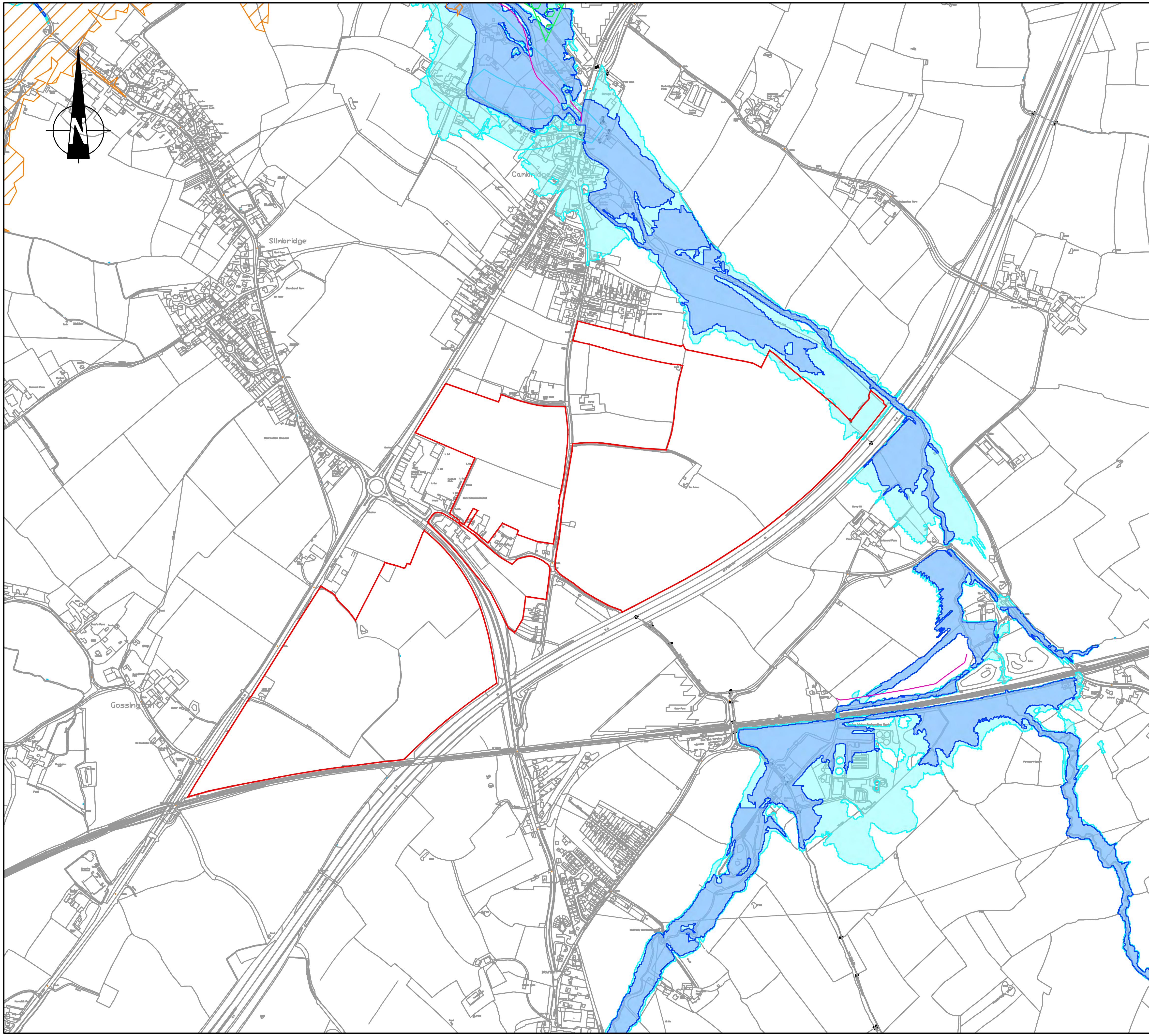
Appendix B Flood Risk

Figure 2 – Environment Agency Flood Zone Information

Figure 3 – Environment Agency Risk of Flooding from Surface Water 1 in 1,000 Year Depth

Figure 4 – Environment Agency Flood Modelling Data



Key:

Flood Zone 3 - Land having a 1 in 100 (1%) or greater annual probability of river flooding; or having a 1 in 200 (0.5%) or greater annual probability of sea flooding.

Flood Zone 2 - Land having between a 1 in 100 (1%) and 1 in 1,000 (0.1%) annual probability of river flooding; or between a 1 in 200 (0.5%) and 1 in 1,000 (0.1%) annual probability of sea flooding.

Flood Zone 1 - Land having a less than 1 in 1,000 (0.1%) annual probability of river or sea flooding.

Flood Defences

Areas benefiting from Flood Defences

Flood Storage Area

Notes:

1. Flood Zones as defined in National Planning Policy Framework (NPPF) Planning Practice Guidance (PPG) 'Flood Risk and Coastal Change' Table 1. Flood Zones do not take account of the possible impacts of climate change or presence of flood defences.

2. Data shown provided by Environment Agency 'Open Data' datasets, available from https://environment.data.gov.uk/. Contains Environment Agency information © Environment Agency and database right.

Wisloe Green

Environment Agency
Flood Zone Information

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NTS	AJ

Figure Number
Figure 2

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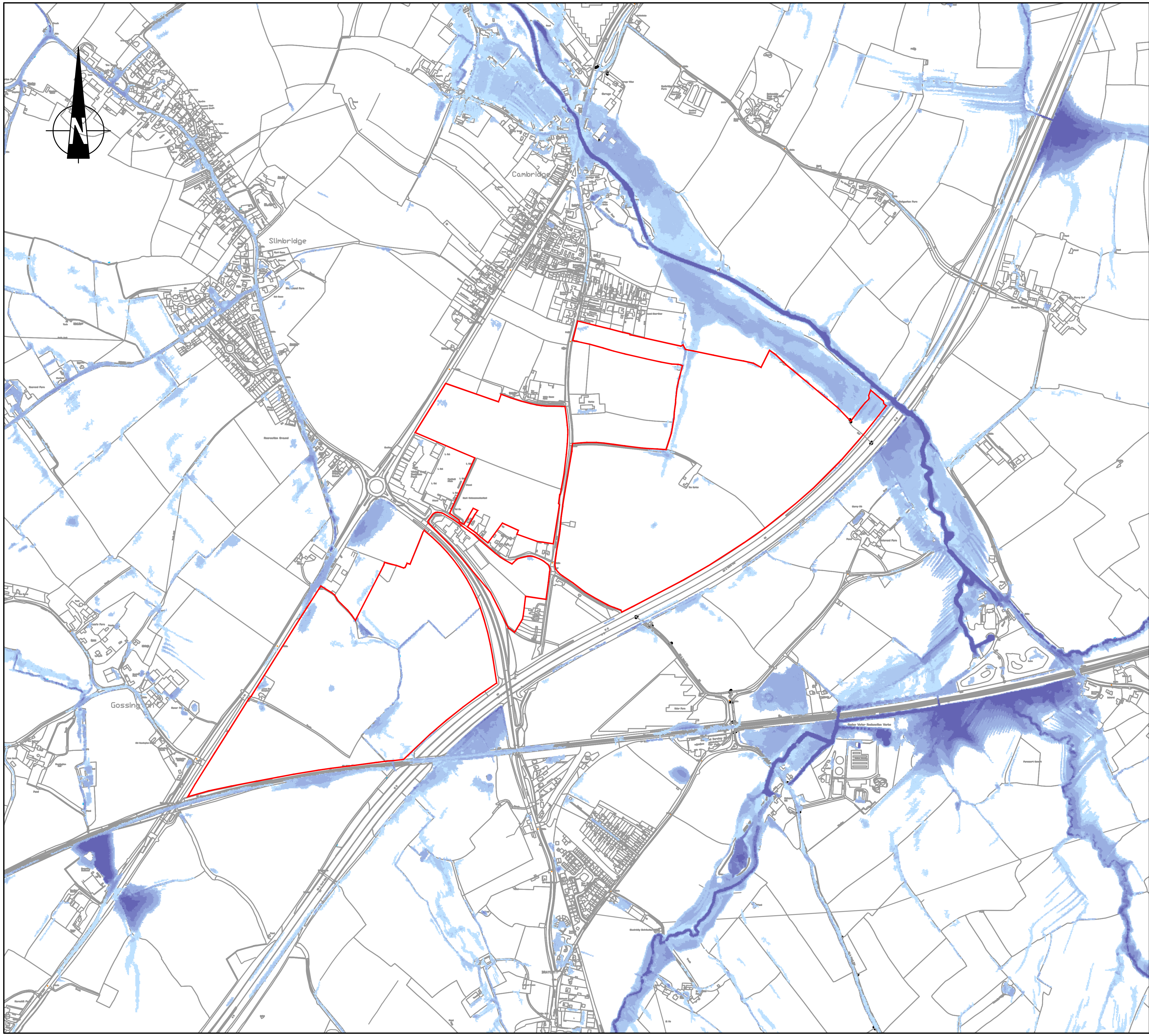

Key:

- 0.00 - 0.15m depth
- 0.15 - 0.30m depth
- 0.30 - 0.60m depth
- 0.60 - 0.90m depth
- 0.90 - 1.20m depth
- >1.20 depth

Notes:

1. Data shown provided by Environment Agency 'Open Data' datasets, available from https://environment.data.gov.uk/. Contains Environment Agency information © Environment Agency and database right.

Wisloe Green
Environment Agency
Risk of Flooding from Surface Water
1 in 1,000 Year Depth

Client
The Ernest Cook Trust & Gloucestershire County Council

Date of 1st Issue	Drawn by
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A3 Scale	Checked by
NTS	AJ

Figure Number
Figure 3

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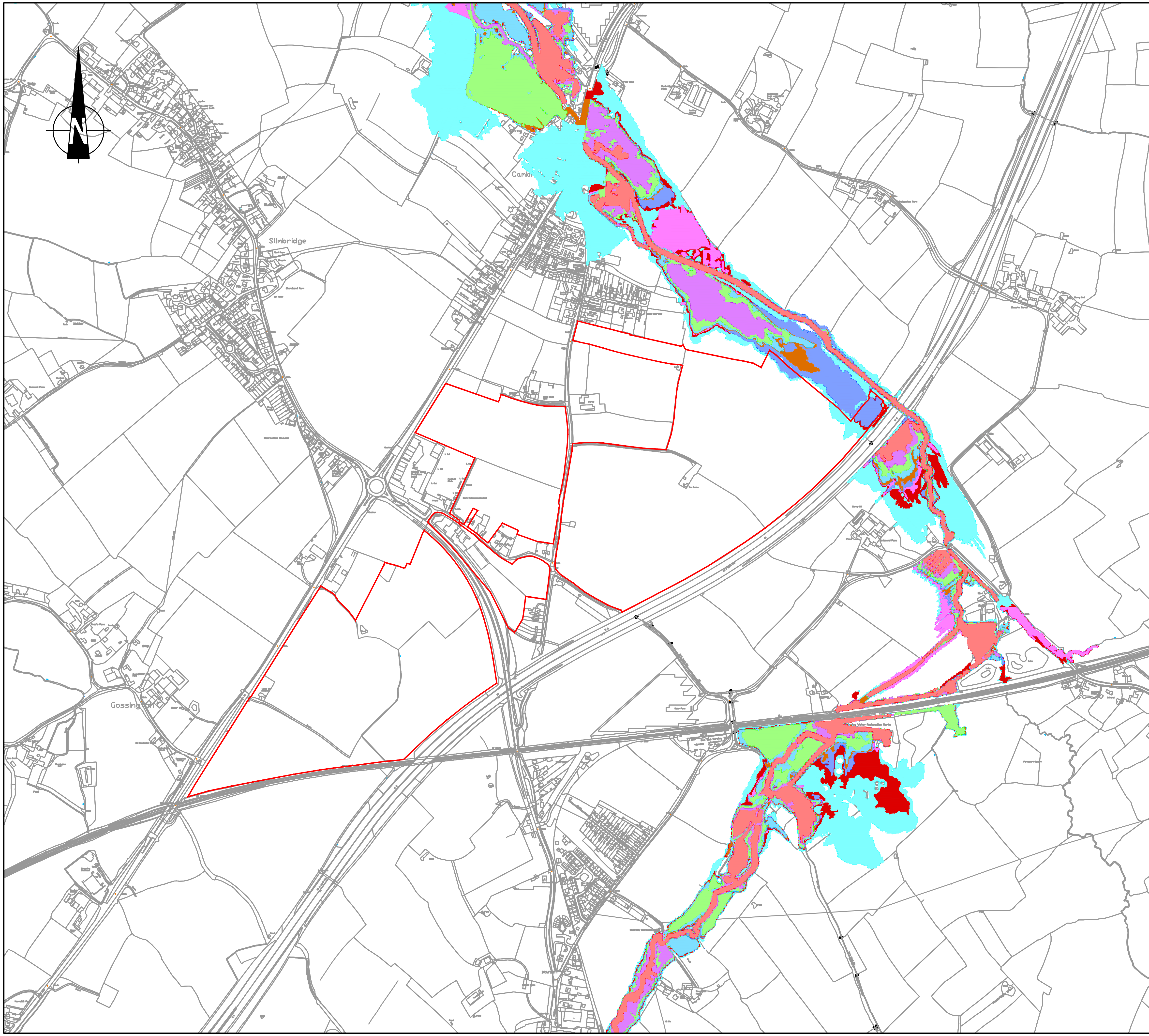

Key:

- 1 in 5 Year Modelled Flood Extents
- 1 in 10 Year Modelled Flood Extents
- 1 in 20 Year Modelled Flood Extents
- 1 in 50 Year Modelled Flood Extents
- 1 in 75 Year Modelled Flood Extents
- 1 in 100 Year Defended Modelled Flood Extents
- 1 in 100 Year Undefended Modelled Flood Extents
- 1 in 100 Year plus Climate Change Modelled Flood Extents
- 1 in 1,000 Year Modelled Flood Extents

Notes:

1. Data shown provided by Environment Agency 'Open Data' datasets, available from https://environment.data.gov.uk/. Contains Environment Agency information © Environment Agency and database right.

Wisloe Green
Environment Agency

Flood Modelling Data

Client: The Ernest Cook Trust & Gloucestershire County Council		
Date of 1st Issue: 10.10.2019	Drawn by: LD	
A3 Scale: NTS	Checked by: AJ	
Figure Number: Figure 4		

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Appendix C Managing Surface Water

FEH Greenfield Runoff Calculations

ICP SuDS Greenfield Runoff Calculations

MicroDrainage Attenuation Requirement (per impermeable ha) Calculations

Figure 5 – Initial Surface Water Drainage Strategy

FEH Greenfield Runoff

Using the 2008 Statistical Method QMED Equation

Project Title	Wisloe Green - Parcels 1-3
Project No	44396/4002

Methodology as set out in SuDS Manual 24.3.2 — SUDS Manual Chapter 24

1 Retrieve FEH Catchment Information

Define BFIHOST definition source		FEH	*see note 1*
Catchment Descriptors	**BFIHOST**	0.571	
	SAAR	710.0	*see note 1*
	FARL	1.0	*see note 2*

2 Derive QBAR (mean annual flood)

Define area	**Site Area**	48.9	ha	
	Applied Area	50.0	ha	*see note 3*
FEH Index Flood (SuDS Manual Equation 24.2)	**QMED (Q_2)**	117.9	l/s	*see note 4*
Calculate QBAR by dividing QMED by 2yr growth factor	**QBAR**	134.0	l/s	*see note 5*

3 Select appropriate growth factors

FSR Hydrological Region		8	*(refer to FSR Hydrological Region tab)*
100yr Growth Curve Factor	**GQ_{100}**	2.42	
30yr Growth Curve Factor	**GQ_{30}**	1.98	
10yr Growth Curve Factor	**GQ_{10}**	1.49	
2yr Growth Curve Factor	**GQ_2**	0.88	
1yr Growth Curve Factor	**GQ_1**	0.78	

4 Derive Flood Frequency

Greenfield Runoff per 1ha

100yr Peak Runoff Rate	**Q_{100}**	324.3	l/s	**Q_{100}**	6.6	l/s/ha
30yr Peak Runoff Rate	**Q_{30}**	265.4	l/s	**Q_{30}**	5.4	l/s/ha
10yr Growth Curve Rate	**Q_{10}**	199.7	l/s	**Q_{10}**	4.1	l/s/ha
QBAR Peak Runoff Rate	**QBAR**	134.0	l/s	**Q_{BAR}**	2.7	l/s/ha
2yr Peak Runoff Rate	**Q_2**	117.9	l/s	**Q_2**	2.4	l/s/ha
1yr Peak Runoff Rate	**Q_1**	104.5	l/s	**Q_1**	2.1	l/s/ha

Location of FEH Point Data (as Hyperlink) — ..\..\..\Project Incoming\FEH export\Parc

DOCUMENT ISSUE RECORD

Rev	Comments	Prepared	Date	Checked	Date
-	Original calculation	LD	08/10/2019		

FEH Greenfield Runoff

Using the 2008 Statistical Method QMED Equation

Project Title	Wisloe Green - Parcel 4
Project No	44396/4002

Methodology as set out in SuDS Manual 24.3.2 — SUDS Manual Chapter 24

1 Retrieve FEH Catchment Information

Define BFIHOST definition source		FEH		*see note 1*
Catchment Descriptors	**BFIHOST**	0.636		
	SAAR	719.0		*see note 1*
	FARL	1.0		*see note 2*

2 Derive QBAR (mean annual flood)

Define area	**Site Area**	29.0	ha	
	Applied Area	50.0	ha	*see note 3*
FEH Index Flood (SuDS Manual Equation 24.2)	**QMED (Q_2)**	56.8	l/s	*see note 4*
Calculate QBAR by dividing QMED by 2yr growth factor	**QBAR**	64.5	l/s	*see note 5*

3 Select appropriate growth factors

FSR Hydrological Region		8
100yr Growth Curve Factor	GQ_{100}	2.42
30yr Growth Curve Factor	GQ_{30}	1.98
10yr Growth Curve Factor	GQ_{10}	1.49
2yr Growth Curve Factor	GQ_2	0.88
1yr Growth Curve Factor	GQ_1	0.78

(refer to FSR Hydrological Region tab)

4 Derive Flood Frequency

Greenfield Runoff per 1ha

100yr Peak Runoff Rate	Q_{100}	156.1	l/s	Q_{100}	5.4	l/s/ha
30yr Peak Runoff Rate	Q_{30}	127.7	l/s	Q_{30}	4.4	l/s/ha
10yr Growth Curve Rate	Q_{10}	96.1	l/s	Q_{10}	3.3	l/s/ha
QBAR Peak Runoff Rate	QBAR	64.5	l/s	Q_{BAR}	2.2	l/s/ha
2yr Peak Runoff Rate	Q_2	56.8	l/s	Q_2	2.0	l/s/ha
1yr Peak Runoff Rate	Q_1	50.3	l/s	Q_1	1.7	l/s/ha

Location of FEH Point Data (as Hyperlink) — ..\..\..\Project Incoming\FEH export\Parc

DOCUMENT ISSUE RECORD

Rev	Comments	Prepared	Date	Checked	Date
-	Original calculation	LD	08/10/2019		

Notes This spreadsheet has been created to allow derivation of greenfield runoff rates using the FEH statistical method applied in a manner consistent with the recommendations of the SuDS Manual. If you have recommendations to improve this spreadsheet please contact Alex Bearne.

Note 1 FEH Web version 3 allows extraction of BFIHOST and SAAR values for each square kilometre grid Export point data from FEH Webs Service as .XML file and save in project folder and import in the FEH Point Data Import tab. If you do not think the BFIHOST value is representative of your site then it is possible to derive it manually. This should not normally be necessary. BFI can be derived manually using the methodology set out in the Flood Estimation Handbook (see Manual Derivation *of BFIHOST tab)* or can be defined from ground investigation information.
As default the sheet references the imported FEH data

Note 2 FARL value is a measure of attenuation from reservoirs and lakes for the majority of studies this should be set to 1 (representing no attenuation). If your site includes a large water body with an attenuating affect on runoff please consult a hydrologist.
FARL is a measurement of studies water bodies in the catchment so that their attenuation effects sc this term becomes 1.0 and therefore drops out. (see page 23 of the Preliminary rainfall runoff management for developments EA/Defra 2013)
Rainfall runoff management for developments.pdf

Note 3 If the site area is less than 50 hectare the spreadsheet will calculate QMED for 50ha and scale the results automatically to the defined Site Area

Note 4 QMED is calculated using the statistical equation as revised by Kjeldsen in 2008

$$Q_{MED} = 8.3062AREA^{0.8510} .0.1536^{(1000/SAAR)} .FARL^{3.4451} .0.0460^{BFIHOST\wedge 2}$$

Rainfall runoff management for developments.pdf
It is reproduced as Equation 24.2 in the SUDS Manual (pg 512)

Note 5 QBAR is calculated by dividing QMED by the growth factor for the 2 year event, as per the methodology set out in paragraph 6.2.2 of 'Rainfall runoff management for developments' .
QBAR is then used as the index flood for the basis of applying the growth factors.

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	SAAR (mm)	800	Urban	0.000
Area (ha)	1.000	Soil	0.450	Region Number	Region 8

Results	**l/s**
QBAR Rural	5.1
QBAR Urban	5.1
Q100 years	12.4
Q1 year	4.0
Q30 years	9.8
Q100 years	12.4

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.330	0.330	2.7	256.1	O K
30 min Summer	0.430	0.430	2.7	342.7	O K
60 min Summer	0.533	0.533	2.7	435.4	O K
120 min Summer	0.633	0.633	2.7	530.3	O K
180 min Summer	0.686	0.686	2.7	582.7	O K
240 min Summer	0.722	0.722	2.7	619.3	O K
360 min Summer	0.773	0.773	2.7	671.1	O K
480 min Summer	0.806	0.806	2.7	706.0	O K
600 min Summer	0.830	0.830	2.7	731.2	O K
720 min Summer	0.848	0.848	2.7	750.0	O K
960 min Summer	0.871	0.871	2.7	775.0	O K
1440 min Summer	0.891	0.891	2.7	796.2	O K
2160 min Summer	0.888	0.888	2.7	793.1	O K
2880 min Summer	0.871	0.871	2.7	775.0	O K
4320 min Summer	0.836	0.836	2.7	737.5	O K
5760 min Summer	0.802	0.802	2.7	701.3	O K
7200 min Summer	0.770	0.770	2.7	667.9	O K
8640 min Summer	0.738	0.738	2.7	635.3	O K
10080 min Summer	0.707	0.707	2.7	603.4	O K
15 min Winter	0.366	0.366	2.7	287.0	O K
30 min Winter	0.477	0.477	2.7	384.2	O K
60 min Winter	0.589	0.589	2.7	488.5	O K
120 min Winter	0.699	0.699	2.7	595.5	O K
180 min Winter	0.757	0.757	2.7	654.7	O K
240 min Winter	0.797	0.797	2.7	696.3	O K
360 min Winter	0.853	0.853	2.7	755.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	137.645	0.0	211.5	19
30 min Summer	92.379	0.0	228.1	34
60 min Summer	59.033	0.0	412.1	64
120 min Summer	36.298	0.0	436.6	124
180 min Summer	26.843	0.0	425.9	184
240 min Summer	21.596	0.0	417.5	244
360 min Summer	15.886	0.0	406.4	364
480 min Summer	12.754	0.0	399.8	482
600 min Summer	10.747	0.0	395.7	602
720 min Summer	9.338	0.0	393.4	722
960 min Summer	7.475	0.0	392.5	962
1440 min Summer	5.451	0.0	394.1	1442
2160 min Summer	3.967	0.0	804.7	2160
2880 min Summer	3.162	0.0	781.0	2508
4320 min Summer	2.292	0.0	735.8	3244
5760 min Summer	1.823	0.0	1304.4	4040
7200 min Summer	1.528	0.0	1361.4	4896
8640 min Summer	1.323	0.0	1393.2	5712
10080 min Summer	1.172	0.0	1350.8	6560
15 min Winter	137.645	0.0	222.4	19
30 min Winter	92.379	0.0	228.5	34
60 min Winter	59.033	0.0	438.1	64
120 min Winter	36.298	0.0	426.6	122
180 min Winter	26.843	0.0	415.4	182
240 min Winter	21.596	0.0	408.8	240
360 min Winter	15.886	0.0	402.3	358

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
480 min Winter	0.891	0.891	2.7	796.4	O K
600 min Winter	0.918	0.918	2.7	826.2	O K
720 min Winter	0.939	0.939	2.7	848.8	O K
960 min Winter	0.967	0.967	2.7	880.1	O K
1440 min Winter	0.994	0.994	2.7	910.7	O K
2160 min Winter	1.000	1.000	2.7	917.5	O K
2880 min Winter	0.986	0.986	2.7	902.1	O K
4320 min Winter	0.942	0.942	2.7	852.8	O K
5760 min Winter	0.899	0.899	2.7	805.6	O K
7200 min Winter	0.856	0.856	2.7	758.2	O K
8640 min Winter	0.811	0.811	2.7	710.6	O K
10080 min Winter	0.765	0.765	2.7	662.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
480 min Winter	12.754	0.0	400.9	476
600 min Winter	10.747	0.0	402.6	596
720 min Winter	9.338	0.0	406.3	712
960 min Winter	7.475	0.0	411.2	944
1440 min Winter	5.451	0.0	412.0	1402
2160 min Winter	3.967	0.0	814.3	2076
2880 min Winter	3.162	0.0	800.5	2712
4320 min Winter	2.292	0.0	777.3	3416
5760 min Winter	1.823	0.0	1456.9	4376
7200 min Winter	1.528	0.0	1507.9	5264
8640 min Winter	1.323	0.0	1474.3	6224
10080 min Winter	1.172	0.0	1399.0	7152

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Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.000

Time From:	**(mins) To:**	**Area (ha)**
0	4	1.000

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Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	712.0	1.000	1140.6	1.300	1288.8

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0078-2700-1000-2700
Design Head (m)	1.000
Design Flow (l/s)	2.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	78
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	2.7	Kick-Flo®	0.622	2.2
Flush-Flo™	0.300	2.7	Mean Flow over Head Range	-	2.4

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.2	0.800	2.4	2.000	3.7	4.000	5.1	7.000	6.7
0.200	2.6	1.000	2.7	2.200	3.9	4.500	5.4	7.500	6.9
0.300	2.7	1.200	2.9	2.400	4.0	5.000	5.7	8.000	7.1
0.400	2.7	1.400	3.2	2.600	4.2	5.500	6.0	8.500	7.3
0.500	2.5	1.600	3.4	3.000	4.5	6.000	6.2	9.000	7.5
0.600	2.3	1.800	3.5	3.500	4.8	6.500	6.5	9.500	7.7

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.313	0.313	2.2	256.5	O K
30 min Summer	0.409	0.409	2.2	343.4	O K
60 min Summer	0.508	0.508	2.2	436.7	O K
120 min Summer	0.605	0.605	2.2	532.7	O K
180 min Summer	0.657	0.657	2.2	586.6	O K
240 min Summer	0.694	0.694	2.2	624.6	O K
360 min Summer	0.745	0.745	2.2	679.4	O K
480 min Summer	0.780	0.780	2.2	717.3	O K
600 min Summer	0.806	0.806	2.2	745.4	O K
720 min Summer	0.825	0.825	2.2	767.1	O K
960 min Summer	0.853	0.853	2.2	798.0	O K
1440 min Summer	0.882	0.882	2.2	830.7	O K
2160 min Summer	0.893	0.893	2.2	843.6	O K
2880 min Summer	0.886	0.886	2.2	835.3	O K
4320 min Summer	0.858	0.858	2.2	803.7	O K
5760 min Summer	0.830	0.830	2.2	772.4	O K
7200 min Summer	0.804	0.804	2.2	743.9	O K
8640 min Summer	0.779	0.779	2.2	716.4	O K
10080 min Summer	0.755	0.755	2.2	689.6	O K
15 min Winter	0.348	0.348	2.2	287.4	O K
30 min Winter	0.453	0.453	2.2	384.9	O K
60 min Winter	0.562	0.562	2.2	489.8	O K
120 min Winter	0.668	0.668	2.2	598.1	O K
180 min Winter	0.726	0.726	2.2	658.8	O K
240 min Winter	0.766	0.766	2.2	701.8	O K
360 min Winter	0.823	0.823	2.2	764.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	137.645	0.0	180.1	19
30 min Summer	92.379	0.0	187.0	34
60 min Summer	59.033	0.0	364.7	64
120 min Summer	36.298	0.0	360.3	124
180 min Summer	26.843	0.0	346.6	184
240 min Summer	21.596	0.0	337.4	244
360 min Summer	15.886	0.0	326.5	364
480 min Summer	12.754	0.0	320.9	484
600 min Summer	10.747	0.0	318.4	602
720 min Summer	9.338	0.0	318.1	722
960 min Summer	7.475	0.0	320.9	962
1440 min Summer	5.451	0.0	322.3	1442
2160 min Summer	3.967	0.0	647.1	2160
2880 min Summer	3.162	0.0	635.0	2880
4320 min Summer	2.292	0.0	616.0	3584
5760 min Summer	1.823	0.0	1268.1	4320
7200 min Summer	1.528	0.0	1235.7	5112
8640 min Summer	1.323	0.0	1176.1	5960
10080 min Summer	1.172	0.0	1111.5	6760
15 min Winter	137.645	0.0	184.4	19
30 min Winter	92.379	0.0	186.9	34
60 min Winter	59.033	0.0	366.8	64
120 min Winter	36.298	0.0	346.6	122
180 min Winter	26.843	0.0	334.5	182
240 min Winter	21.596	0.0	328.1	242
360 min Winter	15.886	0.0	323.3	360

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.390	0.390	5.1	254.4	O K
30 min Summer	0.504	0.504	5.1	339.4	O K
60 min Summer	0.618	0.618	5.1	429.3	O K
120 min Summer	0.724	0.724	5.1	517.9	O K
180 min Summer	0.776	0.776	5.1	563.4	O K
240 min Summer	0.810	0.810	5.1	593.0	O K
360 min Summer	0.852	0.852	5.1	631.0	O K
480 min Summer	0.875	0.875	5.1	652.1	O K
600 min Summer	0.887	0.887	5.1	663.5	O K
720 min Summer	0.893	0.893	5.1	668.8	O K
960 min Summer	0.891	0.891	5.1	667.6	O K
1440 min Summer	0.872	0.872	5.1	649.3	O K
2160 min Summer	0.838	0.838	5.1	618.2	O K
2880 min Summer	0.802	0.802	5.1	586.6	O K
4320 min Summer	0.731	0.731	5.1	523.9	O K
5760 min Summer	0.656	0.656	5.1	460.9	O K
7200 min Summer	0.571	0.571	5.1	391.7	O K
8640 min Summer	0.496	0.496	5.1	333.1	O K
10080 min Summer	0.429	0.429	5.1	282.9	O K
15 min Winter	0.432	0.432	5.1	285.2	O K
30 min Winter	0.557	0.557	5.1	380.9	O K
60 min Winter	0.682	0.682	5.1	482.3	O K
120 min Winter	0.798	0.798	5.1	582.5	O K
180 min Winter	0.856	0.856	5.1	634.8	O K
240 min Winter	0.893	0.893	5.1	669.4	O K
360 min Winter	0.942	0.942	5.1	714.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	137.645	0.0	246.3	19
30 min Summer	92.379	0.0	328.3	34
60 min Summer	59.033	0.0	436.7	64
120 min Summer	36.298	0.0	536.3	124
180 min Summer	26.843	0.0	593.9	182
240 min Summer	21.596	0.0	635.8	242
360 min Summer	15.886	0.0	697.6	362
480 min Summer	12.754	0.0	740.2	482
600 min Summer	10.747	0.0	767.8	602
720 min Summer	9.338	0.0	779.4	720
960 min Summer	7.475	0.0	770.9	960
1440 min Summer	5.451	0.0	738.4	1200
2160 min Summer	3.967	0.0	1065.7	1580
2880 min Summer	3.162	0.0	1131.1	1988
4320 min Summer	2.292	0.0	1221.4	2812
5760 min Summer	1.823	0.0	1311.1	3640
7200 min Summer	1.528	0.0	1373.5	4392
8640 min Summer	1.323	0.0	1426.2	5104
10080 min Summer	1.172	0.0	1470.9	5848
15 min Winter	137.645	0.0	275.6	19
30 min Winter	92.379	0.0	364.0	33
60 min Winter	59.033	0.0	488.9	64
120 min Winter	36.298	0.0	599.7	122
180 min Winter	26.843	0.0	663.0	180
240 min Winter	21.596	0.0	708.0	240
360 min Winter	15.886	0.0	769.3	356

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
480 min Winter	0.969	0.969	5.1	741.4	O K
600 min Winter	0.986	0.986	5.1	757.2	O K
720 min Winter	0.995	0.995	5.1	766.2	O K
960 min Winter	1.000	1.000	5.1	771.1	Flood Risk
1440 min Winter	0.982	0.982	5.1	753.3	O K
2160 min Winter	0.939	0.939	5.1	712.4	O K
2880 min Winter	0.893	0.893	5.1	669.1	O K
4320 min Winter	0.792	0.792	5.1	577.7	O K
5760 min Winter	0.684	0.684	5.1	483.8	O K
7200 min Winter	0.549	0.549	5.1	374.8	O K
8640 min Winter	0.435	0.435	5.1	287.6	O K
10080 min Winter	0.339	0.339	5.1	218.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
480 min Winter	12.754	0.0	796.0	472
600 min Winter	10.747	0.0	795.9	588
720 min Winter	9.338	0.0	790.7	700
960 min Winter	7.475	0.0	778.2	924
1440 min Winter	5.451	0.0	753.3	1342
2160 min Winter	3.967	0.0	1192.9	1684
2880 min Winter	3.162	0.0	1265.4	2136
4320 min Winter	2.292	0.0	1351.8	3068
5760 min Winter	1.823	0.0	1468.5	3976
7200 min Winter	1.528	0.0	1538.6	4688
8640 min Winter	1.323	0.0	1597.8	5360
10080 min Winter	1.172	0.0	1648.4	6048

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Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.000

Time From:	**(mins) To:**	**Area (ha)**
0	4	1.000

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Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	583.0	1.000	975.6	1.300	1113.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0107-5100-1000-5100
Design Head (m)	1.000
Design Flow (l/s)	5.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	107
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	5.1	Kick-Flo®	0.640	4.2
Flush-Flo™	0.297	5.1	Mean Flow over Head Range	-	4.4

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.6	0.800	4.6	2.000	7.0	4.000	9.8	7.000	12.8
0.200	5.0	1.000	5.1	2.200	7.4	4.500	10.3	7.500	13.2
0.300	5.1	1.200	5.6	2.400	7.7	5.000	10.9	8.000	13.6
0.400	5.0	1.400	6.0	2.600	8.0	5.500	11.4	8.500	14.0
0.500	4.9	1.600	6.3	3.000	8.5	6.000	11.9	9.000	14.4
0.600	4.5	1.800	6.7	3.500	9.2	6.500	12.3	9.500	14.8

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
480 min Winter	0.862	0.862	2.2	807.9	O K
600 min Winter	0.891	0.891	2.2	840.7	O K
720 min Winter	0.913	0.913	2.2	866.3	O K
960 min Winter	0.945	0.945	2.2	903.5	O K
1440 min Winter	0.981	0.981	2.2	945.6	O K
2160 min Winter	1.000	1.000	2.2	968.5	O K
2880 min Winter	0.999	0.999	2.2	967.6	O K
4320 min Winter	0.971	0.971	2.2	934.1	O K
5760 min Winter	0.936	0.936	2.2	893.3	O K
7200 min Winter	0.904	0.904	2.2	856.2	O K
8640 min Winter	0.870	0.870	2.2	817.7	O K
10080 min Winter	0.836	0.836	2.2	778.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
480 min Winter	12.754	0.0	324.5	478
600 min Winter	10.747	0.0	328.7	596
720 min Winter	9.338	0.0	332.0	714
960 min Winter	7.475	0.0	335.7	950
1440 min Winter	5.451	0.0	336.2	1414
2160 min Winter	3.967	0.0	664.0	2096
2880 min Winter	3.162	0.0	664.0	2768
4320 min Winter	2.292	0.0	646.8	4020
5760 min Winter	1.823	0.0	1313.5	4552
7200 min Winter	1.528	0.0	1267.4	5472
8640 min Winter	1.323	0.0	1216.5	6400
10080 min Winter	1.172	0.0	1166.3	7360

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Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.000

Time From:	**(mins) To:**	**Area (ha)**
0	4	1.000

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Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	757.0	1.000	1197.4	1.300	1349.1

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0070-2200-1000-2200
Design Head (m)	1.000
Design Flow (l/s)	2.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	70
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	2.2	Kick-Flo®	0.625	1.8
Flush-Flo™	0.307	2.2	Mean Flow over Head Range	-	1.9

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.8	0.800	2.0	2.000	3.0	4.000	4.2	7.000	5.4
0.200	2.1	1.000	2.2	2.200	3.2	4.500	4.4	7.500	5.6
0.300	2.2	1.200	2.4	2.400	3.3	5.000	4.6	8.000	5.8
0.400	2.2	1.400	2.6	2.600	3.4	5.500	4.8	8.500	5.9
0.500	2.1	1.600	2.7	3.000	3.6	6.000	5.0	9.000	6.1
0.600	1.9	1.800	2.9	3.500	3.9	6.500	5.2	9.500	6.3

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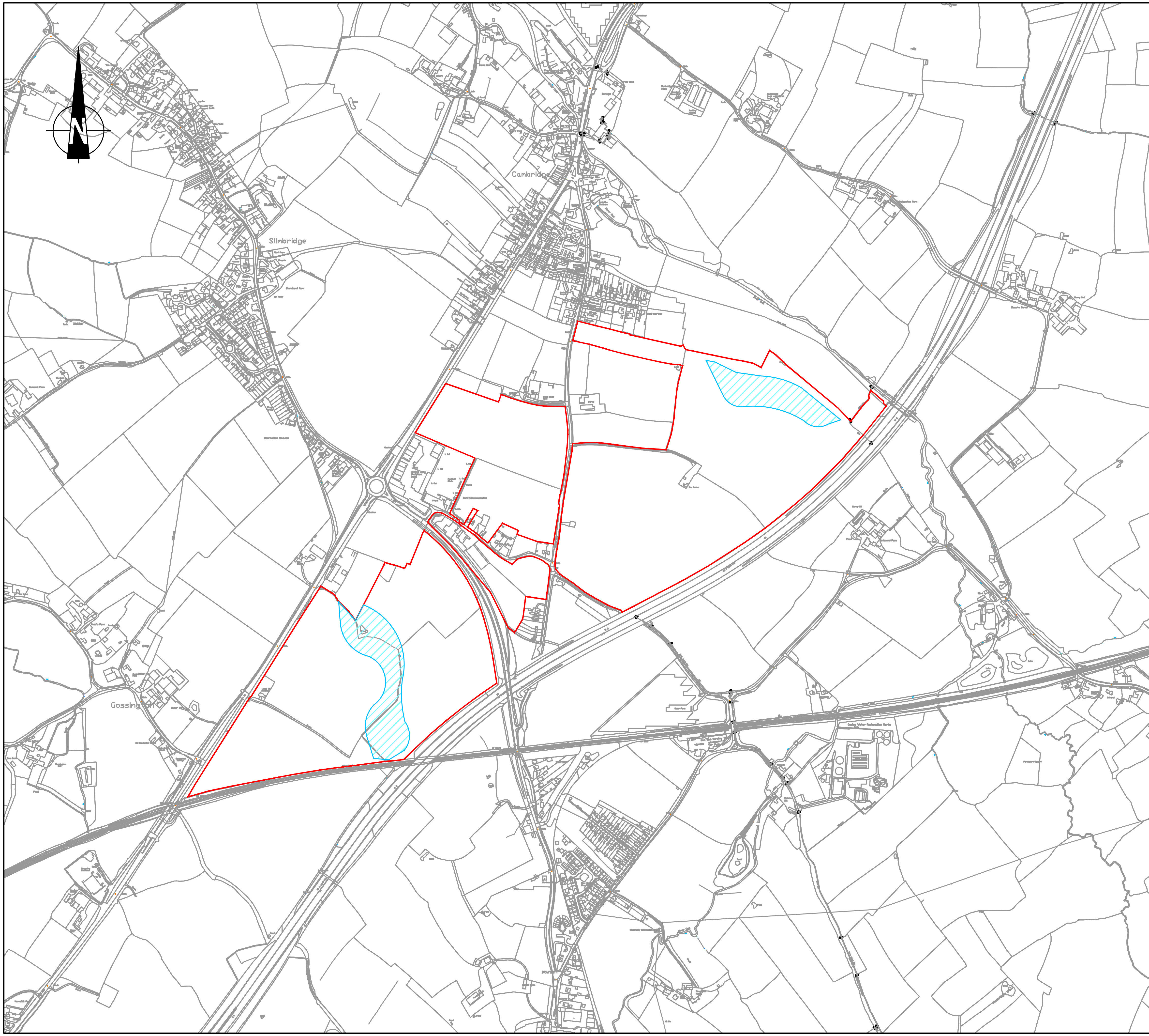

Key:

Indicative Strategic SuDS Locations

Notes:

1. Location of Strategic SuDS based on existing topography and identified surface water discharge outfalls.
2. Areas shown are not indicative of size/land-take requirement. Extent of Strategic SuDS to be determine at further, more detailed stages of design with reference to an emerging site layout.
3. Reference should be made to Landscape Architect's drawings to seek that SuDS are incorporated and integrated into a site-wide Green-Blue Infrastructure Strategy.

Wisloe Green

Initial Surface Water Drainage Strategy

Client: The Ernest Cook Trust & Gloucestershire County Council	
Date of 1st Issue: 10.10.2019	Drawn by: LD
A3 Scale: NTS	Checked by: AJ
Figure Number: Figure 5	

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