



Appendix 16.1

FLOOD RISK ASSESSMENT (INCLUDING DRAINAGE STRATEGY)



Oxford University Development

Begbroke Innovation District

Flood Risk Assessment

July 2023

Buro Happold

Begbroke Innovation District

Flood Risk Assessment

BEG-BHE-XX-XX-RP-X-00001

0052188

19 July 2023

Revision P04

Final

Revision	Description	Issued by	Date	Checked
P01	Draft Issue	GJ	11/05/23	DKR
P02	Second Draft Issue	GJ	02/06/23	DKR
P03	Third Draft Issue for Review	GJ	29/06/23	DKR
P04	Final Issue	GJ	19/07/23	DKR

<https://burohappold.sharepoint.com/sites/052188/Shared Documents/Water/Reports/Flood Risk Assessment/FINAL/BEG-BUR-XX-XX-RP-XX-00001-FRA.docx>

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Glossary & Abbreviations

Term	Definition
Annual Exceedance Probability (AEP)	The Probability that a storm event will be exceeded in any given year.
CC	Climate Change
Discharge	The rate of flow of water measured in terms of volume per unit time
EA	Environment Agency
Flood Risk	The level of risk to personal safety and damage to property resulting from flooding due to the frequency or likelihood of flood events
Flood Risk Assessment (FRA)	An assessment of the flood risks to the Proposed Development over its expected lifetime and the possible flood risks to the surrounding areas, assessing flood flows, flood storage capacity and runoff
Flood Zones	The statistical chance of a flood event occurring in any one year, stated as a percentage. The National Planning Policy Framework identifies three flood zones that have been included in Section XX
Fluvial Flooding	Flooding related or connected to a watercourse (river or stream)
Groundwater	Water present within underground strata known as aquifers
Groundwater Flooding	Water occurring below ground in natural formations (typically rocks, gravels and sands)
Impermeable Surface	A surface that does not permit the infiltration of water and, therefore, generates surface water runoff during periods of rainfall
LLFA	Lead Local Flood Authority
OCC	Oxford County Council
OD	Oxford University Development
SuDS	Sustainable Drainage Systems
TW	Thames Water

Executive Summary

This site-specific Flood Risk Assessment (FRA) has been prepared by Buro Happold on behalf of Oxford University Development Ltd (OUD) as part of the Outline Planning Application for the proposed Begbroke Innovation District (BID) in Begbroke, Kidlington, hereafter referred to as the 'Proposed Development'.

Subject		Findings
Site Description		The Site is located around the current site of Begbroke Science Park, Begbroke Hill, Begbroke, Kidlington (OX5 1PF). The Site is approximately 170 ha, with the majority of land being in agricultural use. Sandy Lane crosses the Site on a west-east alignment, joining the A44 to the west of the Site and Yarnton Road to the east of the Site. The Cherwell Valley railway line passes north-south through the Site. There are a number of watercourses on and adjacent to the site. Rowel Brook flows from west to east across the north of the Site and to the east, the Site is bounded by the Oxford Canal.
Proposal Description		The Proposed Development is a phased, mixed-use development which would encompass the expansion of the existing Begbroke Science Park, residential and associated amenity, education, and community uses.
Existing Flood Risk	Fluvial and Tidal	Baseline Hydraulic Modelling has been undertaken to produce flood mapping to provide more accurate definition of the flood zones than those provided by the EA flood maps. The Site is not at coastal flood risk. The majority of the Site is located within Flood Zone 1 and at low risk of flooding. Areas located in Flood Zone 2 and 3, which are at medium to high flood risk are located along the length of Rowel Brook, the parcel of land to the west of the Oxford Canal, in the North-West of the Site and around the Southern drainage ditch.
	Ground Water	There may be a risk of groundwater flooding in the lower lying areas around the perimeter of the Site due to shallow ground water levels. This has been considered in the design of the surface water drainage strategy with regards to the location and design of attenuation ponds and use of infiltration drainage. Hydrock have confirmed that through a review of the geology encountered on the Site during the investigation works, the areas where potential springs may occur is in the north-east area of the site; north-east of Rowel Brook. The ground water flood risk to the Site is therefore considered to be Low.
	Surface Water	The majority of the Site is subject to Very Low surface water flood risk. There are localised areas of ponding on the Site, which are classified as having Medium to High Risk of surface water flooding. These occur around the drainage channels to the south, around the east and southeast of the Site and also on the land adjacent to the Rowel Brook. These have been considered in the Site layout and the overall surface water drainage strategy and mitigations proposed where necessary.
	Sewers	The existing sewer network includes five active and two abandoned Thames Water sewers which cross the site. These have been flagged for diversion, with the proposed diversion routes being developed in collaboration with TW. Thames Water have confirmed that there is capacity within the sewer infrastructure for connection.
	Artificial Sources	According to the risk of flooding shown on the EA Reservoirs Map, a portion of the Site, mainly to the east/ south-east, is located within the maximum extent of flooding from reservoirs. The SFRA identifies a residual risk of flooding to the Site from overtopping of the Oxford Canal. It is noted that water overtopping from the canal in a more extreme event has been captured in the fluvial flood modelling. The overall flood risk from artificial sources is Low and no further mitigation is required.
Proposed Mitigation Measures		The key principle in the flood risk management strategy is to make space for water in developing the masterplan where possible. However, in the NW of the Site there is an existing overland flow route and measures to mitigate this risk are required. In this location a swale has been proposed to intercept, store and divert the overland flow around the Proposed Development. The proposed location of the Secondary School Site would be permissible following the NPPF guidance however OCC design criteria stipulate that no flooding can occur within the school site boundary for both the 1:100 year and the 1:1000 year event. Regrading has been proposed to ensure no flooding of the school site occurs. Flood storage within the red line boundary to the west

Subject	Findings
	<p>of the school site is proposed to provide effective mitigation on a volume-for-volume basis so as to ensure there are no increases in flood risk outside of the red line boundary or to any development on site.</p> <p>The surface water drainage strategy for the Proposed Development will aim to replicate the predevelopment surface water runoff regime. This is achieved by capturing, filtering and harvesting (where possible) surface water as close to source as possible through source control SuDS features. The SuDS hierarchy will be used to design the Site drainage in the most sustainable way. Building upon OUD's vision for sustainable places.</p> <p>All storm events up to the 1 in 100-year storm event + 40% climate change allowance are proposed to be attenuated on site and discharge from the Site to the proposed outlet at the QBAR rate. The 1 in 1-year storm event will be retained to the corresponding greenfield event. In areas of the Site where the ground conditions allow for it, infiltration is promoted to reduce the volumetric discharge of surface water from the site.</p> <p>The Proposed Development is therefore considered to be at Low flood risk in light of these proposed mitigation measures.</p>
Conclusion	With the proposed mitigation in place, the overall flood risk to the Proposed Development is Low.

1 Introduction

1.1 Background

This site-specific Flood Risk Assessment (FRA) has been prepared by Buro Happold on behalf of Oxford University Development Ltd (OUD) as part of the Outline Planning Application for the proposed Begbroke Innovation District (BID) in Begbroke, Kidlington, hereafter referred to as the 'Proposed Development'. This assessment has been developed in accordance with the National Planning Policy Framework (NPPF) (NPPF, 2021) and the Planning Practice Guidance (PPG) and considers potential flood risk to the Proposed Development from the following sources: tidal, fluvial, surface water, sewer, groundwater, artificial sources and failure of drainage infrastructure.

In order to comply with the NPPF and PPG, this FRA will identify the potential flood risks and demonstrate appropriate flood mitigation measures to ensure that the risk to the Site is acceptable for the level of development proposed.

1.2 Site Description

The Site is located on the current site of Begbroke Science Park, Begbroke Hill, Begbroke, Kidlington (OX5 1PF). BID is within the planning jurisdiction of the Cherwell District Council, North Oxfordshire, with the Lead Local Flood Authority (LLFA) being Oxfordshire County Council.

The Site is approximately 170 ha, of which ~80ha is developable. The Site is located approximately 6.7km north west of Oxford City centre, approximately 625m west of Kidlington village centre and close to the villages of Yarnton and Begbroke. Begbroke Science Park is located within the central northern portion of the Site. It comprises a number of one and two storey buildings which accommodate laboratories, engineering facilities and administrative buildings. Rushy Meadows, an SSSI (Site of Special Scientific Interest) is located just north of the east section of Rowel Brook, outside of the Site boundary.

The majority of the remainder of the Site is in agricultural use for arable farming. Sandy Lane crosses the Site on an appropriate west-east alignment, joining the A44 to the west of the Site and Yarnton Road to the east of the Site. The Cherwell Valley railway line passes through the Site on an approximate north-south alignment. A historical landfill site, known as Sandy Lane East, is located in the centre of the Site and is approximately 5.2ha in area.

The topography varies from 69mAOD to 60mAOD (as seen in Figure 2). The high point is close to the centre of the site, sloping down towards the watercourses to the north, east and south. The flatter areas are to the east and northwest of the site.

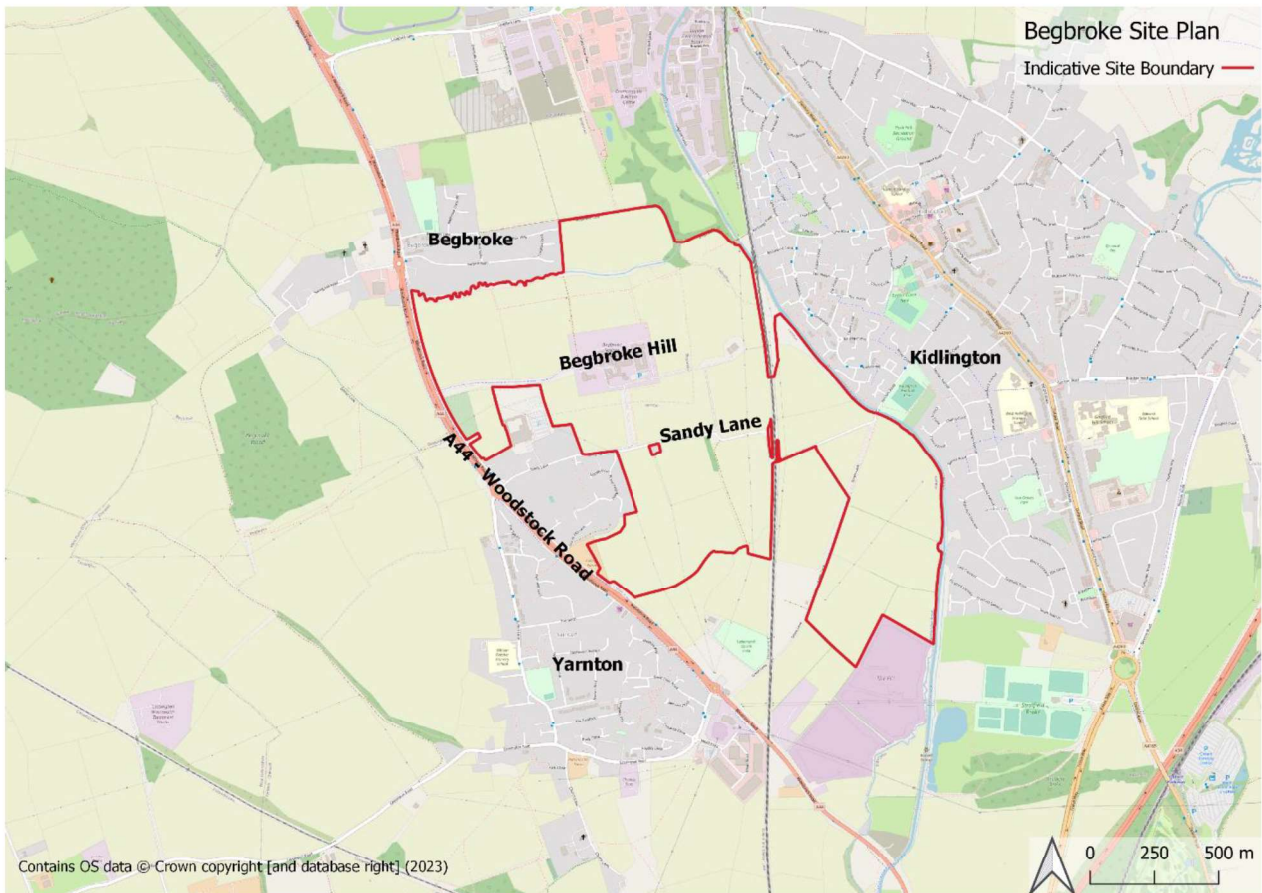


Figure 1 Site location map and red line boundary

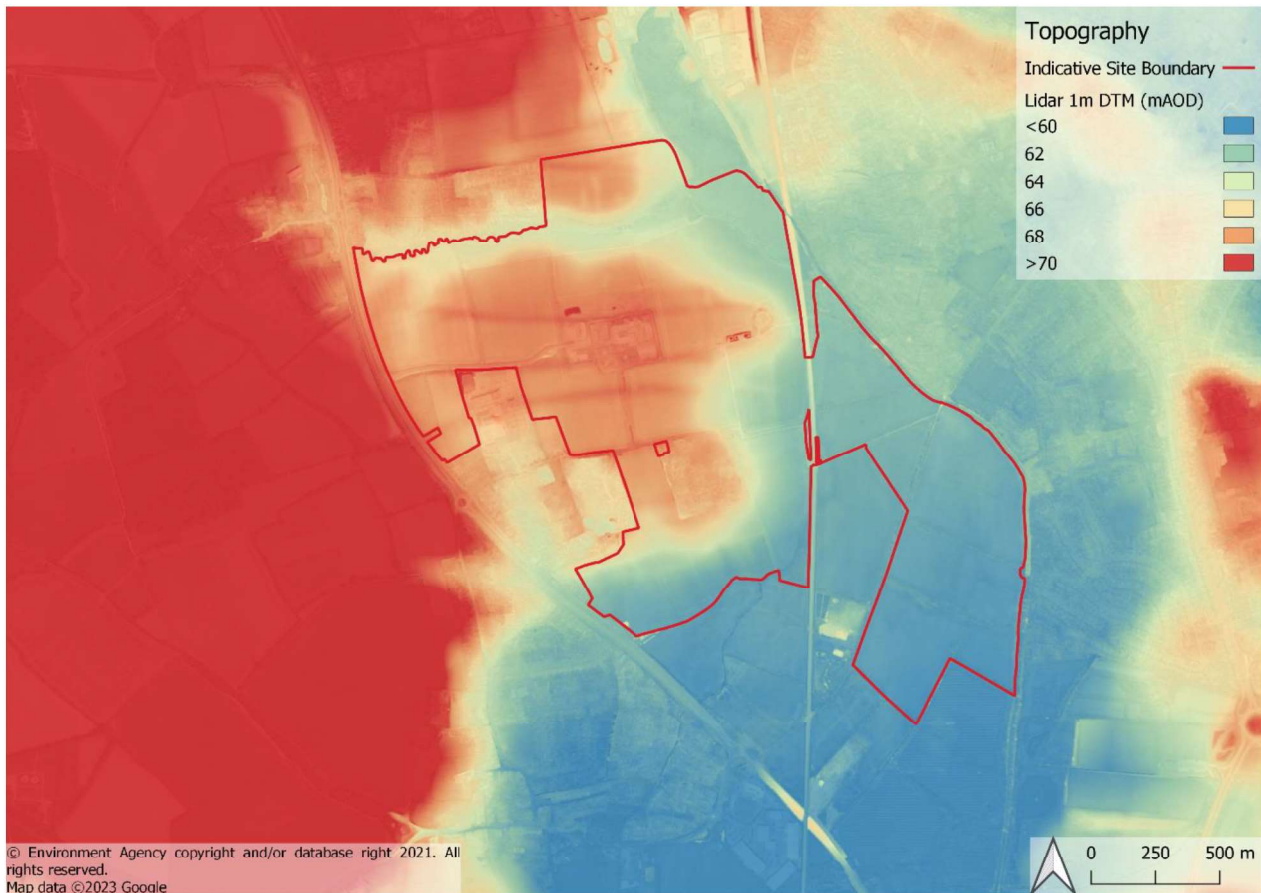


Figure 2 Topographic Lidar Data

1.2.1 Description of Watercourses

There are a number of watercourses on and adjacent to the site. These include the Rowel Brook, the Thrupp ditch, the Southern Drainage Ditch, the Eastern Drainage Ditches as well as other field ditches. To the east, the Site is bounded by the Oxford Canal.

The Rowel Brook flows in an easterly direction along the northern boundary of the Site before joining the Oxford Canal. The Oxford Canal then flows in a southerly direction to the east of the site.

There are a few drainage ditches that capture and convey surface water run-off from the site. These include the Southern Drainage Ditch that is classified as a Main River located to the south of the Site which flows towards Yarnton via a culvert under the A44. An existing culvert also crosses the railway line to the east of the site. It is understood that this culvert conveys flow from the Rowel Brook towards the Oxford Canal, but the outfall location has not been confirmed.

Figure 3 shows those watercourses on the Site which are designated as Main Rivers by the Environment Agency (EA), it is noted that the Oxford Canal is not a designated Main River.

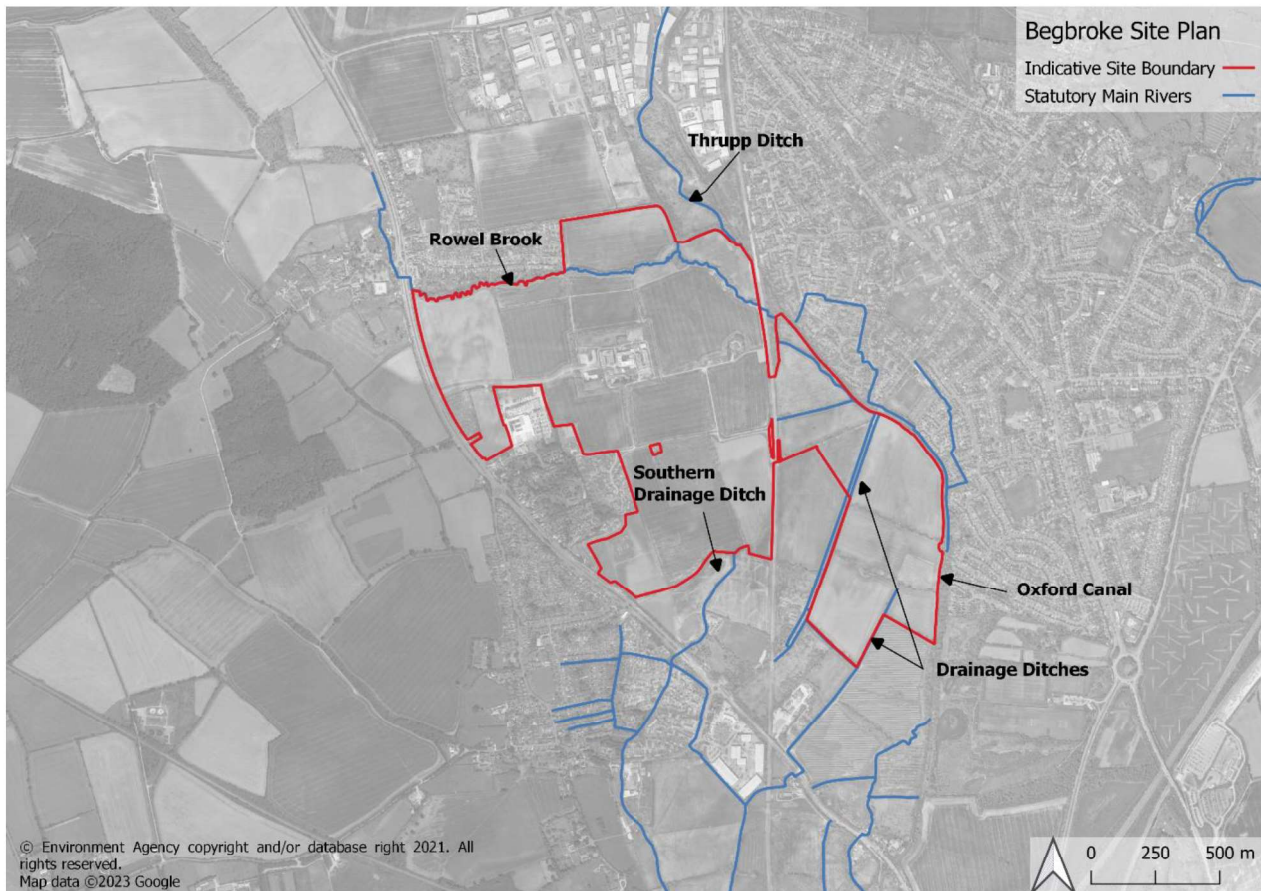


Figure 3 Site Map with key watercourses highlighted and EA Statutory Main Rivers shown

1.3 Proposed Development

The Proposed Development is a phased, mixed-use development which would encompass the expansion of the existing Begbroke Science Park, residential and associated amenity, education, and community uses. The Description of Development is as follows:

- Up to 215,000 square metres gross external area of residential floorspace within Use Class C3/C4 and large houses of multiple occupation (Sui Generis);
- Supporting social infrastructure including secondary school/primary school(s) (Use Class F1); health, indoor sport and recreation, emergency, and nursery facilities (Class E(d)-(f))
- Supporting retail, leisure and community uses, including retail (Class E(a)), cafes and restaurants (Class E(b)), commercial and professional services (Class E(c)), local community uses (Class F2), and other local centre uses within a Sui Generis use including public houses, bars and drinking establishments (including with expanded food provision), hot food takeaways, venues for live music performance, theatre, and cinema.
- Up to 155,000 square metres gross external area of flexible employment uses including research and development, office and workspace and associated uses (Use E(g)), industrial (Use Class B2) and storage (Use Class B8) in connection with the expansion of Begbroke Science Park;
- Highway works, including new vehicular, cyclist and pedestrian roads and paths, improvements to the existing Sandy Lane and Begbroke Hill road, a bridge over the Oxford Canal, safeguarded land for a rail halt, and car and cycle parking with associated electric vehicle charging infrastructure;

- Landscape and public realm, including areas for sustainable urban drainage systems, allotments, biodiversity areas, outdoor play and sports facilities (Use Class F2(c));
- Utility, energy, water, and waste water facilities and infrastructure;
- together with enabling and associated works, including temporary meanwhile uses.

The Parameter Plan showing development areas and land uses and the illustrative masterplan are shown below in Figure 4 and Figure 5 respectively.

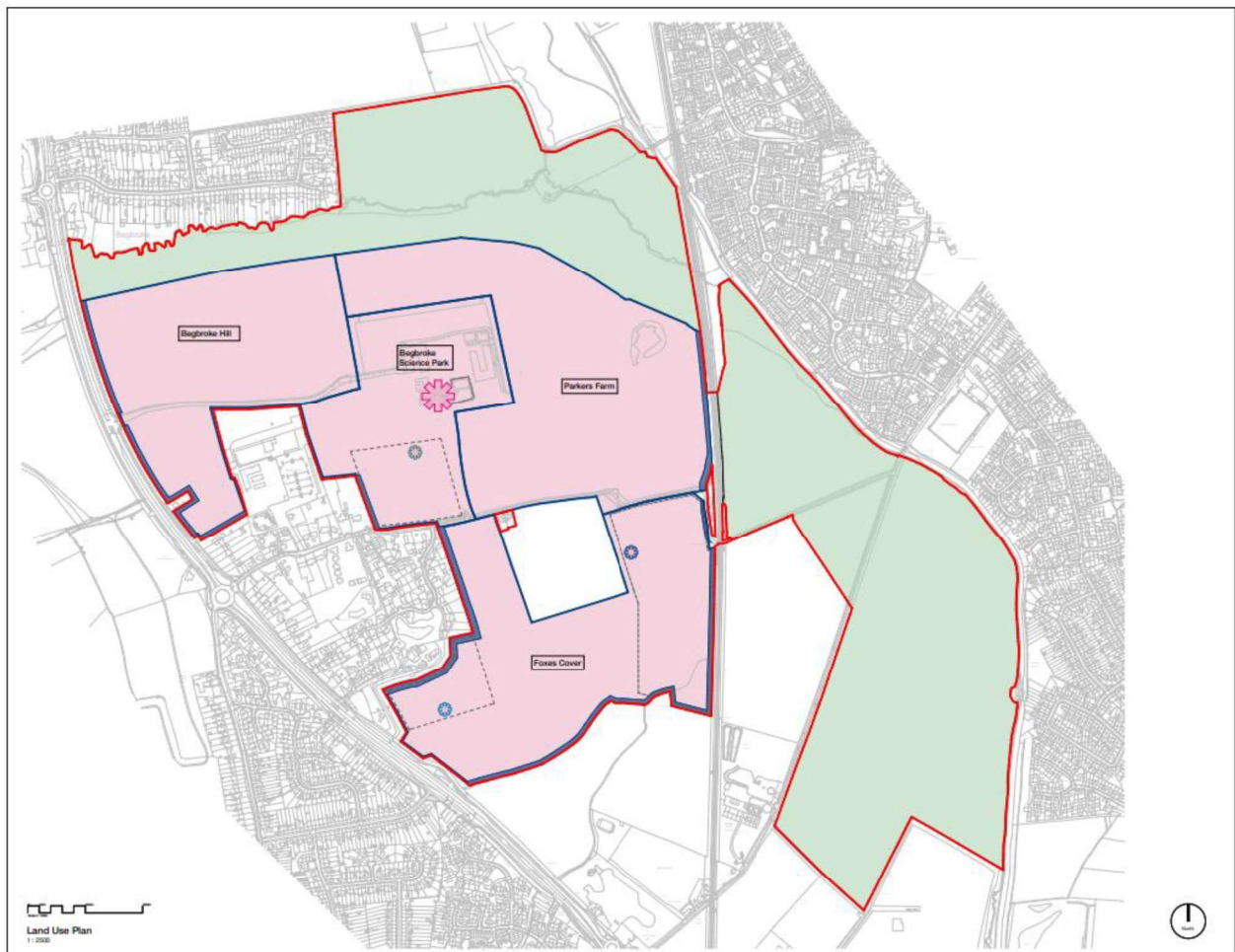


Figure 4 Parameter Plan - Development Zones (Drawing No. BEG-HBA-SW-ZZ-SK-A-SK81) (Hawkins Brown, 15/05/23)



Figure 5 Illustrative Masterplan (Hawkins Brown)

2 Planning Context

2.1 Overview

This site-specific FRA has been prepared in accordance with the policies, legislation and guidance applicable to the Development provided by UK national and local governments. This policy and guidance has been produced to inform flood related decision-making in all stages of development. The documents applicable to the Proposed Development are:

- National Planning Policy Framework (NPPF) (July 2021);
- National Planning Policy Framework Planning Practice Guidance (Updated: 24 June 2021);
- Cherwell Level 1 Strategic Flood Risk Assessment (SFRA) Update (May 2017);
- Cherwell Level 2 SFRA (May 2017);
- Cherwell Level 2 SFRA Addendum (February 2018);
- Oxfordshire County Council Local Flood Risk Management Strategy (LFRMS) (undated);
- Oxfordshire County Council Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire (December, 2021);
- Oxfordshire County Council Key Design Criteria for Secondary School Sites (undated);
- The Cherwell Local Plan 2011 – 2031 (July 2015); and
- The Cherwell Local Plan Part 1 Partial Review (September 2020).

2.2 National Planning Policy Framework

2.2.1 Flood Risk Assessment

The NPPF aims to avoid inappropriate development in areas at the highest risk of flooding. The Planning Practice Guidance to the NPPF contains a series of tables that help identify the risk of flooding to a development, see Appendix A for the tables. A summary is provided below:

- Table 1 (Appendix A) defines four Flood Zones based on the annual probability of river or sea flooding;
- Table 2 (Appendix A) identifies specific land use types for each of the five flood risk vulnerability classifications (Essential Infrastructure, Highly Vulnerable, More Vulnerable, Less Vulnerable and Water Compatible Uses). For example, office buildings are classified as Less Vulnerable; and
- Table 3 (Appendix A) identifies where development is appropriate for each flood risk vulnerability classification and whether the Exception Test is required.

The Flood Zones are defined in the NPPF as follows:

Flood Zone 1 Low Probability:

< 1 in 1,000 annual probability of river or sea flooding in any given year (<0.1% Annual Exceedance Probability (AEP))

Flood Zone 2 Medium Probability:

Between 1 in 100 and 1 in 1,000 annual probability of river flooding in any year (1% - 0.1% AEP), or
Between 1 in 200 and 1 in 1,000 annual probability of sea flooding in any year (0.5% - 0.1% AEP).

Flood Zone 3a High Probability:

> 1 in 100 annual probability of river flooding in any year (>1% AEP), or
> 1 in 200 annual probability of sea flooding in any year (>0.5% AEP).

Flood Zone 3b Functional Floodplain:

> 1 in 30 annual probability of flooding in any year (3.3% AEP).

2.2.2 Flood Risk & Vulnerability Classification

The PPG of the NPPF outlines the Vulnerability Classifications of land use types and building uses. The Proposed Development is comprised of residential, commercial and academic uses. In accordance with the EA, the vulnerability classifications for the Proposed Development are described in Table 1 below:

Table 1 Proposed land uses on the Site with their associated vulnerability classification

Land Use	Vulnerability Classification
Residential	More Vulnerable
Educational Establishments	More Vulnerable
Commercial	Less Vulnerable
Primary Substation	Essential

2.2.3 Climate Change

Allowances for the predicted effects of climate change should be considered when preparing site-specific flood risk assessments. This is the principal means of ensuring that a development is designed with appropriate resilience.

The NPPF guidance contains sensitivity ranges that are recommended to be applied to peak rainfall intensities, peak river flows, sea level rise, offshore wind speeds and extreme wave heights. The general trend is for each parameter to increase in the future, which in turn increases the risk of flooding to any site.

Peak river flow allowances show the anticipated changes to peak flow by management catchment. Based on the EA’s peak river flow map, the following climate change allowances should be considered for the Site as it is part of the Gloucestershire and the Vale Management Catchment:

Table 2 Gloucestershire and the Vale management catchment peak river flow allowances (EA, 2021)

Period of CC	Central (50 th percentile)	Higher (70 th percentile)	Upper (95 th percentile)
Total potential change anticipated for the ‘2020s’ 2015 to 2039	11%	17%	33%
Total potential change anticipated for the ‘2050s’ 2040 to 2069	11%	19%	43%
Total potential change anticipated for the ‘2080s’ 2070 to 2115	26%	41%	84%

The latest guidance states that in flood zones 2 or 3a all development types should use the Central Allowance except for *Essential Infrastructure* which should use the Higher Allowance.

Therefore, the Minimum Design Flood Event (DFE) for the Site for fluvial flooding has been identified as the 1 in 100 year including 26% climate change allowance, based on NPPF guidance. However, given the sustainability aspiration to increase climate resilience further, the Higher Allowance stated in the table above has been considered for all development types.

The following peak rainfall allowances should be considered for the Site for a 1% annual exceedance rainfall event:

Table 3 Gloucestershire and the Vale management catchment 1% annual exceedance rainfall event allowances (EA, 2021)

Period of CC	Central (50 th percentile)	Upper (95 th percentile)
Total potential change anticipated for the ‘2050s’ 2040 to 2069	20%	40%
Total potential change anticipated for the ‘2080s’ 2070 to 2115	25%	40%

It is recommended by the guidance that both the central and upper-end allowances are assessed in order to understand the range of the impact. The guidance further notes that the following considerations be made to decide the allowances that are adopted to inform the flood risk management strategy for a development:

- Likely depth, speed and extent of flooding for each allowance of climate change over time, considering the allowances for the relevant epoch (2020s, 2050s and 2080s);
- Vulnerability of the proposed types of development or land use allocations to flooding;
- ‘Built-in’ resilience measures used, for example, raised floor levels; and
- Capacity or space in the development to include additional resilience measures in the future, using a ‘managed adaptive’ approach.

Given the proposed land use types and the design life of the residential being a minimum of 100 years, an allowance for a 40% increase in peak rainfall intensity is being used in the Surface Water Drainage Strategy, prepared by Buro Happold.

2.3 Cherwell District Council Local Plan

The Site falls within the administration of Cherwell District Council which has created the Cherwell Local Plan 2011-2031 which was adopted in 2015. A Partial Review for Oxford’s unmet housing need was then published in September 2020. The Local Plan guides the changing use of land in the district through long term strategic spatial visions, with strategic spatial framework and policies to help deliver this vision. The Proposed Development is located in PR8 and neighbours PR3a, PR7b and PR9.

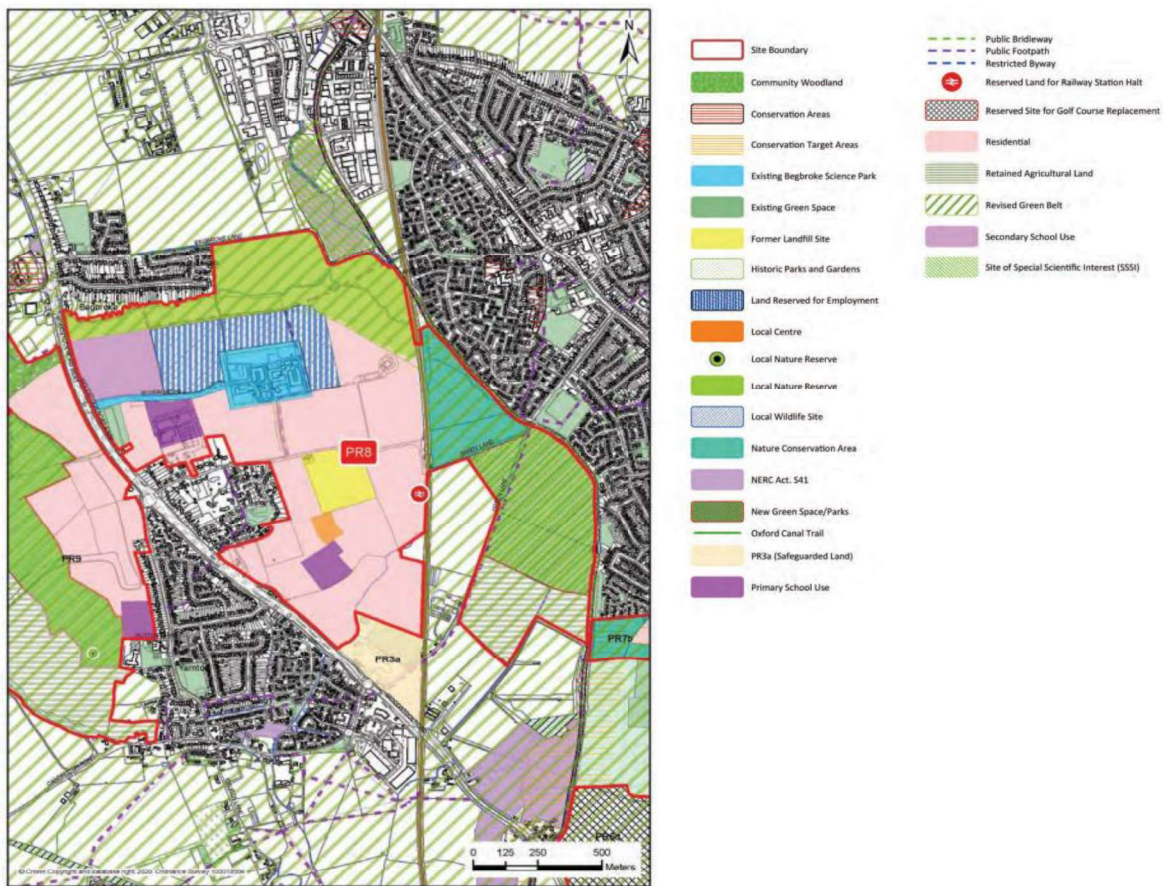


Figure 6 PR8 Local Plan Designation (The Cherwell Local Plan 2011-2031 (Part1) Partial Review (September 2020))

Below are the relevant policies from the Local Plan that have to be adhered to in developing the site’s flood risk and drainage strategy:

- ESD 1: Mitigation and Adapting to Climate Change
- ESD 6: Sustainable Flood Risk Management
- ESD 7: Sustainable Drainage Systems (SuDS)
- ESD 8: Water Resources
- ESD 16: The Oxford Canal

Policy ESD 6 in the Cherwell District Local Plan presents the policy around sustainable flood risk management. The key points have been summarised below:

- The Council will manage and reduce flood risk in the district through using a sequential approach to development, locating vulnerable developments in areas at lower risk of flooding.
- Development will only be permitted in areas of flood risk when there are no reasonably available sites in areas of lower flood risk and the benefits of the development outweigh the risks from flooding.
- Opportunities will be sought to restore natural river flows and floodplains, increasing their amenity and biodiversity value.
- Flood risk assessments should assess all sources of flood risk and demonstrate that:
 - There will be no increase in surface water discharge rates or volumes during storm events up to and including the 1 in 100 year storm event with an allowance for climate change (the design storm event).
 - Developments will not flood from surface water up to and including the design storm event or any surface water flooding beyond the 1 in 30 year storm event, up to and including the design storm event will be safely contained on site.
- This section sets out that where there is no EA modelled data available from the EA, a Level 3 FRA including hydraulic modelling may be required for sites in close proximity to the Rowell Brook or the River Cherwell.

2.4 Strategic Flood Risk Assessment

SFRAs are required to be carried out by Local Authorities to guide developers on the authority's strategies to avoid, reduce and manage flood risk. A Level 1 and 2 SFRA has been carried out for Cherwell District Council in 2017, with an addendum to the Level 2 SFRA in 2018. The addendum provides a more detailed analysis of the fluvial flood risk within the PR8 land allocation, although still in lieu of any detailed modelling. This analysis aims to provide confidence that the proposed land uses within PR8 are likely to be deliverable, with respect to climate change.

The Cherwell Council's SFRAs consider the risk of flooding from the following potential sources:

- Fluvial (rivers);
- Tidal;
- Surface water;
- Groundwater; and
- Sewers.

The risk of flooding to the Proposed Development from each source listed above will be assessed in Section 3.

2.5 Design Criteria for Secondary Schools

The OCC's document which outline's key design criteria for Secondary School Sites notes the following requirements relevant to flood risk:

- No part of a school site shall be located on Flood Zones 2 or 3;
- No runoff or surface water from adjoining land will be accepted;
- Any ditches shall be infilled prior to site transfer.

These criteria have been considered within the masterplanning, assessment of flood risk and any consequent mitigation required.

2.6 Consultation

Consultation has been undertaken with the EA, LLFA (OCC) and CRT in relation to flood risk and mitigation strategies. The consultation has been undertaken as a combination of email and telephone correspondence.

Email correspondence with the EA advised that the current hydraulic modelling (which the EA flood maps are based on) is likely to be based on JFLOW data, which is not suitable for this site-specific FRA. The EA instructed that detailed hydraulic modelling is required to support the Outline Planning Application.

Following this instruction, a meeting was held with representatives from the EA and OCC on 16th November 2022. The key objectives of this meeting were to:

- Agree the methodology to be used to define the fluvial flood extents for the project; and
- Receive flood risk pre-application advice and comments on strategy and the Proposed Development.

A Technical Note with the proposed methodology for the detailed hydraulic modelling was prepared and shared with the EA and OCC prior to the meeting. Table 4 gives a summary of the key items discussed in consultation with each Statutory Consultee.

Table 4 Summary of Consultation comments and design actions

Consultee	Key Theme	Consultee Comments/ Considerations
EA	Detailed Hydraulic Modelling Methodology	<ul style="list-style-type: none"> • It was requested that the technical note be updated to include strong justification for each assumption within the proposed methodology. This updated methodology statement was shared with the EA and LLFA 02/12/22 and is included in Appendix B for reference. • EA noted the importance of capturing all surface water flows which might enter the watercourses in the hydraulic model and that the interaction between surface water and fluvial flows is carefully considered. • The EA requested justification for the assumption that the Oxford Canal forms a hydrological barrier to demonstrate that there is no fluvial flooding from the Canal onto the Site due to surface water flows from Kidlington.
	Climate Change Allowances	<ul style="list-style-type: none"> • It was recommended that the 'Central' allowance of 26% be tested as well as the 'Higher' allowance of 41% for peak river flow allowances to check that Infrastructure classified as 'Essential' is not impacted.