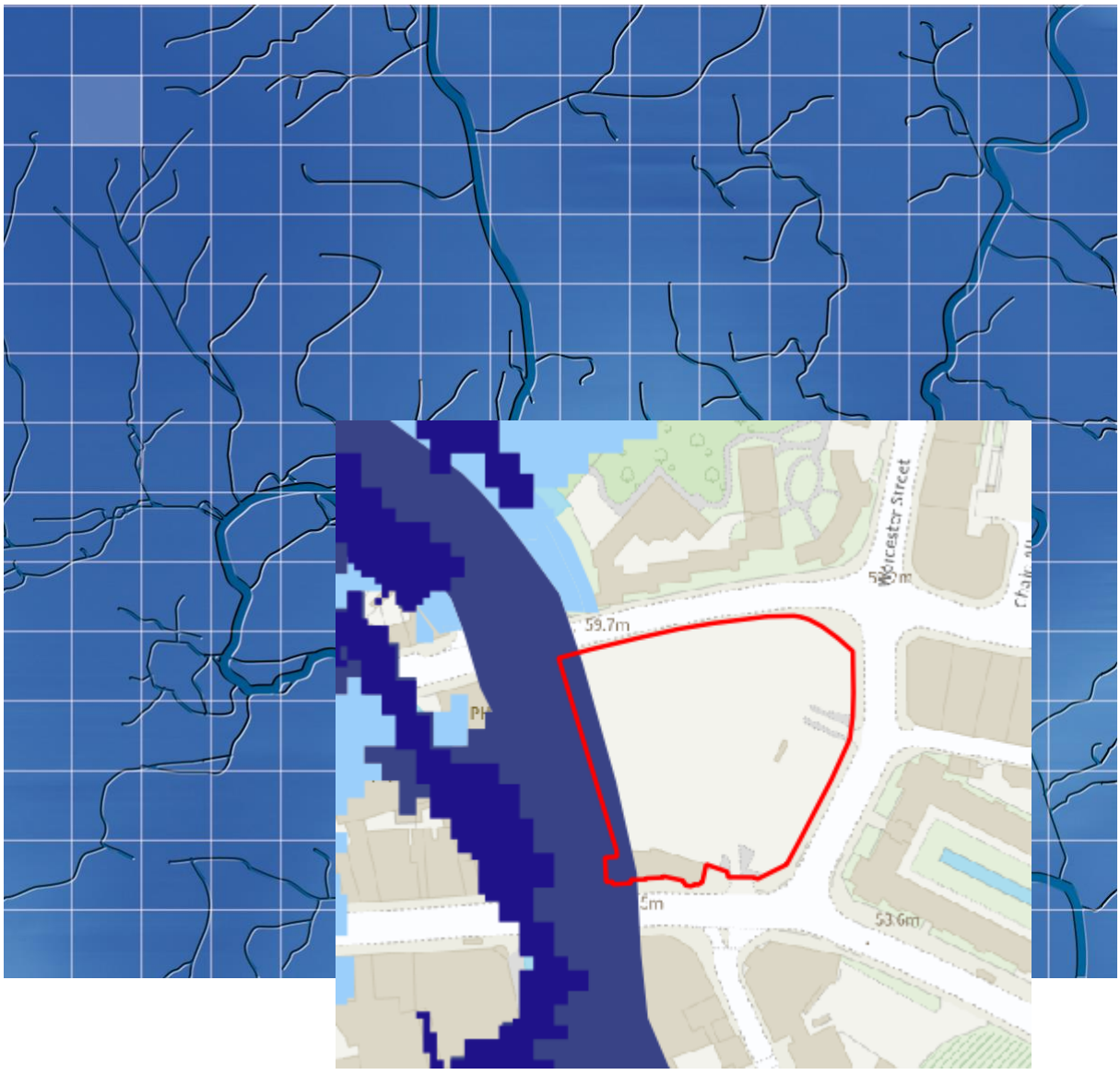
Oxford City Council

January 2026

Worcester Street Car Park and Public House (81)

Level 2 Strategic Flood Risk Assessment



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Worcester Street Car Park and Public House (81) Level 2 Strategic Flood Risk Assessment

Document issue details

WHS10237

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Worcester Street Car Park and Public House (81) Level 2 SFRA

Flood Risk Overview

Fluvial Flood Risk	**M**
Pluvial Flood Risk	**M**
Other Sources of Flood Risk	**M**
Confidence in Assessment	**M**

Flood Risk

Overall fluvial flood risk is considered moderate at the site, however there is some uncertainty in the available flood extents. The EA Flood Map for Planning shows 8.0% of the site is located within Flood Zone 2 (0.1% AEP), and Flood Zone 3a (1.0% AEP).

The River Thames Model (2018, re-run in 2023) 1.0% AEP + 26% CC design event extent shows no flooding on site and nor does the EA's FMfP 1.0 AEP climate change extents. The 1.0% AEP +26% CC flood level is 57.58 m AOD, slightly below the site's average ground level of 58.20 m AOD. Only about 2% of the site lies below this level, so it is thought that the current Flood Zone 3a extent likely reflects coarse representation of the Castle Mill stream channel and may overstate flood risk. A site-specific FRA should confirm this.

Pluvial flood risk is considered to be moderate with surface water from the north and east flowing into the site. The risk from other sources of flooding is considered to be moderate with the potential for groundwater and reservoir flooding.

The overall confidence in the assessment is moderate as whilst detailed modelling is available there are inconsistencies in flood extent data at the site. EA national mapping has also been used to assess pluvial flood risk.

Conclusions and Recommendations

A sequential approach to the siting of the development should be used, with development prioritised first within Flood Zone 1 prior to consideration of any siting within Flood Zone 2 or 3a.

In terms of fluvial flooding, it should be possible to locate the majority of infrastructure in Flood Zone 1 and outside of the design flood extent. However, as noted there is some uncertainty in the flood risk shown in the FMfP and the protection offered by a wall running along the western boundary of the site. Therefore, a site-specific FRA should investigate fluvial flooding further with updated modelling potentially required.

Surface water flood risk is also significant at the site, whilst manageable a sequential approach should also be followed with development located outside of high-risk areas.

Contents

1 Introduction

1.1 Background

Wallingford HydroSolutions Ltd has been commissioned by Oxford City Council (OCC) to undertake a Level 2 Strategic Flood Risk Assessment (SFRA) at Worcester Street Car Park and Public House (reference: 81) in accordance with the National Planning Policy Framework (NPPF), Planning Practice Guidance (PPG) and associated guidance from the Environment Agency (EA).

Where there is a risk of flooding at the site, this risk has been quantified with the latest available datasets and any associated limitations with the assessment have been identified.

Where applicable, recommendations for improving our understanding of flood risk and/or mitigating the risk has also been included in this report.

1.2 Assessment of Flood Risk

For the site, a detailed assessment of the nature of flood hazard was undertaken. This included using the relevant fluvial modelling data to assess:

- The proportion of the site inundated for a range of return periods
- The speed of onset
- Flood depth
- Flood velocity
- Flood Hazard

The sites were assessed against a range of return periods, however the design event, the 100-year (plus central climate change) event, was considered most important for planning purposes.

In addition to the analysis of modelling data, the location, standard and condition of existing flood defences was assessed. Other sources of flooding were also reviewed at each site. This included an assessment of surface water flooding and an assessment of groundwater flooding based on available hydrogeological information from BGS and Soilscapes. Potential access/egress routes were identified with respect to the risk posed from all sources of flooding.

Following a review of flood risk, flood defences and the identification of access/egress routes, an assessment was made on whether a future site-specific FRA would be able to show that the site can be allocated for development. The assessment takes into account the flood risk vulnerability of the development, the scale of development proposed along with any requirements for the Exception Test. In this context, any mitigative actions in the form of ground raising and compensatory storage are identified.

The site assessments also include guidance for the preparation of FRAs, including information about the use of SuDS.

1.3 Report Structure

This FRA follows the structure summarised below:

1 - Introduction (this section)

2 - Site Description

3 - Flood Risk

4 – Detailed Review of Primary Flood Risk

5 – Development Viability and FRA Recommendations

2 Site Description

2.1 General Location Plan

Worcester Street Car Park and Public House (81) is a 0.51 ha site located along the eastern bank of Castle Mill Stream, between Hythe Bridge and Pacey's Bridge to the west of Oxford city centre, see Figure 1. The entire site is hardstanding and is currently used as a car park.

Proposed development at the site consists of redevelopment for residential purposes.

2.2 Topography

Based on 1m LiDAR data, the site is relatively flat, see Figure 2. The site is bounded by higher ground to the north along the A4144 Hythe Bridge Street and further east towards Oxford City Centre. Ground levels within the site boundary range from 56.7 to 59.2 m AOD. The average ground level is approximately 58.2 m AOD.

2.3 Nearby Watercourses

Castle Mill Stream is located adjacent to the site's western boundary, see Figure 1. Wareham Stream is located further to the west of Castle Mill Stream, approximately 30m from the site at its closest point. The end of the Oxford Canal is located approximately 40m to the north of the site. All of these watercourses are interlinked and form backwaters to the River Thames.

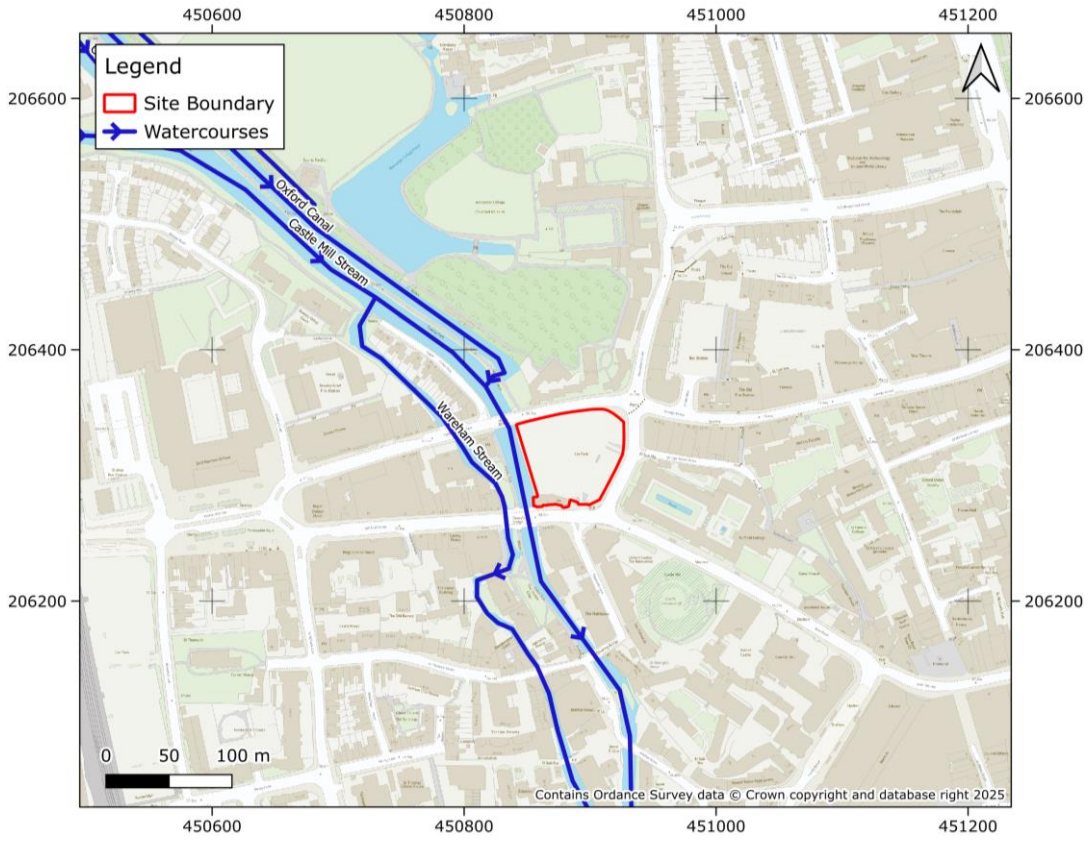

Figure 1 - Site Location

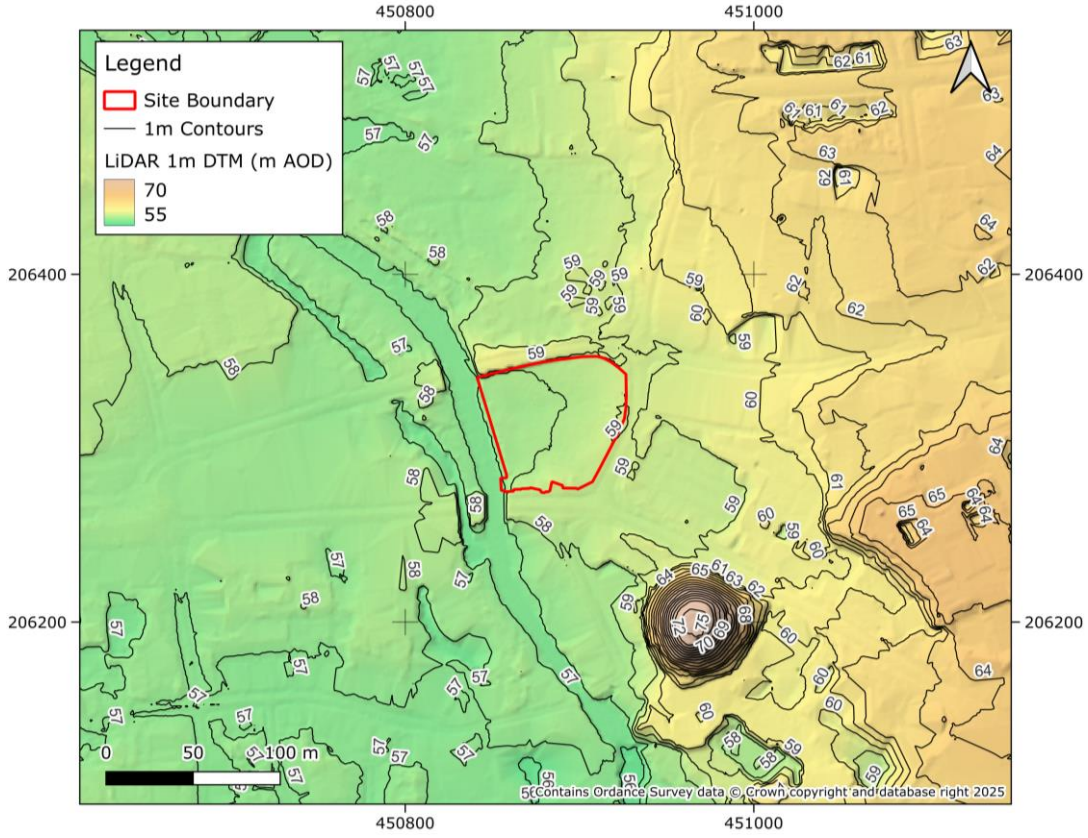

Figure 2 – Topography

3 Flood Risk

3.1 Historical Flooding

The EA has multiple historical records of flooding along Castle Mill Stream, Wareham Stream and the Oxford Canal in the vicinity of the site, however none of these events affected the site directly, see Figure 3.

3.2 Fluvial Flood Risk

In the existing Flood Map for Planning (FMfP), 8.0% of the site is located within Flood Zone 2 (0.1% AEP), and Flood Zone 3a (1.0% AEP), see Figure 4. Flooding onsite is associated with the Castle Mill Stream.

These Flood Zones consider the undefended scenario whereas the national layers for Flood Zone 3b (3.3% AEP) consider the defended scenario. This extent shows none of the site to be located within Flood Zone 3b. Though the undefended 3.3% AEP River Thames (2018) modelled extent is available and similar, the EA defended 3.3% AEP extent is slightly greater in the vicinity of the site and so is used in this assessment as a conservative measure. It is noted in this location neither 3.3% dataset represents flooding in the Castle Mill stream channel.

The EA climate change fluvial outputs for the 0.1% AEP and 1.0% AEP undefended extents have also been assessed, these show 17.9% of the site inundated during the 0.1% AEP event. Counterintuitively for the 1.0% AEP event whilst flood extents increase for areas outside of the site none of the site is inundated, a reduction relative to the present-day 1.0% AEP event. The climate change extent for the 3.3% AEP defended event also shows no inundation onsite, see Figure 5. Similar to the present day 3.3% AEP extents, the climate change extents for the 3.3% AEP and 1.0% AEP events do not represent flooding within the Castle Mill stream channel. This disparity is thought to be due to difference in the modelling techniques used to derive the 3.3% AEP and climate change layers against the present day FMfP extents. It is noted that all of the outputs from the River Thames (2018) model also do not include the Castle Mill stream channel, typically associated with the omission of water level lines (WLLs) in the model build process.

Based on the information available fluvial flood risk is considered to be moderate however it is subject to uncertainty. In this regard it is assessed in more detail in section 4.

3.3 Flood Defence Infrastructure

The west of the site is bordered by a wall which runs along the left bank of Castle Mill Stream. This is not recognised as formal flood defence infrastructure by the EA but may offer some protection to the site. No part of the site is an area associated with a Reduction in Risk from Rivers and Sea, nor is the site located within a flood storage area.

3.4 Surface Water Flood Risk

The EA's surface water flood maps show 4.2% of the site to be inundated during a 3.3% AEP event, 7.8% is inundated during a 1.0% AEP event, and 19.3% is inundated during a 0.1% AEP event, see Figure 6. The areas at risk are located in the centre of the site. Surface water is generated across the urbanised areas on higher ground to the north and east of the site and flows into the site from the junction of George Street and Worcester Street.

When considering the effects of climate change, the proportion of the site at risk for each event increases to 6.7%, 10.1%, and 25.2% respectively, see Figure 7.

Overall, the surface water flood risk to the site is moderate and is assessed in more detail in Section 4.

3.5 Groundwater Flooding

The site is underlain by a bedrock of clay and mudstone in the form of Oxford Clay Formation and West Walton Formation. It is expected to permit low amounts of infiltration. Superficial deposits of alluvium are present at this site in the areas closest to Castle Mill Stream, whilst there are Northmoor Sand and Gravel deposits present across the eastern half of the site; both are expected to have variable permeabilities. No information is available on the underlying soils for most of the site, however closer to Castle Mill stream the soils are defined as loamy and clayey floodplain soils with naturally high groundwater.

Based on the data available there is a moderate risk of groundwater flooding, however more data is required at the planning stage to confirm this and establish the soil type present in the east of the site.

3.6 Reservoir Flood Risk

The FMfP shows that the west of the site is at risk from reservoir flooding during the dry day scenario only, see Figure 8. It is unclear why the site is not at risk during a wet day scenario. In any case, whilst the site is shown to be at risk, it should be noted that reservoir failure is a rare event with a very low probability of occurrence. Current reservoir regulations aim to make sure that all reservoirs are properly maintained and monitored to detect and repair any problem. If required, the local planning authority (LPA) can consult the local resilience forum for emergency planning advice in relation to reservoir failure.

3.7 Flood Warning Service

The site is not located within or adjacent to any EA Flood Warning Area.

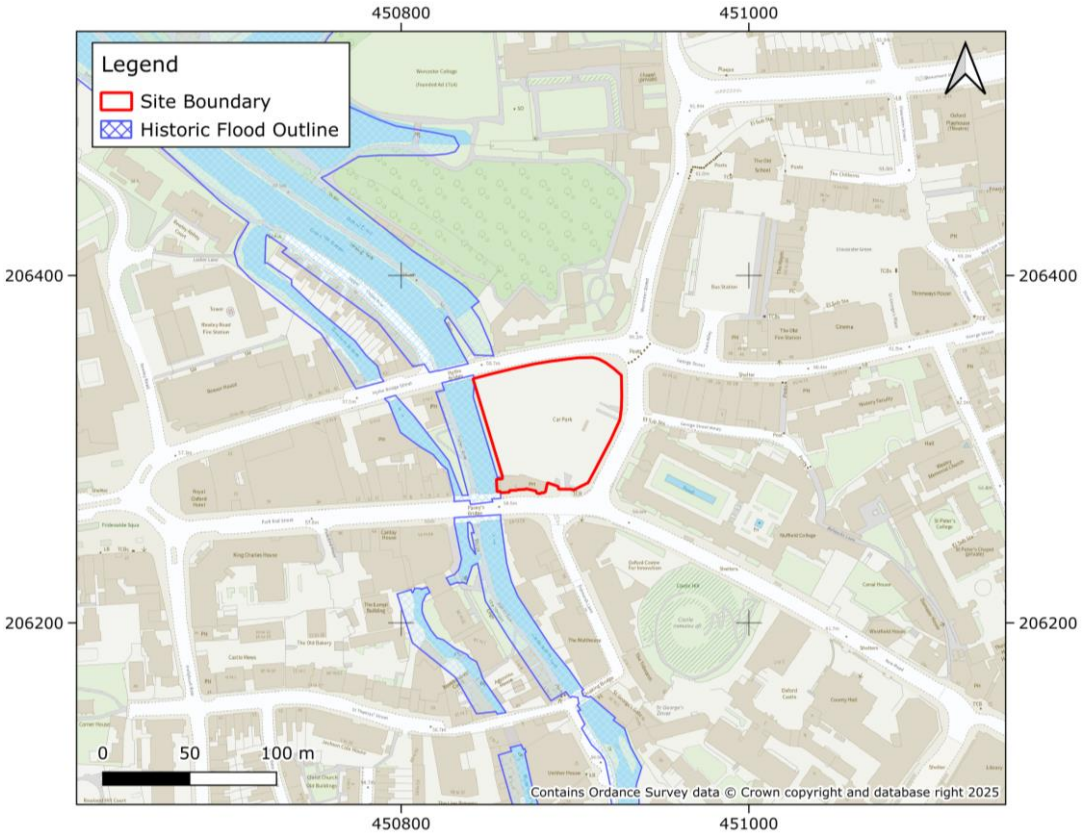

Figure 3 – Historic Flood Map

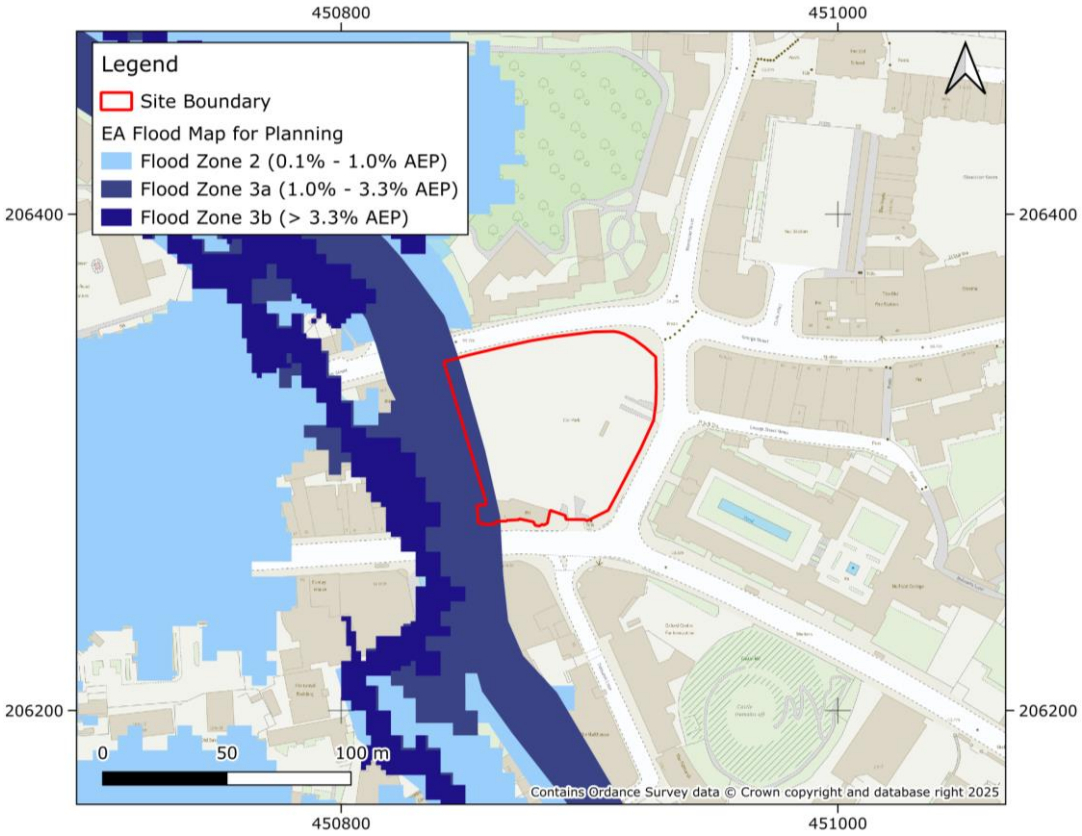

Figure 4 - Fluvial Flood Map

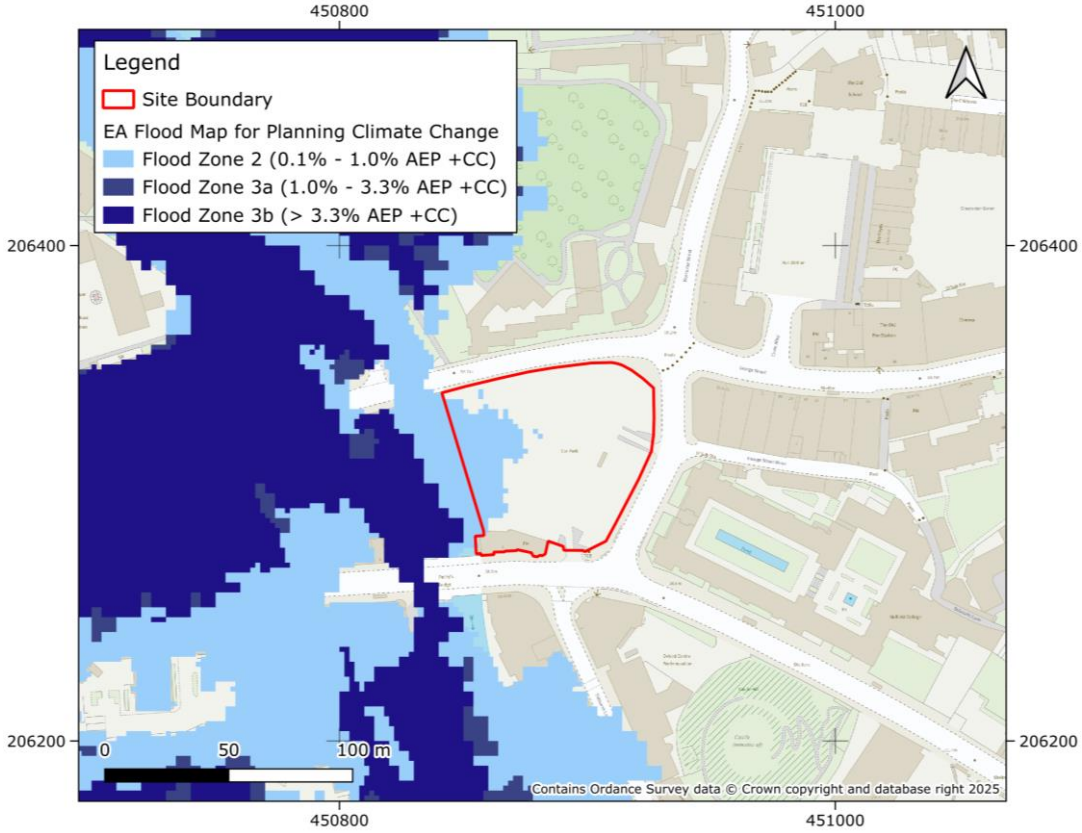

Figure 5 – Fluvial Climate Change Flood Map

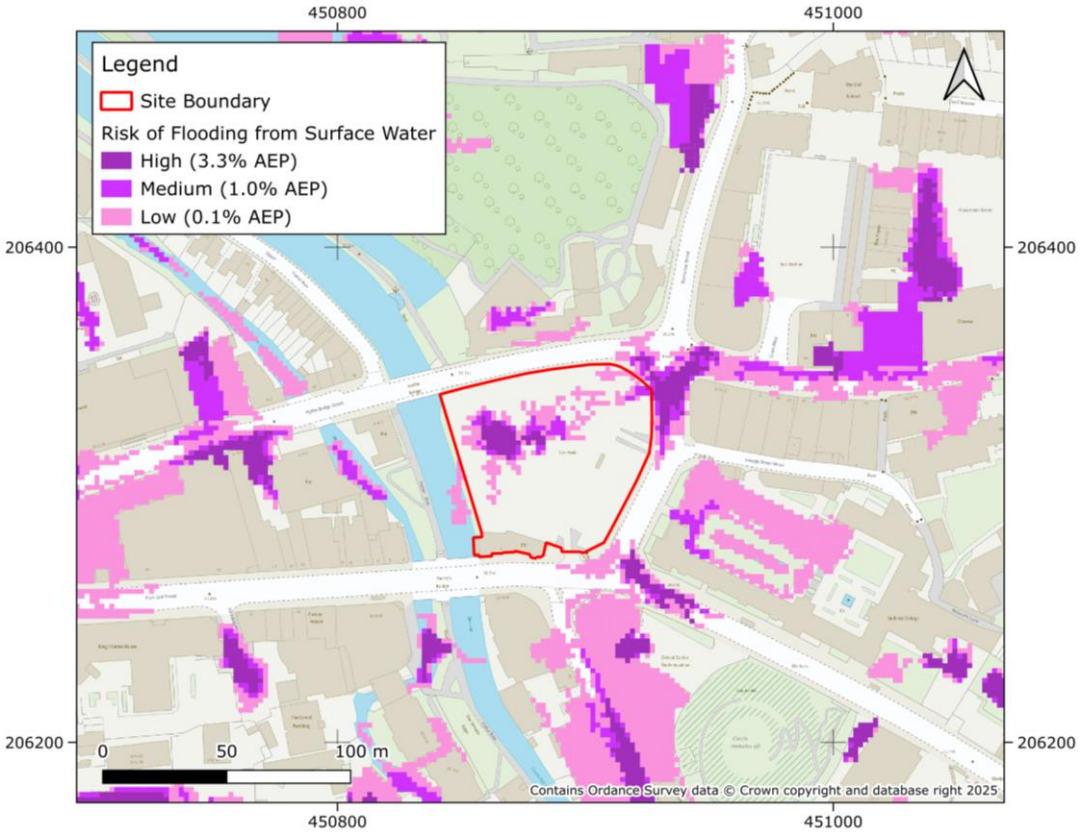

Figure 6 – Surface Water Flood Map

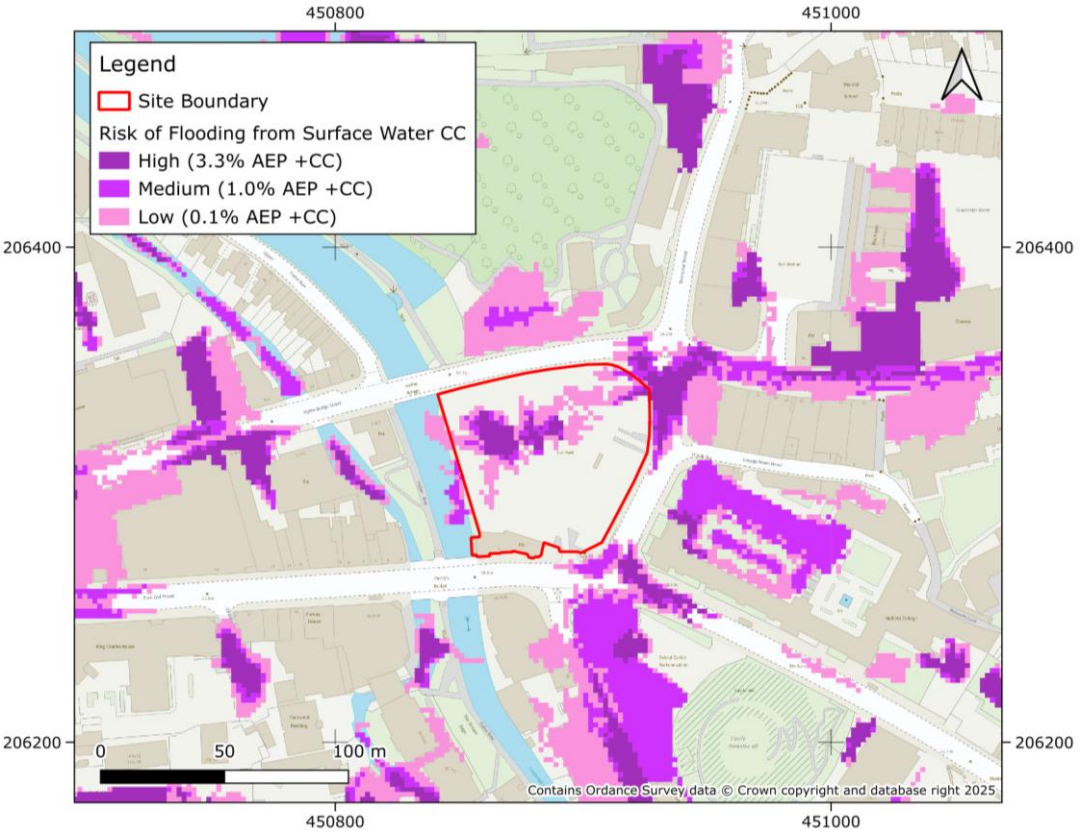

Figure 7 -Surface Water Climate Change Flood Map

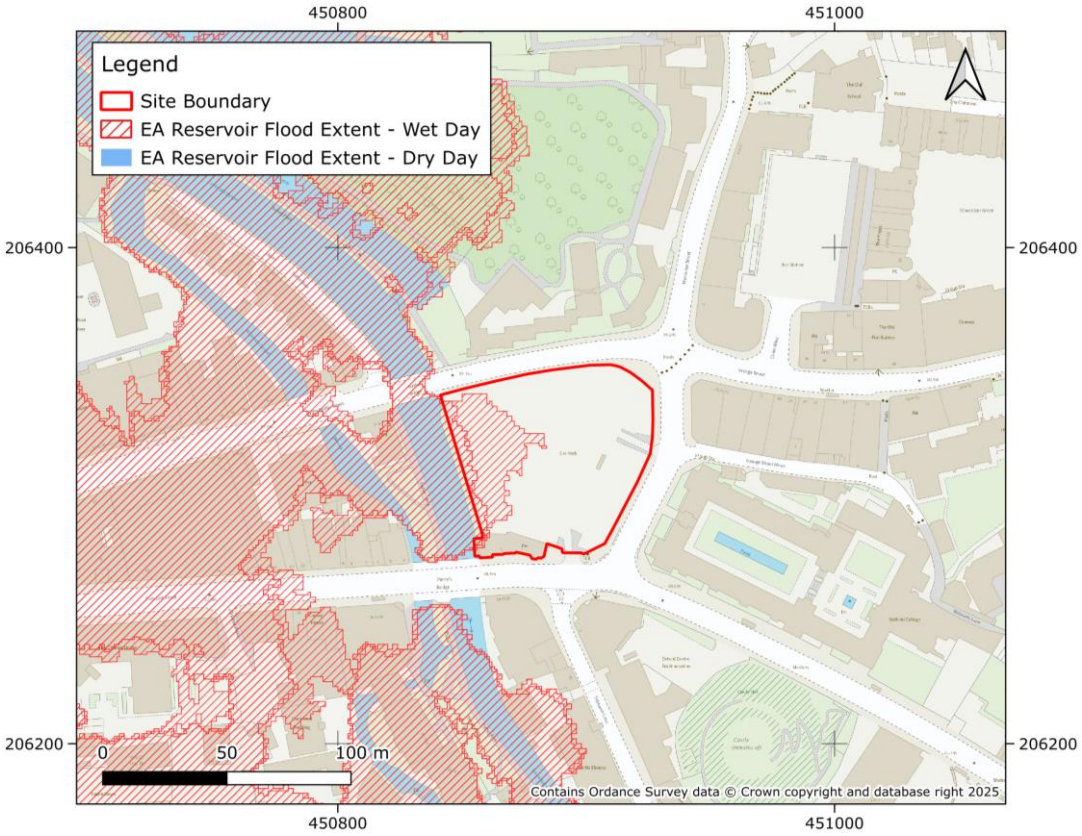

Figure 8 - Reservoir Failure Flood Map

4 Detailed Review of Primary Flood Risk

4.1 Primary Flood Risk

Flood risk to the site occurs via both fluvial and pluvial mechanisms. Therefore, the flood risk generated by both mechanisms is quantitively assessed in more detail below.

4.2 Flood Risk Metrics

As outlined in section 3.2 there are inconsistencies in the flood extents for the site, these are thought to be associated with differences in how water levels in the Castle Mill stream channel are represented.

To better determine the flood risk at the site, the River Thames Model (2018) depth and height data has been reviewed in more detail. Satellite and street view imagery have also been used to determine any flood protection offered to the site.

The River Thames Model (2018) was re-run as part of the previous SFRA for Oxford City in 2023. This was to obtain results applying the latest climate change allowances.

The results for the 100-yr plus central (26%) climate change design event are assessed to attain further detail on fluvial flooding. The depth mapping for the design event (see Figure 9) shows no flooding at the site. The west of the site is bound by a brick wall, which appears to offer some protection to the site. In street view this wall is mostly continuous although there is a small gap midway along the site's western boundary, which could potentially allow flood water in.

Adjacent to the site, the design flood level for the 1.0% AEP +26% CC event is 57.58 m AOD, just below the average ground level at the site based on LIDAR (58.20 m AOD). Approximately 2% of the site is below this level so even if the wall was breached, flood water would only impact a small area located adjacent to the site's western boundary in the design event.

Based on this further assessment and the levels for the 1.0% AEP + 26% CC event, it would appear that the present-day Flood Zone 3a extent is based on a relatively coarse infilling of the Castle Mill stream channel and may not reflect true flood risk at the site. This should be explored in more detail as part of a site-specific FRA.

The Risk of Flooding from Surface Water (RoFSW) depth data for the 100-yr plus climate change design event was assessed to attain further detail on surface water flooding.

The depth mapping (see Figure 10) shows surface water flooding is more widespread across the site than fluvial flooding in the design event. The east of the site is at risk from overland flow from Oxford city centre to the east of the site. The inundation in this area is generally between 0.2–0.3m. Surface water pooling also occurs in the slightly lower topography in the centre of the site, with depths here also between 0.2-0.3m.

4.3 Access and egress

Current access to the site is assumed to be via the entrance to the car park on Park End Street and the exit to Worcester Street. The best identified route of egress leaves the site via Worcester Street, before heading east on George Street, and continuing north along Magdalen Street. Site users are able to continue travel towards flood free areas.

This route lies entirely outside of the design flood extents, and Flood Zones 2 and 3. Whilst the route lies outside of the design fluvial extent, there is some pluvial flood risk along the route. Whilst this risk is generally considered manageable, a site-specific FRA should consider in more detail the nature of the flood risk to determine how quickly it occurs and the degree of hazard.

It should be noted that the site is not currently located within an EA Flood Warning Area. However, other areas of Oxford are covered by flood warning areas and so these Flood Warnings should be considered when assessing the need for evacuation from the site.

Once the development layout is known, a site-specific FRA should consider onsite routes across the site and any infrastructure required to reach the proposed access route. The proposed route should also be reassessed in a site-specific FRA when all access points to the site are known, to ensure the route with the lowest hazard remains the same.

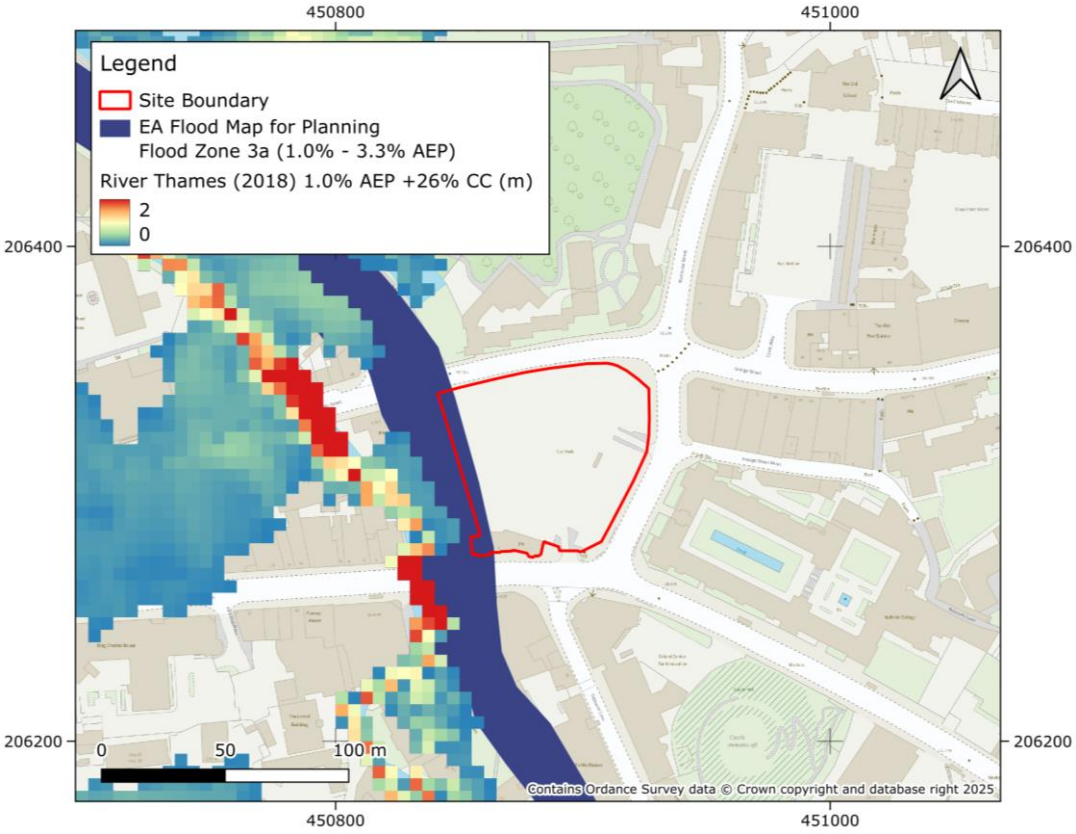

Figure 9 – RoFRS Depth Data for 1.0% AEP + 26% Climate Change Event

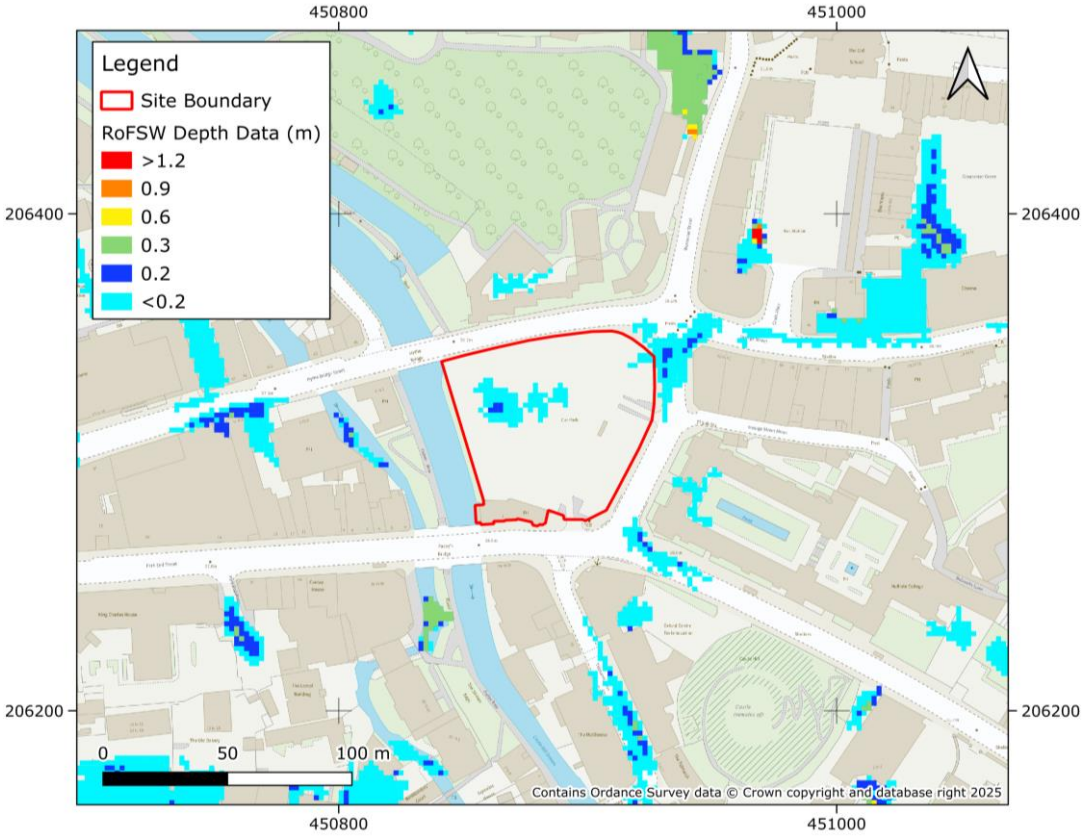

Figure 10 - RoFSW Depth Data for 1.0% AEP + Climate Change Event

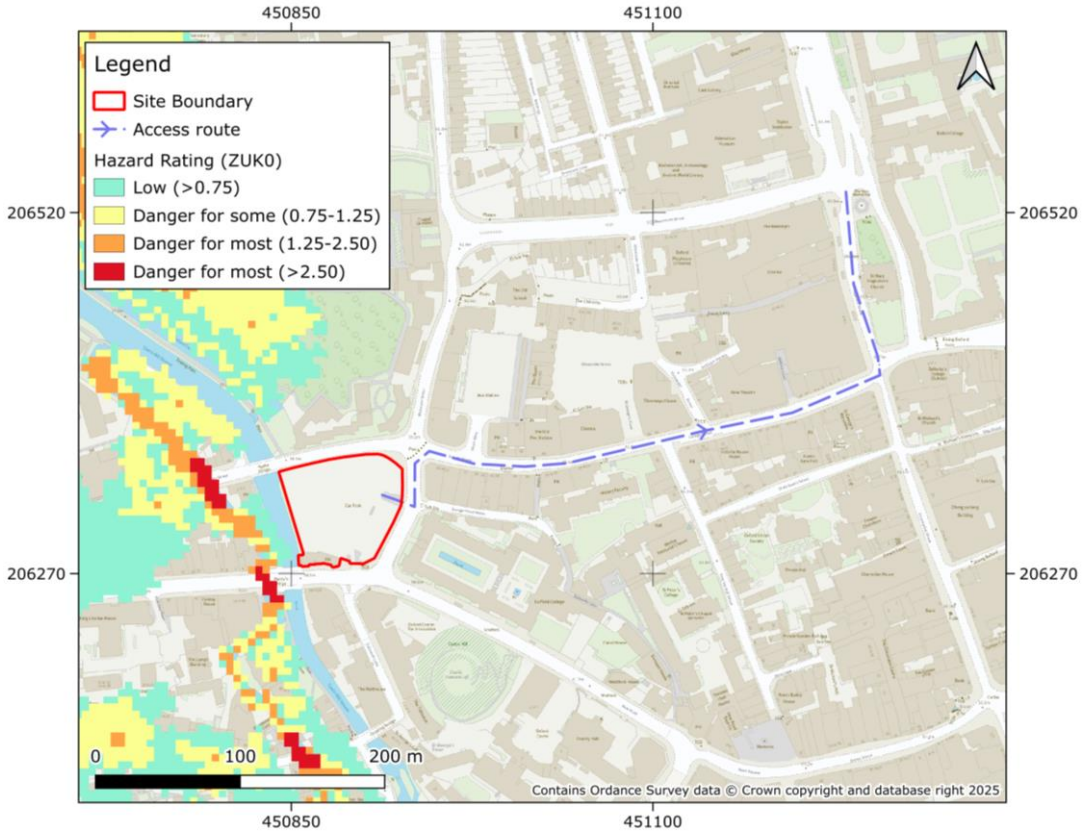

Figure 11 – Access/Egress Routes showing Flood Hazard (ZUK0) for the 1.0% AEP +26% CC Event

5 Development Viability and FRA recommendations

5.1 Development Categorisation

A sequential approach to the siting of the development should be used, with development prioritised first within Flood Zone 1 prior to consideration of any siting within Flood Zone 2 or 3a.

The proposed development at the site is residential. Residential areas are classed as More Vulnerable Development, which is permissible in Flood Zone 2, but needs to pass the Exception Test to justify development in Flood Zone 3a. No development is permissible in Flood Zone 3b.

In terms of fluvial flooding, it should be possible to locate the majority of infrastructure in Flood Zone 1 and outside of the design flood extent. However, as noted there is some uncertainty in the flood risk shown in the FMfP and the protection offered by a wall running along the western boundary of the site. Therefore, a site-specific FRA should investigate fluvial flooding further with updated modelling potentially required.

Surface water flood risk is also significant at the site, whilst manageable a sequential approach should also be followed with development located outside of high-risk areas.

5.2 Scale of Development

The total site area is currently 0.51 ha; at this stage no detail has been provided on the proposed layout of the site or the number of dwellings.

The at-risk areas are mainly concentrated in the west of the site. Given the gradual slope of the site, with the ground rising away from Castle Mill Stream, it should be possible to locate all infrastructure in Flood Zone 1. This is provided there are no constraints (non-flood related) which require development to be located in at-risk areas.

5.3 Sequential Approach

It is important that a sequential approach is implemented at the site, prioritising development in Flood Zone 1 wherever possible, followed by Flood Zone 2 and then Flood Zone 3a. As already stated, no development should be located in Flood Zone 3b. If required more vulnerable housing development should be prioritised in lower flood risk areas with less vulnerable development, such as open spaces, located in higher flood risk areas if required. This is on the assumption that it does not increase flood risk elsewhere and is designed to be appropriately resistant and resilient to flooding.

Note, surface water flood risk is also present in smaller areas across the centre and east of the site. Therefore, it should be used to inform the development layout with development located outside of high-risk areas if possible.

5.4 Other Site-Specific Considerations

Development will need to be set at a floor level to provide an appropriate freeboard (typically 300mm minimum) above the design flood level of 55.91 m AOD for the defended 1.0% AEP (plus central climate change allowance) design event. If ground raising is implemented within the design flood extents, modelling will need to be undertaken to assess 3rd party impacts and compensatory storage requirements. However as mentioned it should be possible to locate all development outside of the design extent.

A site-specific FRA should also consider in more detail the nature of the surface water flood risk in more detail to determine how quickly it occurs and the degree of hazard on site. It should be noted that the climate change allowances used in the pluvial design event scenario are based on the 2050's epoch (2041-2069) and reflect the median estimate of rainfall

increases. If the development has a lifetime beyond this time period, the site-specific FRA should consider the climate change impacts for the 2080's epoch (2075-2125).

The drainage strategy for the proposed development should be suitably designed to manage additional runoff arising from the development and ensure that surface water flood risk at the site and to third party land is not increased. In assessing and demonstrating the viability of any drainage solution for the site, a site-specific FRA should follow the national standards for SuDS and any relevant Local Authority Local Plan policies. It is noted that the existing site is comprised of hard standing so there is potential for the site to offer a significant betterment on existing rates. The geology at the site has low permeability and this combined with soils which have naturally high groundwater, means the effectiveness of infiltration SuDS solutions may be limited. It is recommended that a geotechnical investigation is undertaken at this site to obtain further information relating to infiltration rates, this will confirm whether infiltration could be viable in some areas. Attenuated discharge to a watercourse or a sewer will also need to be considered as part of a site-specific FRA.

Due to some parts of the site being in the wet day reservoir failure inundation extent, any development in this area could affect the reservoirs risk designation, design category and how it is operated with potential cost implications for developers. However, it is noted that the quantum of development is very small in comparison to the existing development in Oxford already lying within the reservoir flood extents so any change in designation is assumed to be unlikely.