



Land West of Kidmore End Road: FRA and Drainage Strategy

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Land West of Kidmore End Road: FRA and Drainage Strategy

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1. Introduction

1.1. Instruction

Aqua Terra Consultants Ltd (Aqua Terra) was instructed by Fairfax (Reading) Limited and RGC (SODC) Limited (the Client) to provide a Flood Risk Assessment (FRA) and Outline Drainage Strategy (ODS) for the redevelopment of a parcel of land west of Kidmore End Road, Oxfordshire (the Site). Instruction to proceed was provided by email on the 8th June 2022.

1.2. Background

The Client is seeking to obtain planning permission to develop a parcel of land at Reading Golf Course, Emmer Green, Reading. The proposed development is residential in nature and the plot is currently a greenfield site (golf course). It is proposed to build up to 70No. new properties with public green spaces and access roads. Further details of the proposed development are provided in Section 3.

1.3. Scope of the report

The scope of this assessment is as follows:

- Preparation of an FRA, written in line with the National Planning Policy Framework (NPPF) and supporting Planning Practice Guidance (PPG) to satisfy the South Oxfordshire District Council (SCDC) and the Lead Local Flood Authority (LLFA, Oxfordshire County Council) that all potential flood risks to and from the proposed development have been considered and that the proposed development is appropriate, as defined in the NPPF;
- Consideration of appropriate Site-specific flood risk mitigation measures; and,
- Development of an outline SuDS strategy to mitigate the potential increase in runoff and deterioration in water quality as well as providing amenity and biodiversity benefits.

1.4. Data sources

The main sources of data utilised in this assessment are summarised below:

- A topographical survey of the Site;
- Proposed Site development plans as provided by the Client;
- Site infiltration test data collected between 30th August and 1st September 2022;
- Site groundwater monitoring results from between October 2022 and April 2023;
- EA flood risk data;
- South Oxfordshire and Vale of White Horse Council Level 1 Strategic Flood Risk Assessment (SFRA) (JBA, 2024);
- Reading Borough Council Level 1 SFRA (WHS, 2024);
- Local standards and guidance for surface water drainage on major developments in Oxfordshire (Oxfordshire County Council, 2021);
- LiDAR digital terrain model (DTM) data;
- Ordnance Survey mapping; and,
- British Geological Survey (BGS) mapping.

1.5. Limitations

This report is written strictly for the benefit of the Client and bound by the conditions presented in Appendix A.

2. Site Description

2.1. Site setting and surrounding area

The Site is located to the northwest of Emmer Green, Reading (see Figure 2-1) with the majority within South Oxfordshire and small areas of the Site (parts of the access points in the south) falling within Berkshire. The National Grid Reference for the approximate centre of the Site is SU 71412 77098 and the nearest postcode is RG4 8QP.

Figure 2-2 presents an aerial image of the Site area showing the current layout and condition. The Site covers an area of approximately 5.9ha. and is currently a greenfield site - covered primarily with grass and trees comprising part of the northern half of the former Reading Golf Club.

The Site is bounded to the east by Kidmore End Road, and to the west by Highdown Hill Road. Cucumber Wood is located just north of the Site. More of the former Reading Golf course is located to the north and south of the Site. Residential properties are located to the east and west of the Site.

Figure 2-1 Site location

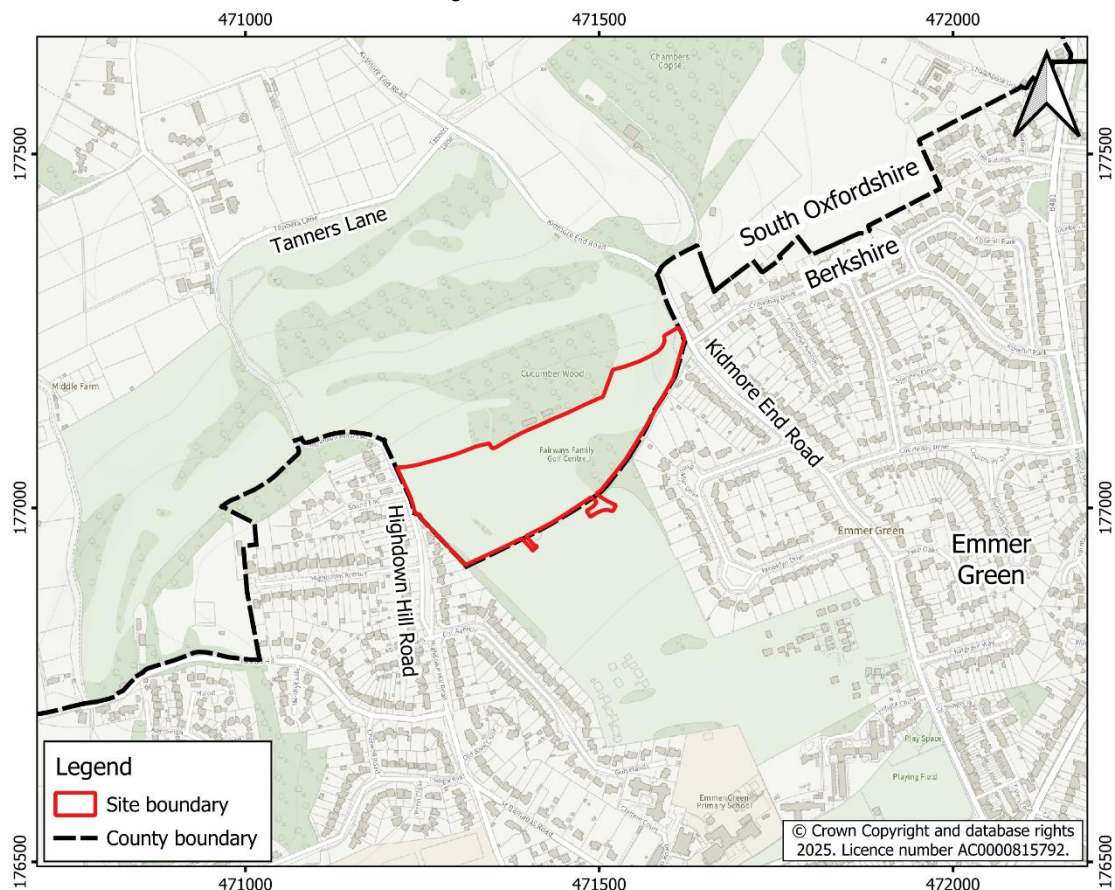


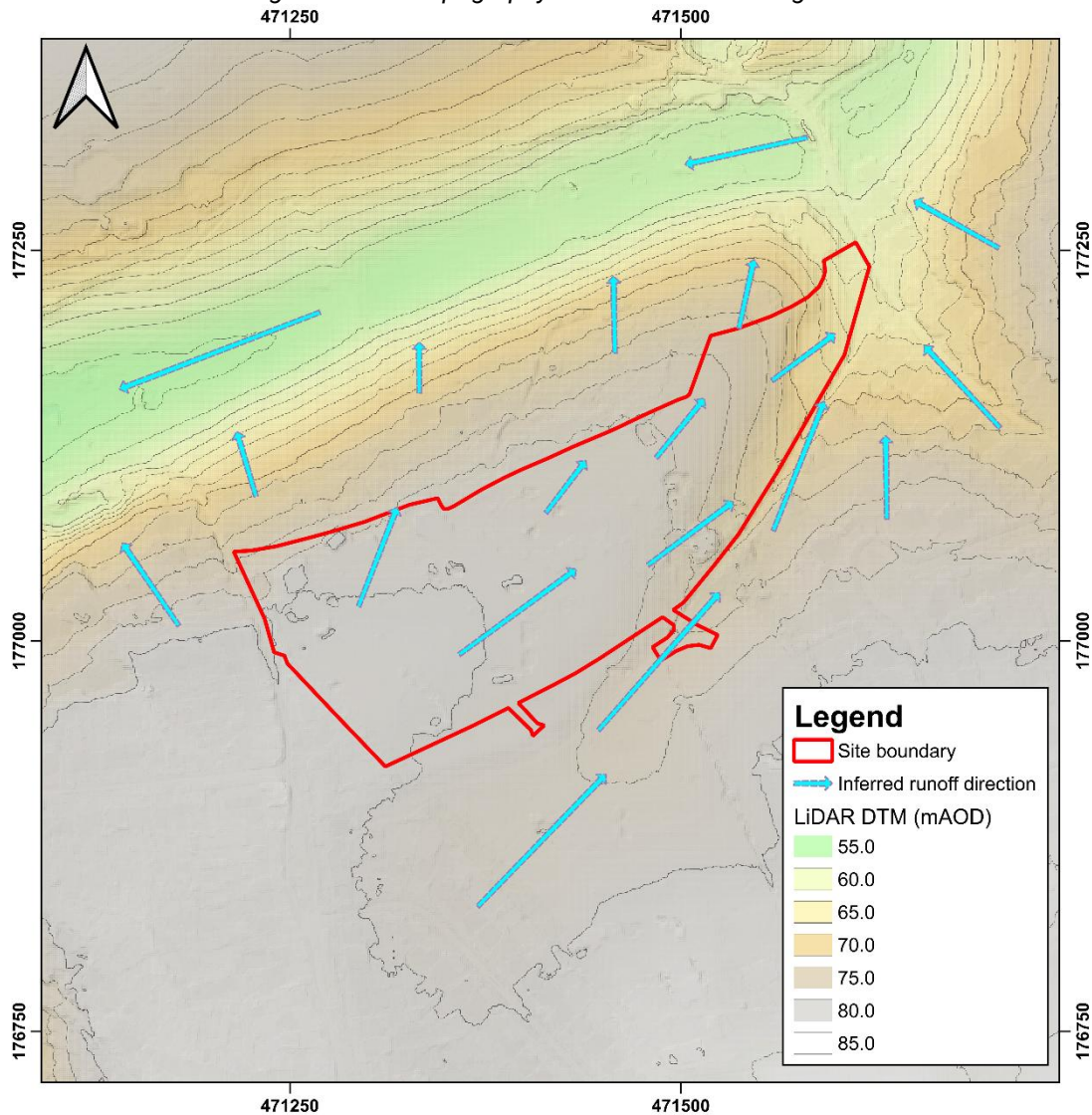
Figure 2-2 Existing Site layout



2.2. Topography

The general ground elevation at the Site falls from approximately 80.5m above Ordnance Datum (m aOD) in the southwest to approximately 62.0m aOD in the northeast. A figure showing LiDAR topographical data is included in Figure 2-3 and a topographical Site survey is presented in Appendix B. A large dry valley runs northeast to southwest just to the north of the Site and a minor valley feature is noted along the south-eastern Site boundary.

Figure 2-3 Site topography and current runoff regime



2.3. Geology and hydrogeology

The following information has been compiled from intrusive site investigation works undertaken in 2022 (trial pitting and soakaway testing – see below and Appendix D) and British Geological Survey (BGS) 1:50,000 scale mapping.

The geological sequence underlying the Site is as follows:

- Soil: The soil on-Site during trial pitting was noted as being typically 0.05-0.10 m thick grass-covered topsoil with abundant rootlets.
- Superficial deposits: Black Park Gravel Member (sand and gravel) present in the western area of the Site (see Figure 2-4). This was described during trial pitting as dark brown, gravelly sand to sandy gravel.
- Solid geology: White Chalk under the entire Site. Typically encountered during trial pitting as structureless chalk, composed of off-white, slightly clayey gravel.

The Black Park Gravel Member is classified as a 'Secondary A' Aquifer. These are described by the EA as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

The underlying White Chalk bedrock is classified as a Principal Aquifer. These are described by the EA as layers of rock that have high intergranular and/or fracture permeability, meaning they usually provide a high level of water storage and transmission. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifers.

The White Chalk on Site is classed by the BGS as being at Medium-High vulnerability with Soluble Rock Risk. The Site is located within Zone 3 ('Total Catchment') of a groundwater Source Protection Zone (SPZ).

The log for BGS borehole SU77NW68 located along the northern boundary of the Site gives a depth to groundwater in the White Chalk of 44m bgl in February 1991. On-Site groundwater monitoring results are included in Section 2.3.2.

2.3.1. Soakaway test results

Soakaway testing was undertaken in six locations shown on Figure 2-4. Full details of the site work and results are presented in Appendix D.

Infiltration test results are presented in Table 2-1. Infiltration was observed in each exploratory position, with the calculated average infiltration rates ranging between 0.05-2.26m/hr. No seepages or groundwater strikes were noted in any of the exploratory positions during trial pitting. Several of the localities drained away within 10 minutes (TP02 and TP06) and these results may therefore not be typical of actual drainage characteristics for the majority of the Site.

Figure 2-4 BGS Superficial deposits map and soakaway test locations at the Site

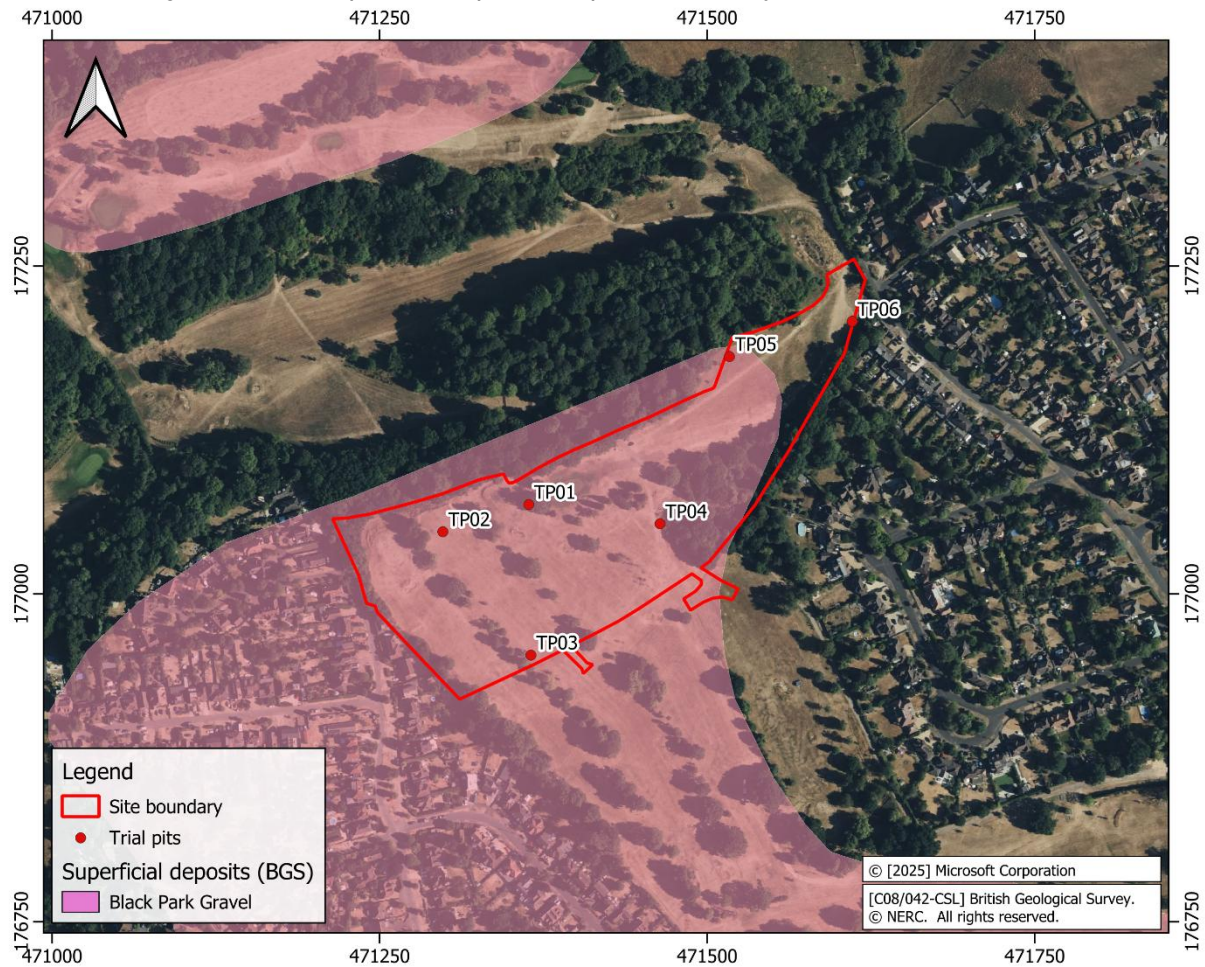


Table 2-1 Infiltration testing results

Trial pit	Test	Depth of pit (m)	Geology of test section	Permeability (m/hr)	Average (m/hr)
TP01	1	2.9	Black Park Gravel Member	0.24	0.20
	2	2.6		0.16	
	3	2.23		0.18	
TP02	1	2.84	Black Park Gravel Member	6.23	2.26
	2			0.30	
	3			0.25	
TP03	1	3.0	Black Park Gravel Member	0.21	0.14
	2	2.5		0.11	
	3	2.2		0.08	
TP04	1	3.0	Black Park Gravel Member	0.04	0.05
	2			0.03	
	3			0.08	
TP05	1	2.94	White Chalk	0.30	0.32
	2			0.33	
	3			0.32	
TP06	1	2.9	White Chalk	1.92	1.41
	2			1.13	
	3			1.18	

2.3.2. Groundwater monitoring results

Upon completion of the soakaway testing, selected trial pits at the uppermost, mid and lowest elevations (TP02, TP04 and TP06) were backfilled with clean single sized gravel with a 50 mm diameter monitoring standpipe and raised cover. Water level data loggers were installed in each of the monitoring standpipes to enable continuous groundwater monitoring with regular manual dips for calibration.

Groundwater levels were monitored between October 2022 and June 2023. The results indicate that TP02, which is located at the highest elevation, remained dry for the duration of the monitoring period. Limited groundwater was recorded in the base of TP04 and TP06 by manual dips (approximately 3m bgl). Full results of the groundwater monitoring are presented in Appendix D.

2.4. Climate

The Standard Average Annual Rainfall (SAAR) for the Site area is 670 mm per annum (mm/a) (CEH, 2025).

2.5. Hydrology

The local area of the Site comprises dry valleys (see Figure 2-3). Given the high permeability of the area and depth to groundwater, there are no surface water features in the vicinity of the Site. The nearest surface water feature is Emmer Green pond located approximately 540m south-east of Site.

2.6. Current drainage arrangements

The Site is currently greenfield. At present, the Site does not have a formal drainage system and surface water runoff will either infiltrate or flow overland with the topography. However, as the Site is laid to grass with vegetated borders in a chalk catchment, runoff is likely to be of a very low order of magnitude. Hydrological descriptors for the Site are provided in Table 2-2.

Table 2-2 Hydrological point descriptors

Descriptor	Value
NGR	SU 71433 77066
Bfihost19	0.828
Propwet	0.290
SAAR6190	670m

3. Proposed Development

The illustrative masterplan for the Site is provided in Appendix C. The proposal is for a residential led development including up to 70No. dwellings with green spaces, access roads and parking facilities. The Site will be accessed via two vehicular / pedestrian access routes at the south of the Site.

A grassed attenuation basin will be positioned in the central-northern of the Site to manage Site water runoff. This will discharge to a two-section swale to the east (see Section 8).

The proposed development will change the use of the Site from greenfield to residential, therefore the Site's flood risk vulnerability classifications would change from "Water compatible / Less vulnerable" to "More vulnerable".

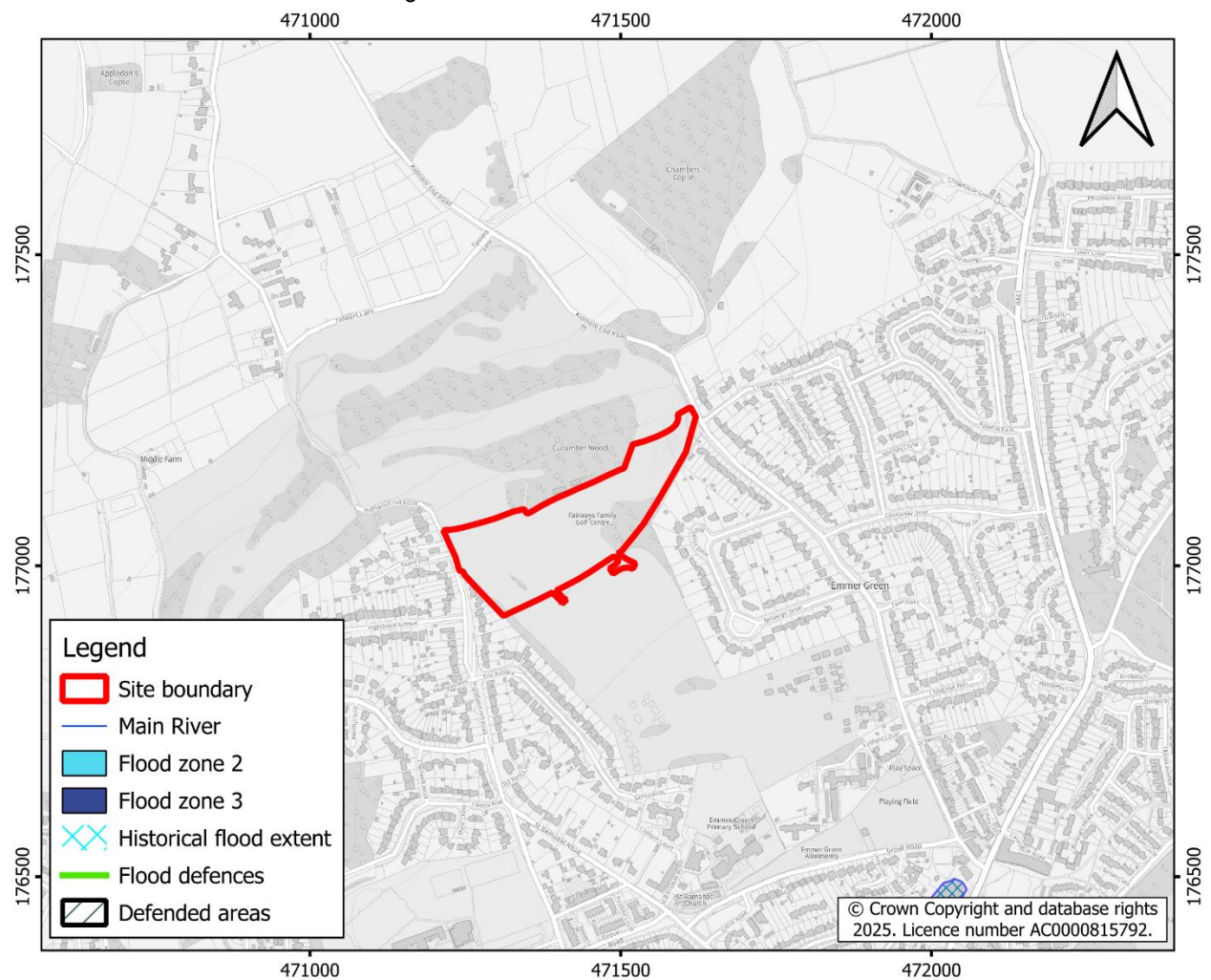
A total lifespan of 100 years has been considered within this assessment.

4. Flood Risk to the Development

4.1. Rivers and Seas

The EA's Flood Map for Planning (see Figure 4-1) indicates that the Site is located entirely in Flood Zone 1, and as such has a Low Probability of flooding from rivers and the sea (i.e. less than a 0.1% annual probability of flooding from these sources). As such, the risk to the proposed development from flooding from rivers or the sea is not considered further.

Figure 4-1 EA Fluvial Flood Risk Data



4.2. Surface Water

Surface water (pluvial) flooding is usually associated with extreme rainfall events but may also occur when rain falls on land that is already saturated or has a low permeability. Rainfall that is unable to infiltrate into the ground generates overland flow which can lead to flooding or 'ponding' in localised topographical depressions before the runoff is able to enter local drainage systems and watercourses.

A map of EA's Risk of Flooding from Surface Water (RoFSW) data is shown in Figure 4-2, and the risk of surface water flooding reaching or exceeding a depth of 0.2 m is shown in Figure 4-3. This data includes the 'Central' climate change allowance for the 2050s epoch (2040-2060).

The majority of the Site is at negligible risk of surface water flooding. The only exception is a small (c. 65 m²) area at the southern section of the Site, at the Site's primary access route, with a Low (<1% annual chance) risk of surface water flooding. The majority (c. 50 m²) of this area has a Negligible risk of reaching/exceeding a flood depth of 0.2 m, with the rest having a Low risk.

The Site is not thought to be within a Critical Drainage Area (CDA) based upon the setting, although it is not defined in the SFRA (JBA, 2024) and the Surface Water Management Plan (SWMP) could not be found on the Council's website. The Site would drain to SuDS features and infiltrate to ground post development in any case, as detailed in Section 8.

Figure 4-2 Flood Risk from Surface Water (with climate change allowance)

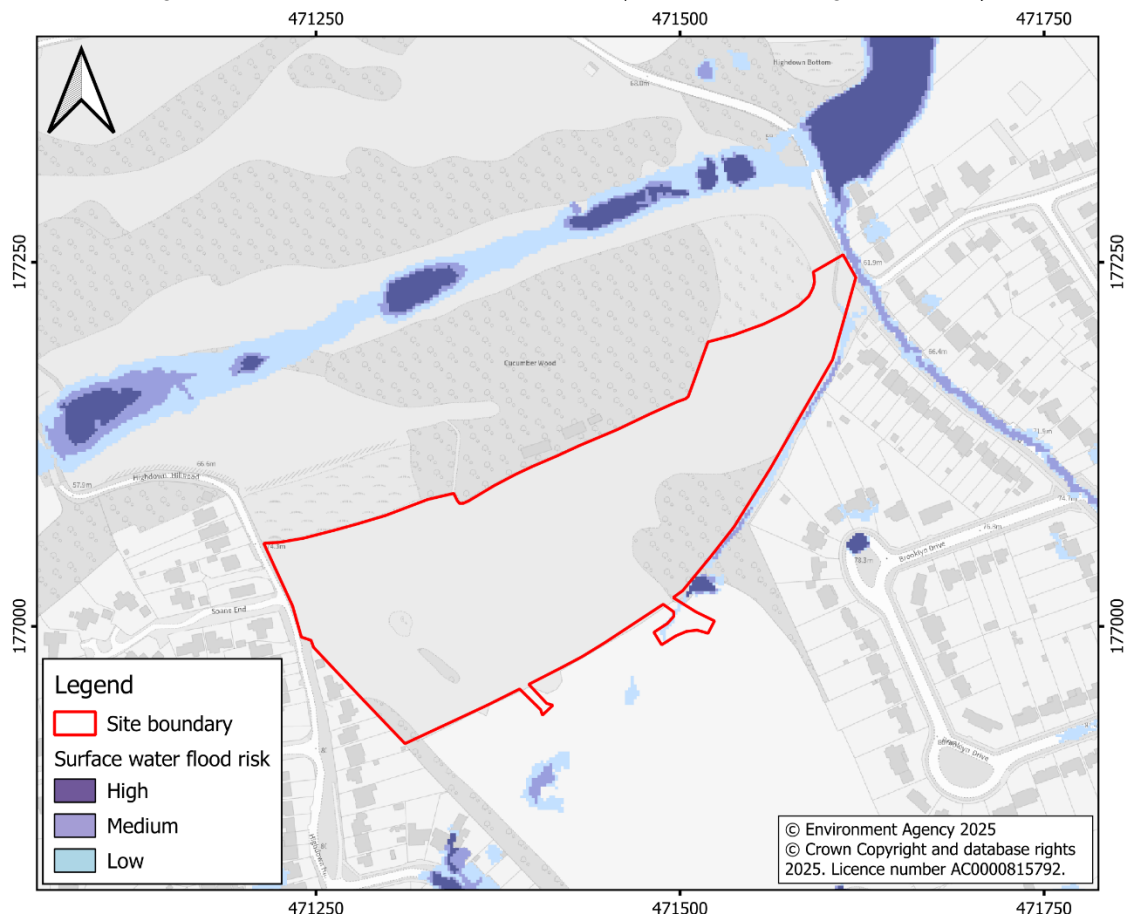
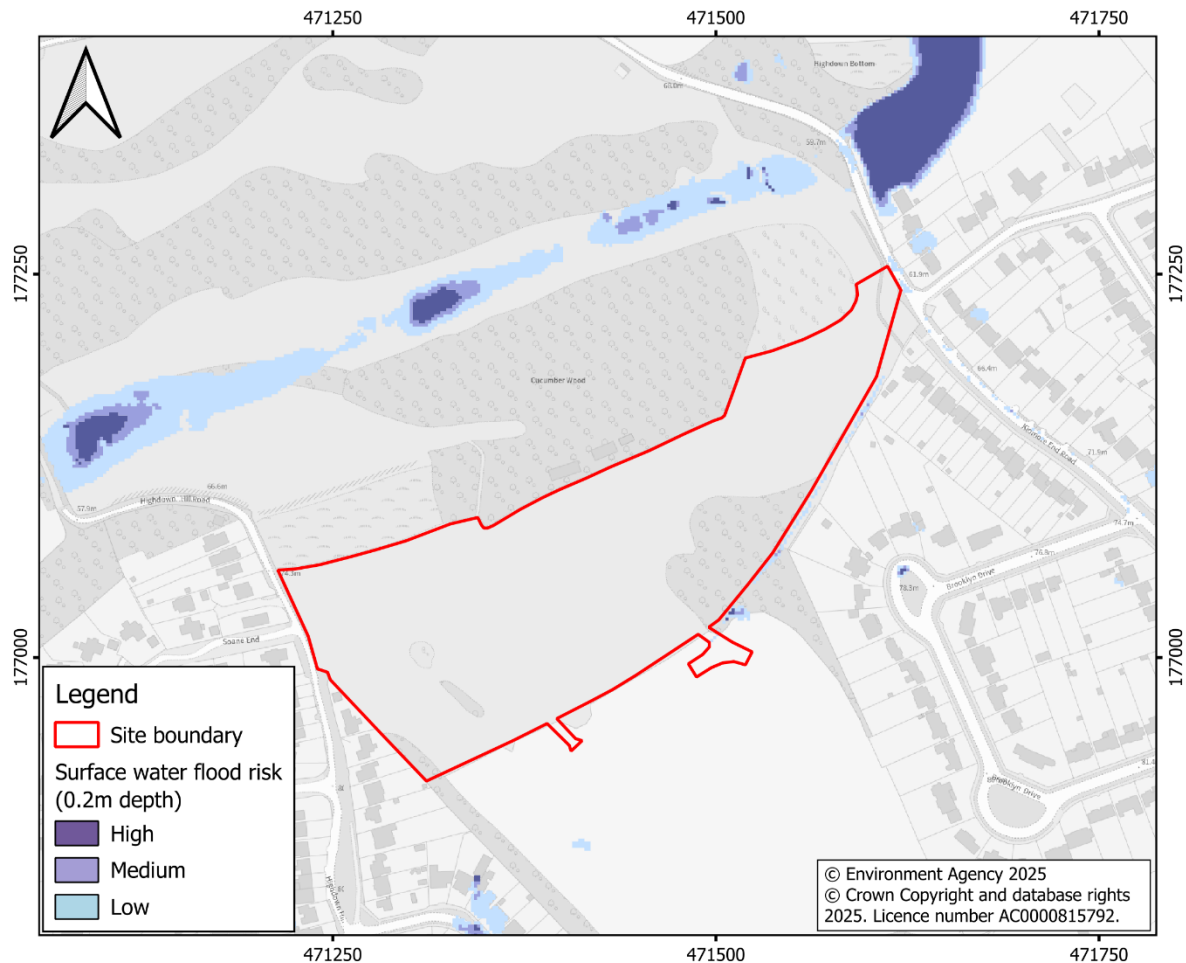


Figure 4-3 EA surface water flood depth risk (0.2m; with climate change allowance)



4.3. Groundwater

Groundwater flooding is caused by the natural emergence of water at surface level originating from underlying permeable sediments or rocks (aquifers). The groundwater may emerge as one or more-point discharges (springs) or as diffuse upwelling of water over an extended area. Groundwater flooding tends to be more persistent than other sources of flooding, typically lasting for weeks or months rather than hours or days. Groundwater flooding does not generally pose a significant risk to life due to the slow rate at which the water level rises, however it can cause considerable damage to property, especially in urban areas.

Groundwater flood risk mapping provided in the SFRA (JBA, 2024) indicates that the entire Site area is at a Low risk of groundwater flooding (groundwater >5m below the surface elevation in the 100-year return period flood event). Groundwater monitoring results (see Section 2.3.2) support the Low risk assessment, given the observed groundwater levels of at/below approximately 3m bgl.

4.4. Sewers

Sewer flooding can occur during periods of intense rainfall and/or if a sewer becomes blocked with debris. The Site is not currently served by a sewer system but is adjacent to some residential streets which would be.

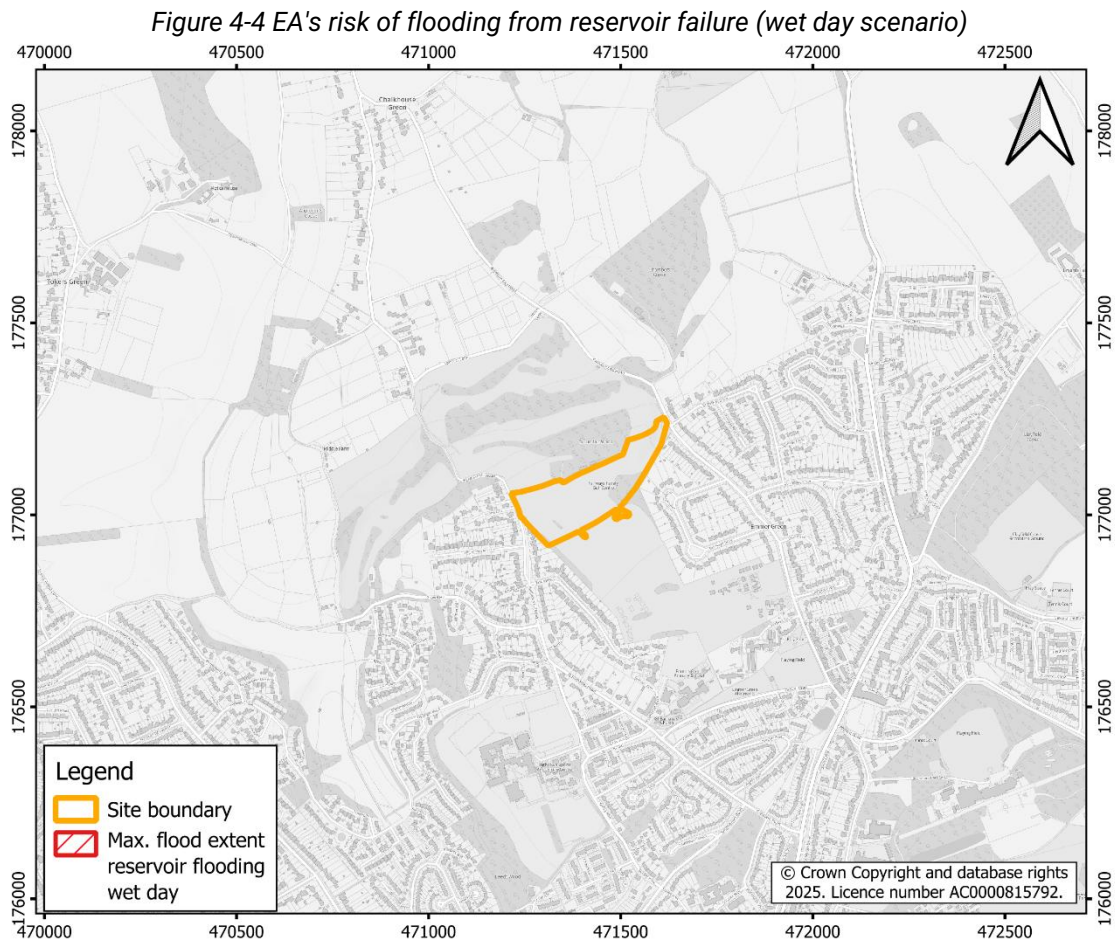
The South Oxfordshire's SFRA (JBA, 2024) does not list the Site's area as having experienced sewer flooding. However, the Reading Borough's SFRA (WHS, 2024) holds Thames Waters' sewer flood records, which indicate a total of 22 sewer flood incidents in the Site's 'RG4' postcode between 1989-2024.

Therefore, the sewer flood risk at the Site is deemed to be Low.

4.5. Reservoirs

This section considers catastrophic failures of water bearing infrastructure in the area of interest.

The risk of reservoir flooding is related to the failure of a large water storage reservoir. The Site is not at risk of flooding in the event of reservoir failure according to EA data. No canals or other significant water bodies exist in close proximity to the Site.



4.6. Historical Flooding

The EA database of historical flooding (see Figure 4-1), South Oxfordshire SFRA (JBA, 2024), and Reading Borough SFRA (WHS, 2024) contains no records of historical flooding occurring at the Site or in the local vicinity.

5. Suitability of the Development

5.1. Sequential Test

The Sequential Test, outlined in the PPG for Flood risk and Coastal Change, identifies that developments should be directed to areas at the lowest probability of flooding.

The entire Site is within Flood Zone 1 and is at a low risk of flooding from other sources. The development is classified as "More Vulnerable" with regards to flood risk. According to the NPPF (see Table 5-1), "More Vulnerable" site use is considered appropriate within Flood Zones 1 and an Exception Test is not required.

Therefore, the Sequential Test is considered passed.

Table 5-1 Flood risk vulnerability and flood zone compatibility.

Flood risk vulnerability classification	Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Zone 1 (low probability)	✓	✓	✓	✓	✓
Zone 2 (medium probability)	✓	✓	Exception Test required	✓	✓
Zone 3a (high probability)	Exception Test required	✓	✗	Exception Test required	✓
Zone 3b (functional floodplain)	Exception Test required	✓	✗	✗	✗

✓ Development is appropriate.

✗ Development should not be permitted.

5.2. Sequential development

Where flood risk is present to varying degrees across a Site, layouts should be tailored to ensure the most sensitive parts of a development are located in parts of the Site least at risk of flooding. The only elevated flood risk at the Site is due to small area of surface water flood risk at the Site's primary access that will be mitigated post-development by the implementation of drainage infrastructure (see Section 8).

6. Flood Risk from the Proposed Development

The National Planning Policy Framework (NPPF) stipulates that all new developments must be “safe, without increasing flood risk elsewhere”. As such the following stipulations are provided in the EA guidance for managing rainfall runoff (Environment Agency, 2013):

- Stormwater runoff rates and volumes discharged from urban developments should approximate to the Site greenfield response over a range of storm frequencies of occurrence (return periods).
- Runoff for extreme events should be managed on-site. This requires:
 - the peak rate of stormwater runoff to be limited;
 - the volume of runoff to be limited;
 - the pollution load to receiving waters from stormwater runoff to be minimised; and,
 - the assessment of overland flows and temporary flood storage across the Site.

The Sustainable Drainage Strategy for the Site (see Section 8) has been designed in such a way as to prevent any increase in runoff from the Site under a range of design storm scenarios. This includes suitable allowances for future increases in rainfall intensity caused by climate change.

7. Flood Risk Mitigation Measures

7.1. Key considerations

To meet the PPG requirements, all land uses will be considered appropriate for location within Flood Zone 1 provided the following additional requirements are met:

- Remains safe in times of flooding whilst taking climate change into account;
- Does not result in a net loss of floodplain storage;
- Does not impede existing water flow pathways; and,
- Does not increase the volume and rate of surface water runoff leaving a site over its intended design lifetime.

Each of these requirements is discussed in relation to the proposed development in Sections 7.2 to 7.5 below.

7.2. Remain safe in times of flooding

The development area is considered to be at low to negligible risk of flooding from all sources. Therefore, no specific mitigation measures are deemed necessary.

7.3. No net loss of floodplain storage

The proposed development would not result in a net loss of river floodplain storage as the development area is not shown to be within the floodplain.

7.4. No impediments to flood water flows

The proposed development would not result in any impedance of flood flows. The Site is not within a floodplain nor is it intersected by a surface water flowpath.

7.5. No increase in the volume and rate of surface water runoff

The Sustainable Drainage Strategy discussed in Section 8 would ensure that runoff rates and volumes are not increased as a result of the proposed development.

8. Outline Sustainable Drainage (SuDS) Strategy

8.1. Introduction

The following sections describe the outline SuDS Strategy for the proposed development with due regard to DEFRA's Non-Statutory Technical Standards for SuDS (DEFRA, 2015); the CIRIA SuDS manual and the local standards and guidance for surface water drainage Oxfordshire (Oxfordshire County Council, 2021)

The proposed residential development will be located on largely previously undeveloped, 'greenfield' land. A proportion of the Site would comprise impermeable areas following its development (for example, rooftops and roads). Without appropriate management, this would result in an increase in both the volume and rate of surface runoff generated by the Site, which could lead to an increase in surface water flood risk elsewhere (i.e. downstream). Surface runoff from the developed Site will, however, be sustainably managed using SuDS, as described in the following sections.

SuDS aim to mimic the natural drainage characteristics of a site prior to its development by controlling surface water runoff as close to where the rain falls as possible e.g. through interception and re-use, evaporation and infiltration into the ground. Furthermore, SuDS provide opportunities to remove pollutants from runoff and also provide amenity and biodiversity benefits.

8.2. Greenfield runoff and permissible discharge rates

All runoff from the development area will be discharged to ground post-development (as described in the following Sections). The greenfield runoff rate has been calculated below, for completeness.

The Institute of Hydrology Report 124 (IH124) method in the 'Rural Runoff' calculator within MicroDrainage was utilised to estimate the greenfield runoff rates for the existing Site (see Appendix C). The calculation was carried out for an assumed Site area of 50ha, with the rate then pro-rated per unit area (as recommended in the Interim Code of Practice for SuDS Design and Environment Agency/DEFRA Report: Rainfall-Runoff Management for Developments (Environment Agency, 2013). The 'QBAR' (i.e. 1 in 2.3 year return period) greenfield runoff rate for the Site was thus determined along with runoff rates for other return period storm event using the regional growth curve (see Table 8-1).

Table 8-1 Greenfield runoff

Return period (yrs)	Runoff rate (l/s)
1	1.8
2.3 (Qbar)	2.1
30	4.7
100	6.7

The Oxfordshire County Council guidance for surface water management (Oxfordshire County Council, 2021) recommends using either the greenfield QBAR runoff rate or 2 l/s/ha (whichever is greater) as

the 'permissible discharge rate' for new developments. As such, a 10.34 l/s (5.17ha * 2l/s/ha) 'permissible discharge' rate may be assumed in this instance.

8.3. Runoff destination and proposed SuDS layout

The future Outline SuDS Strategy for the proposed development will be developed with due regard to DEFRA's Non-Statutory Technical Standards for SuDS (DEFRA, 2015) and local standards and guidance for surface water drainage on major developments in Oxfordshire (Oxfordshire County Council, 2021), which recommend the following hierarchy for the disposal of surface water from new developments:

1. Discharge to ground via infiltration techniques (most preferred)¹;
2. Discharge to a surface water body;
3. Discharge to a surface water sewer;
4. Discharge to a local highway drain; and,
5. Discharge to a combined sewer (least preferred).

On-Site testing (following the BRE Digest 365 methodology) has been undertaken which confirms the underlying geological sequence as being a suitable receptor(s) for surface water discharge (see Section 2.3.1).

It is noted that dissolution of the White Chalk and the reactivation of existing solution features is a potential hazard in this area. However, it is considered that the risk of significant collapse occurring is likely to be reduced based on the limited thickness of the Black Park Gravel Member on Site. At this stage, discrete point soakaways have been avoided in close proximity to buildings and a suitable minimum standoff (20m) has been included between the infiltration feature (i.e. the eastern swale) and the nearest houses and infrastructure within the Outline SuDS Strategy (in accordance with CIRIA guidance C574 - Engineering in the chalk).

The depth to groundwater at the Site is expected to be a minimum of c. 2.85m bgl as indicated by on-Site data collection. This would yield a suitably thick unsaturated zone beneath the Site.

There are no watercourses with 1 km of the Site boundary. Therefore, discharging surface water to a watercourse is not a viable option in this instance.

Whilst discharge to sewer may be feasible this is not a preferred option unless infiltration drainage is not deemed suitable.

Water recycling is recommended in the form of water butts but rainwater harvesting cannot be relied on for stormwater management unless sophisticated "smart" systems are employed to ensure storage features are empty ahead of incoming storm events.

Water will pass through a number of SuDS features before discharging to ground. These include a large attenuation basin, a high-capacity, lined swale and permeable paving distributed throughout the Site. These features will slow the progress of water to the discharge point, provide attenuation capacity as well as amenity, water quality and biodiversity benefits.

The post-development Site has been sub-divided into three catchment areas that will each drain via gravity to one of the principal SuDS features (the Attenuation basin or Western swale). Note that the Western swale will ultimately drain to the Eastern swale and discharge to ground via this feature. These

¹ On-site water reuse is now also considered to be a preferred method for surface water disposal.

sub-catchments have been delineated based on the development layout plan included in Appendix C and LiDAR Digital Terrain Model (DTM) data.

Figure 8-1 Catchment areas serving the proposed SuDS features

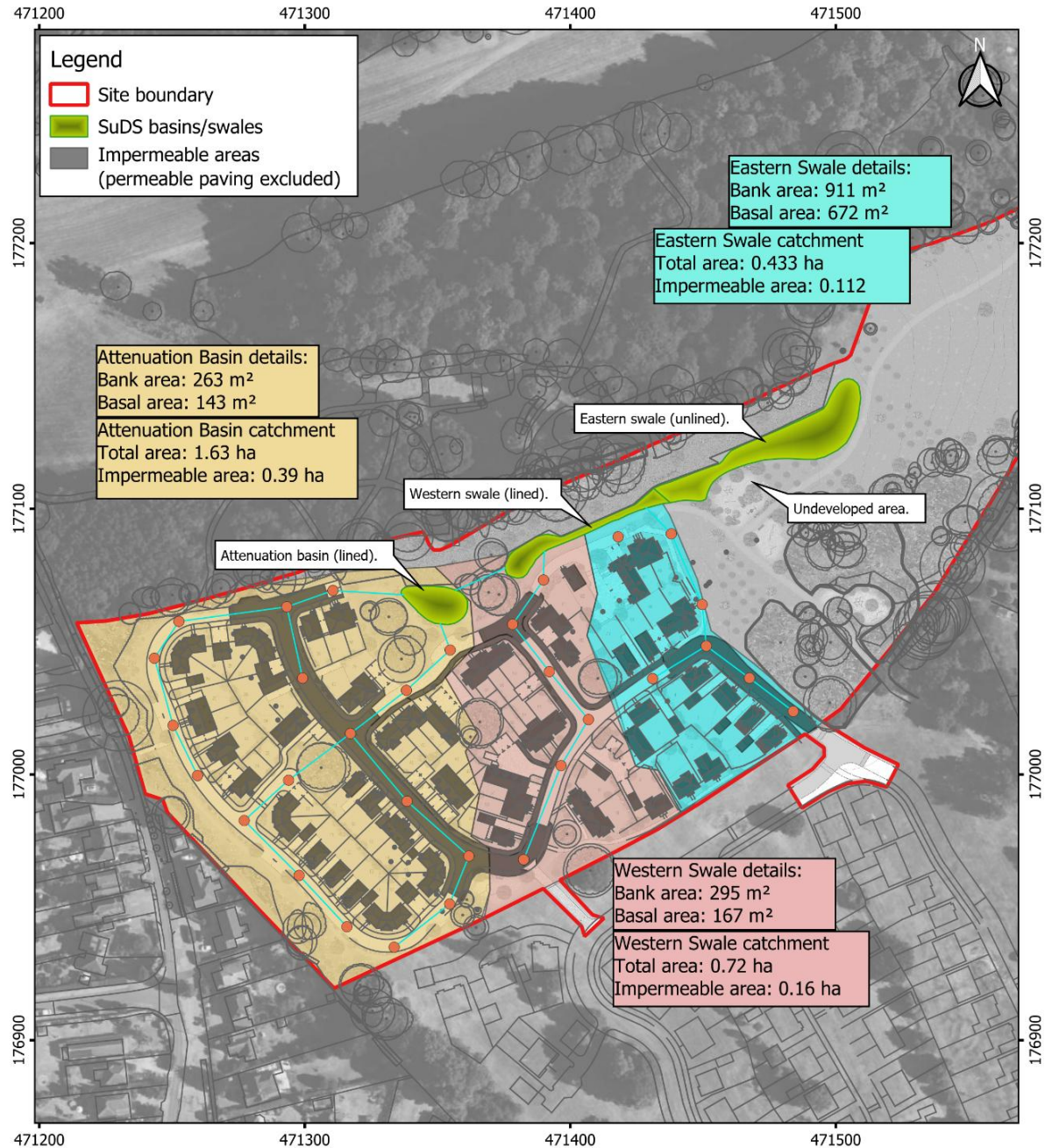
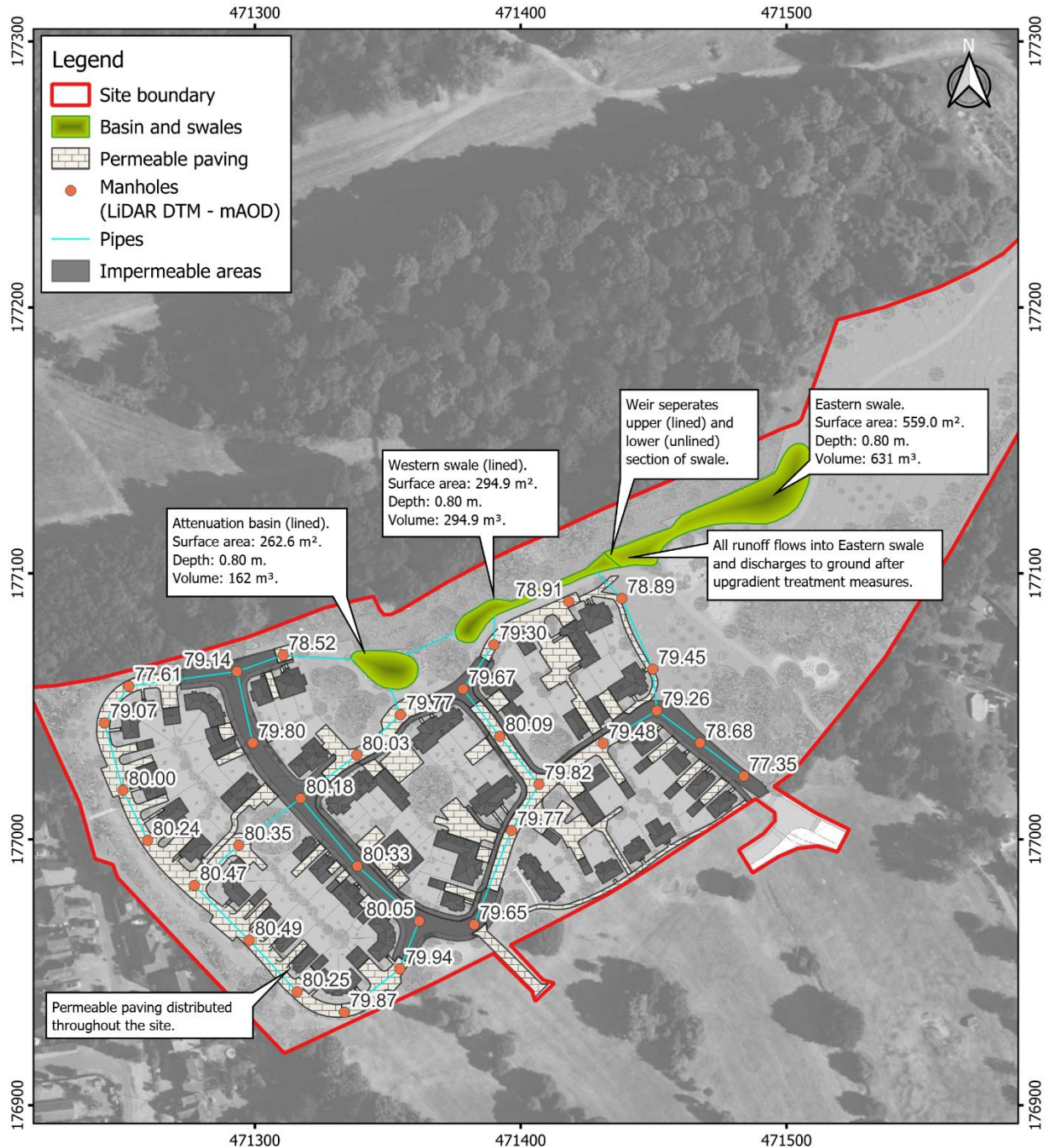


Figure 8-2 Outline drainage strategy



The initial drainage network has been drafted based upon the outline development plan and the current topography (see Figure 8-2). Indicative key node (manholes or inspection chambers) locations are included in Figure 8-2 along with current ground levels at each location (extracted from LiDAR data).

Some land reprofiling may be required to accommodate a gravity driven drainage system from the southern part of the Site to the attenuation basin. There is a gradient to the east across the majority of Site and this is unlikely to be problematic given the topography of the area. This will be considered in greater details during the detailed design phase

8.4. SuDS features design and performance calculations

The initial design of the SuDS features has been undertaken using the Causeway “Flow” v 14 industry standard software. Simulations were run for the 1 in 30-year event plus a 35% CCA and the 1 in 100-year event plus a 40% CCA (as defined by the EA for the Thames and South Chilterns Management Catchment for the 2070s epoch).

Hydrological descriptors for the Site were obtained from the Flood Estimation Handbook (FEH) website (CEH, 2025). These are shown in Table 8-2 below.

Table 8-2 FEH Hydrological Descriptors

Catchment Descriptor	Abbreviation	Value
Base Flow Index associated with each HOST soil class	BFIHOST19	0.828
Proportion of time when soil moisture deficit was equal to, or below, 6mm during 1961-90	PROPWET	0.29 (i.e. 29% of the time)
Average Annual Rainfall (1961 – 1990)	SAAR	670 mm

GIS software was used to calculate the total area within the sub-catchment draining to each SuDS feature as well as the impermeable area within each (see Table 8-3 below). Note that the impermeable area values have been uplifted by 12% in the calculations to account for urban creep and a small amount of runoff from residual green spaces.

Table 8-3 Catchment areas draining to each SuDS feature

Catchment	Total area (ha)	Contributing impermeable runoff area in catchment(ha)	Uplifted areas used in calculations (ha)
Attenuation basin (lined)	1.63	0.39	0.437
Western swale (lined)	0.72	0.16	0.179
Eastern swale (unlined)	0.43	0.11	0.123

The dimensions/ details of each SuDS feature are presented below (see Table 8-4). The infiltration rate for the attenuation basin and western swale SuDS features was set to zero, as these features will be lined and used for attenuation and water treatment functionality within the on-Site SuDS train. The infiltration rate for the eastern swale was set to 0.194m/hr (with a suitable safety factor), which represents the mean of the final test values for the three most proximal test locations (TP01, TP04 and TP05). All runoff from the development area would ultimately discharge to ground post-development.

The infiltration and storage potential of the permeable paving has not been explicitly included in the modelling process at this stage, but the areas proposed to be covered with permeable paving were excluded in the overall impermeable area values used in the calculations. These features can be included in greater detail within the detailed drainage design calculations.

Note that the Site has a gradient to the east so some check dams within the swales would maximise the storage capacity available. This fine tuning of the scheme can be achieved during the detailed

design phase. Sloping features (i.e. with a representative longitudinal gradient) have been included in the calculations to represent the reduced storage capacity available.

Appendix E contains the output from the drainage model simulations. This confirms that, based on the parameters described above, the proposed drainage scheme will be able to manage all runoff generated during the 1 in 100 year storm event with a 40% allowance for climate change. The simulated maximum water levels over 300 mm below of the bank level for each of the SuDS features under the 1 in 30 year +CCA event. A summary of the performance of each feature is included in Table 8-5.

Table 8-4 Details of SuDS features

Feature	Feature Depth (m)	Longitudinal gradient	Side slopes	Area of base (m ²)	Surface area at bank (m ²)	Total volume (m ³)	Outfall	Outfall elevation (m aOD)
Attenuation basin (lined)	0.80	1:300	1:3	143	263	162	Dual orifice (Ø150 mm)	77.88
Western swale (lined)	0.80	1:94	1:3	167	295	184	Orifice (Ø150 mm)	78.73
Eastern swale (unlined)	0.80	1:62	1:3	725	909	488	None	m/a

Table 8-5 Performance of the SuDS features within drainage calculations.

Feature	Critical duration (mins)	Max. water level (m aOD)	Min. freeboard remaining (m)	Half drain time (mins)
T30+CCA				
Attenuation basin (lined)	30 (summer)	79.19	0.33	36
Western swale (lined)	60 (summer)	78.22	0.46	51
Eastern swale (unlined)	120 (summer)	76.87	0.43	90
T100+CCA				
Attenuation basin (lined)	60 (summer)	79.34	0.19	36
Western swale (lined)	60 (summer)	78.27	0.41	51
Eastern swale (unlined)	120 (Winter)	76.97	0.19	90

* Estimated peak elevation near outfall to detention basin.

It should be noted that the Flow model calculations for the SuDS features are conservative, as they assume that these are the only SuDS features that will serve the proposed development. As the detailed layout plan evolves, it will be possible to include further SuDS techniques within the development layout in order to enhance the 'SuDS Management Train'. Techniques such as rainwater capture and re-use and bio-retention areas will be considered during the development of the detailed layout to maximise water efficiency, water quality, biodiversity, health and wellbeing, and amenity benefits.

8.5. Exceedance routes

The available freeboard within each feature will ensure that their respective capacity will, in reality, be somewhat greater than the 1 in 100-year (plus 40% for climate change) event. Due consideration, however, also needs to be given to the exceedance routes that could occur during events above the design standard of the various components of the proposed SuDS Strategy (i.e. surface water sewers, swale and the detention basin).

Figure 8-3 shows exceedance routes for two scenarios:

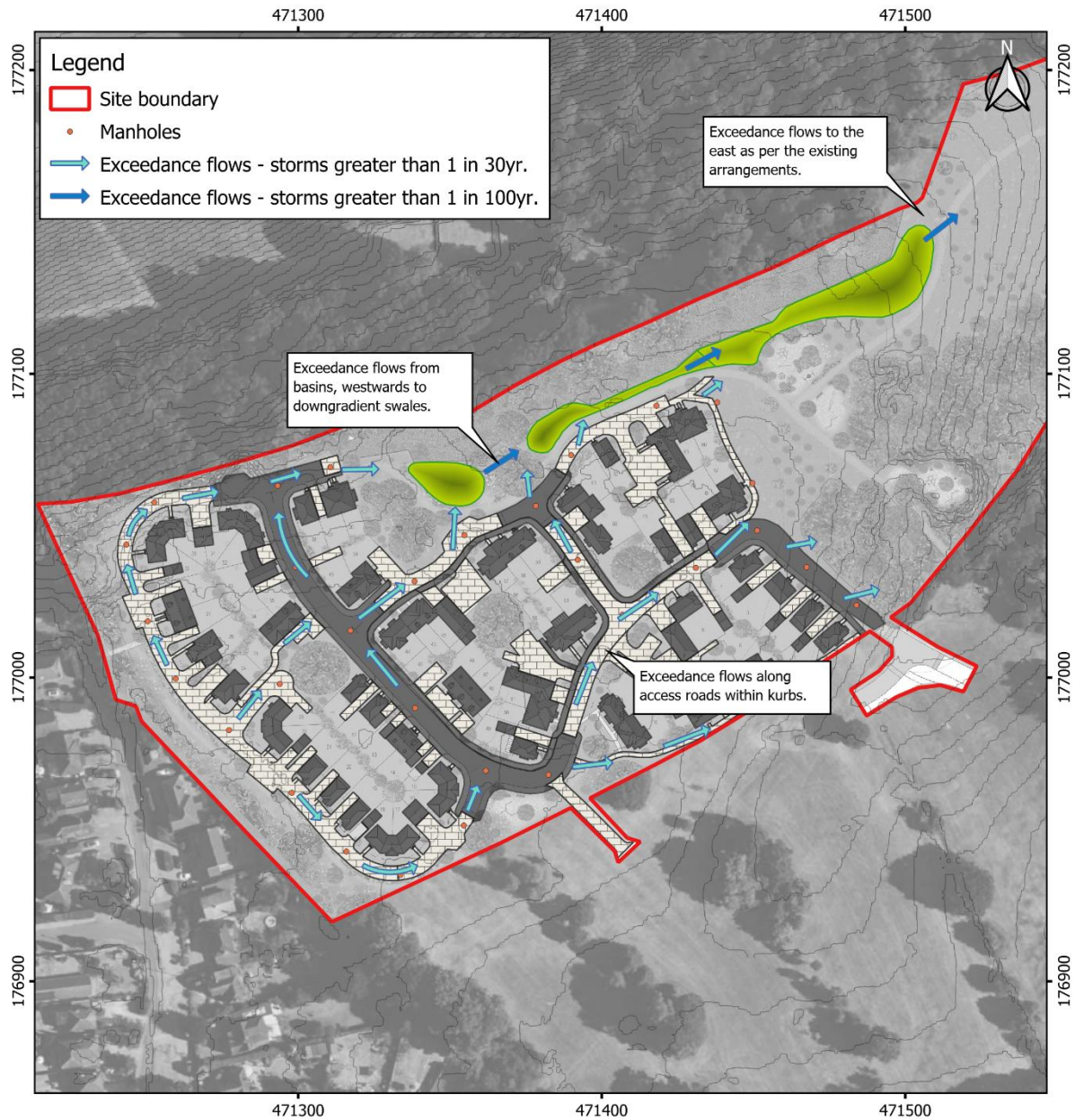
- Surcharging water from the proposed surface water sewers under storm conditions ranging from the 1 in 30-year event to the 1 in 100-year event plus climate change.

Under this scenario, water would surcharge from manholes/inspection chambers and be conveyed along the road surfaces to the Attenuation basin and swales. These exceedance routes have been calculated using the proposed stormwater drainage routes (see Figure 8-2) and the existing LiDAR DTM data. These exceedance flows would be shallow and contained within road kerbing. Exceedance flows via southeastern area would runoff to the green areas to the southeast to the preferential flowpath indicated in Figure 2-3.

- Over-topping of the SuDS features under events well in excess of the 1 in 100 year plus 40% return period - which has been used for the feature design in this instance.

Under these extreme events, exceedance flows from the SuDS features will runoff along the existing preferential surface water runoff direction (i.e. to the east).

Figure 8-3 Exceedance flow routes



8.6. Water quality

SuDS techniques can be used to effectively manage the quality of surface water flowing across a site. Different methods can be used to intercept pollutants and allow them to degrade or be stored in-situ without impacting the quality of water further downstream. Frequent and short duration rainfall events are those that are most loaded with potential contaminants (silts, fines, heavy metals and various organic and inorganic contaminants). Therefore, the first 5mm to 10 mm of rainfall (i.e. the 'first flush') should be adequately treated using SuDS.

The proposed development will include residential dwellings, low traffic roads and driveways. The CIRIA SuDS manual categorises runoff from residential dwellings as presenting a very low water quality hazard and runoff from low usage roads and residential driveways as presenting a low hazard rating (see Table 8-6).

Table 8-6 Water quality hazard ratings (CIRIA, 2015)

Land use	Hazard level
Residential roof drainage	Very Low
Residential, amenity uses including low usage car parking spaces and roads, other roof drainage.	Low
Commercial uses including car parking spaces and roads (excluding low usage roads, trunk roads and motorways).	Medium
Sites with heavy pollution (e.g. haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemical and fuels (other than domestic fuel oil) are delivered, handled, stored used or manufactured, industrial sites.	High
Trunk roads and motorways	High

Site runoff will infiltrate to ground via the infiltration features set out in Section 8.3 (primarily via the swale/ infiltration basin in the east).

The Site is within Zone 3 (total catchment area) of a Source Protection Zone. Adequate water quality treatment measures will therefore be required although the residential nature of the proposed development is not regarded as high risk in this regard.

The CIRIA SuDS manual (CIRIA, 2015) advocates a qualitative approach to designing a SuDS scheme for a site with a low hazard rating. This should provide adequate controls on pollutants contained in runoff water.

As the proposed development is residential in nature with a low hazard rating, hazard indices of 0.5 for total suspended solids (TSS), 0.4 for metals and 0.4 for hydrocarbons are considered applicable.

The measures detailed in

Table 8-7 are examples which are suitable for inclusion in a drainage strategy for a residential development to mitigate a potential increase in sediment load within on-site and off-site runoff – note text in bold are measures included in this SuDS Strategy. Removal indices are included for each feature type relative to the specific pollutant.

Table 8-7 Mitigation indices for SuDS components

Component Type	TSS	Metals	Hydrocarbons
Filter drain	0.4	0.4	0.4
Swale	0.5	0.6	0.6
Permeable paving	0.7	0.6	0.7
Detention basin	0.5	0.5	0.6
Pond	0.7	0.7	0.5

The results are presented in Table 8-8. The combination of SuDS features making up the proposed drainage scheme is considered suitable mitigation in this instance.

Sediment traps (i.e. sumps within the inspection chambers of the final manhole upstream of each feature) will be used to facilitate the maintenance of these features and reduce the build-up of potentially polluted material.

All runoff from roads will pass through at least one water treatment feature prior to discharging to ground (details to be included at the detailed design phase).

Table 8-8 Water quality assessment (SuDS manual)

SUMMARY TABLE		DESIGN CONDITIONS			
		1	2	3	4
Land Use Type	Residential parking				
Pollution Hazard Level	Low				
Pollution Hazard Indices					
TSS	0.5				
Metals	0.4				
Hydrocarbons	0.4				
SuDS components proposed					
Component 1	Pervious pavement (where the pavement is not designed as an infiltration component)	SuDS components can only be assumed to deliver these indices if they follow design guidance with respect to hydraulics and treatment set out in the relevant technical component chapters of the SuDS Manual. See also checklists in Appendix B			
Component 2	Detention basin	SuDS components can only be assumed to deliver these indices if they follow design guidance with respect to hydraulics and treatment set out in the relevant technical component chapters of the SuDS Manual. See also checklists in Appendix B			
Component 3	Swale	SuDS components can only be assumed to deliver these indices if they follow design guidance with respect to hydraulics and treatment set out in the relevant technical component chapters of the SuDS Manual. See also checklists in Appendix B			
SuDS Pollution Mitigation Indices					
TSS	>0.95				
Metals	>0.95				
Hydrocarbons	>0.95				
Groundwater protection type	Bioretention component underlain by 300 mm minimum depth of soils with good contamination attenuation potential	All designs must include a minimum of 1 m unsaturated depth of subsoil or aquifer material between the infiltration surface and the maximum likely groundwater level. Infiltration components should always be preceded by upstream component(s) that trap(s) silt, or designed specifically to retain sediment in a separate lined zone, easily accessible for maintenance, such that the sediment will not be re-suspended in subsequent events	The underlying soils must provide good contaminant attenuation potential (eg as recommended in Sniffer 2008 (a) and (b) / Scott Wilson (2010) or other appropriate guidance). Alternative depth and soil combinations must provide equivalent protection to the underlying groundwater		
Groundwater protection Pollution Mitigation Indices					
TSS	0.8				
Metals	0.8				
Hydrocarbons	0.8				
Combined Pollution Mitigation Indices					
TSS	>0.95				
Metals	>0.95				
Hydrocarbons	>0.95				
Acceptability of Pollution Mitigation					
TSS	Sufficient	Reference to local planning documents should also be made to identify any additional protection required for sites due to habitat conservation (see Chapter 7 The SuDS design process). The implications of developments on or within close proximity to an area with an environmental designation, such as a Site of Special Scientific Interest (SSSI), should be considered via consultation with relevant conservation bodies such as Natural England			
Metals	Sufficient				
Hydrocarbons	Sufficient				

8.7. SuDS maintenance

Inspection and long-term maintenance of SuDS components ensures efficient operation and prevents failure.

This section outlines the maintenance and management schedules for the proposed stormwater drainage system. The schedules have been formulated in line with guidelines contained within the CIRIA SuDS Manual. There are three categories of maintenance activities referred to in this report:

- **Regular maintenance** – tasks which are required to be undertaken on a weekly or monthly basis, or as required.
- **Occasional maintenance** – tasks which are required to be undertaken periodically, typically at intervals of three months or more.
- **Remedial maintenance** – tasks which are not required on a regular basis but are done when necessary.

This section is intended to give an overview of the operation and maintenance for the range of drainage features included within the surface water drainage strategy and in relation to typical/ standard details only.

Maintenance schedules for the proposed SuDS components are provided in the following tables. These requirements will be implemented following the completion of the proposed development, and will be likely undertaken by a private management company, subject to discussions regarding this responsibility. These schedules are not exhaustive and should be reassessed at regular intervals to determine if any additional maintenance requirements are required to preserve the performance and condition of the drainage system.

Table 8-9 Management and maintenance requirements for pipes and manholes

Maintenance schedule	Required action	Maintenance frequency
Regular maintenance	Remove any accumulation of silt, sediment, leaves and debris etc	Monthly, or as required
	Inspect for evidence of poor operation	Monthly (during the first year), then half yearly
Occasional maintenance	High pressure water jet removal of silt build-up and avoid blockages, particularly at bends or changes in direction	Six monthly, or as required
	Remove or control tree roots where they are encroaching pipe runs, using recommended methods	As required
Remedial actions	Clear pipework and gully grates of blockages	As required
	Replace any damaged or failed pipes, gullies or manholes	As required

Table 8-10 Management and maintenance requirements for permeable paving

Maintenance schedule	Required action	Maintenance frequency
Regular maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface)	Once a year, after autumn leaf fall, or reduced frequency as required.
Occasional maintenance	Stabilise and mow contributing and adjacent areas	As required
	Removal of weeds or management using glyphosate applied directly into the weeds by an applicator rather than spraying	As required - once per year on less frequently used pavements
Remedial actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving	As required
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing material	As required
	Rehabilitation of surface and upper substructure by remedial sweeping	Every 10 to 15 years or as required
Monitoring	Initial inspection	Monthly for three months after installation
	Inspect for evidence of poor operation and/or weed growth - if required, take remedial action	Three-monthly, 48 h after large storms in first six months
	Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually
	Monitor inspection chambers	Annually

Table 8-11 Management and maintenance requirements for swales

Maintenance schedule	Required action	Maintenance frequency
Regular maintenance	Remove litter and debris	Monthly, or as required
	Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly
	Manage vegetation and remove nuisance plants	Monthly at start, then as required
	Inspect inlets, outlets and overflows for blockages, and clear if required	Monthly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48 hours	Monthly, or as required

Maintenance schedule	Required action	Maintenance frequency
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Half yearly
Occasional maintenance	Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required	As required, or if bare soil is exposed over 10% or more of the swale treatment area
Remedial actions	Repair erosion or other damage by re-turfing or reseed	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required

Table 8-12 Management and maintenance requirements for infiltration basins

Maintenance schedule	Required action	Maintenance frequency
Regular maintenance	Remove any accumulation of silt, sediment, leaves and debris etc	Monthly, or as required
	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), or 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
	Check any penstocks and other mechanical devices	Annually
	Tidy all dead growth before start of growing season	Annually
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 outlets, forebays and main basin when required	Every 5 years, or as required
Remedial actions	Repair erosion or other damage by reseed 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

8.8. Further SuDS considerations

Rainwater harvesting (i.e. the use of water butts or more sophisticated tank systems) could be implemented at the Site to capture and reuse runoff at source. These systems collect water from clean surfaces (such as rooftops) for (generally non-potable) use on-site. Rainwater harvesting is particularly useful at sites with a low infiltration potential and limited space for attenuation features. It also has wider sustainability benefits with regards to lowering the water supply demand.

Additional SuDS options that may be considered for the Site are as follows:

- Rainwater harvesting/water butts are primarily used to collect rainwater from impermeable areas and roofs for the use within development buildings and other miscellaneous usage. Due to the relatively small amounts of attenuation provided by rainwater harvesting tanks in this instance and the requirement to retain water for non-potable uses such as toilet flushing or garden maintenance, the volume of runoff which could be attenuated by rainwater harvesting has not been considered within the report. Cost in regard to rainwater harvesting is mainly due to the provision of a storage tank, pumps and pipework which is required for the system to be fully operational.
- Raingardens and smaller ponds/swales are additional attenuation features which could be located across the Site. These would also provide increased biodiversity and amenity benefits.

8.9. Biodiversity and amenity

SuDS schemes present opportunities to enhance habitat for wildlife on-site and this often improves the biodiversity of the surrounding areas. Ponds, constructed wetlands and other surface water features are landscape assets that have amenity value and improve the aesthetics of a site more than conventional drainage systems. The use of grassed detention basins and a large swale/detention basin (with larger, more mature vegetation along the tops of the banks) will enhance the biodiversity and amenity value of the Site post-development. Ecological diversity should be enhanced by the use of native planting within each feature.

9. Conclusions

The Site is entirely within Flood Zone 1. As noted in Section 4, there is a low risk of flooding from fluvial, surface water, groundwater, sewer and catastrophic sources at the Site.

The proposed development will be residential in nature, with a vulnerability classification of 'More Vulnerable' with regards to flood risk. All types of development are permissible within Flood Zone 1.

Given the apparent low flood risk present at the Site, no specific mitigation measures are proposed other than the implementation of a Sustainable Drainage Strategy to mitigate any potential increases in off-site flood risk.

This report provides an Outline SuDS Strategy for the Site. The principal components of the scheme are a Detention basin, a large lined swale, and a large unlined swale located in the downgradient parts of the Site. The geological sequence underlying the Site is considered an appropriate medium to receive stormwater. This was confirmed during permeability testing in the chalk at the Site (see Appendix D).

A preliminary assessment of the performance of the proposed system under the 1 in 1 year, 1 in 30 year + CCA and 1 in 100 year + CCA storm events was undertaken and shows that the proposed SuDS features are capable of accommodating and infiltrating the required stormwater runoff volumes.

Appropriate management and maintenance arrangements for the proposed SuDS scheme will be in place throughout the lifetime of the proposed development.

10. References

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