Herefordshire Council

HEREFORD CITY STRATEGIC FLOOD RISK ASSESSMENT

Level 2

AUGUST 2020

CONFIDENTIAL

Herefordshire Council

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TYPE OF DOCUMENT (VERSION) CONFIDENTIAL

PROJECT NO. 70056468

DATE: AUGUST 2020

Herefordshire Council

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QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2	Revision 3
Remarks	Issued for comment	Amendments following BBLP review	EA comments addressed	
Date	November 2019	January 2020	August 2020	
Prepared by	S Haberfield / L Sanders	S Haberfield / L Sanders	S Haberfield / L Sanders	
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Authorised by	J Goodwin	J Goodwin	J Goodwin	
Signature			Digitally signed by Goodwin, Joanna (Joanna.Goodwin) Reason: I am approving this document Date: 2020.08.14 18:20:21 +01'00'	
Project number	70056468	70056468	70056468	
Report number	1.0 (Draft)	2.0 (Draft)	3.0 (Final)	

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APPENDICES

1 INTRODUCTION

1.1 OVERVIEW

1.1.1. This Hereford City Level 2 Strategic Flood Risk Assessment (SFRA) builds on the Herefordshire Level 1 SFRA and provides a more detailed assessment of flood risk at a number of strategic and emerging development sites located within the city of Hereford. The Hereford City Level 2 SFRA forms part of the evidence base of the Hereford Area Plan (HAP) that is being developed by the Council and will be used to inform the review of the Local Plan Core Strategy. This Level 2 SFRA has been completed in accordance with the National Planning Policy Framework (NPPF) and its supporting Planning Practice Guidance.

1.1.2. The Herefordshire Level 1 SFRA published in April 2019 assesses the risk of flooding within Herefordshire from all sources, now and in the future, taking into account climate change. The Level 1 SFRA provides the basis for the application of the Sequential Test and, where required, the Exception Test, and summarises key development control policies for the management of flood risk and surface water runoff.

1.1.3. This Level 2 SFRA applies the recommendations of the Level 1 SFRA to specific site locations and considers their vulnerability in accordance with the requirements of the Sequential and Exception Tests, subsequently providing advice on appropriate policies for each site that should be demonstrated as part of any subsequent planning application.

1.1.4. The sites that have been considered within this Level 2 SFRA include the strategic sites identified in the Core Strategy and the further site options that are identified in the HAP consultation documents to aid the delivery of the remainder of the Council's housing and employment targets. Only those sites that are considered to be at notable flood risk and that have not been granted planning permission at the time of preparing this report have been subject to detailed assessment within this Level 2 SFRA. The sites therefore assessed in this Level 2 SFRA include:

- Core Strategy strategic sites:
  - Three Elms
  - Lower Bullingham
- HAP site options:
  - Central Hereford – Cen21 Edgar Street Grid (ESG)
  - South Hereford - Hol12a, Hol12b and Hol13
  - West Hereford - Thr23
  - North Hereford - Bur09
  - Central North – Thr34

1.1.5. Each of the sites / group of sites listed above are discussed within a location-specific appendix to this report to enable appendices to be updated independently if required.

1.1.6. Generic policy recommendations for all other sites that have not been subject to detailed assessment in this Level 2 SFRA are provided below, although reference should always be made to the Level 1 SFRA for a comprehensive summary of these requirements for all developments within Herefordshire.

1.1.7. This Level 2 SFRA has been reviewed and approved by the Environment Agency as a statutory consultee under NPPF.

1.2 DATA SOURCES

1.2.1. The Level 2 SFRA has been informed through predominantly desk-based review of the data sources summarised within the Level 1 SFRA. This has been supplemented by climate change analysis of the River Wye and detailed hydraulic modelling of the Yazor, Withy, Norton and Red Brooks.

1.2.2. Analysis of the potential impacts of climate change on predicted flood extents associated with the River Wye within Hereford was undertaken to inform the Hereford Integrated Catchment Study (ICS)[1] in 2019. The analysis was based on the existing 1D Flood Modeller Pro (FMP) hydraulic model held by the Environment Agency. At the time of writing this SFRA it is understood that the Environment Agency is a planning a comprehensive update to the Wye model, which will incorporate conversion to a 2D model as well as an update to the model hydrology and inclusion of the current climate change allowances. Once completed this will provide the best available information for the River Wye. This assessment of climate change is intended as an interim measure.

1.2.3. The existing model of the Yazor Brook held by Herefordshire Council was updated in 2019 to inform the Hereford ICS. The model comprises a 1D-2D Flood Modeller Pro (FMP)–Tuflow model of the watercourse from upstream of Credenhill to its confluence with the River Wye, encompassing its downstream bifurcations of the Widemarsh and Eign Brooks. In summary, the model updates included a review of the model hydrology to better reflect current estimates and locations of model inflows, and improved representation of key culverts and other structures informed by updated survey. The model does not include the Ayles Brook that joins the Yazor Brook in the centre of Hereford (noting that the Ayles Brook is currently represented using JFLOW modelling at the time of preparing this report) although inflows from the Ayles Brook have been included within the updated Yazor model. The model / model outputs for the Yazor Brook can be requested from Herefordshire Council to inform site-specific flood risk assessments.

1.2.4. It should be noted that the Herefordshire Level 1 SFRA used an earlier version of the hydraulic model for the Yazor Brook and Widemarsh Brook, and as a result there are some minor differences between the mapped flood extents between the Level 1 SFRA and this Level 2 SFRA.

1.2.5. A new hydraulic model of the Withy, Norton and Red Brooks was built in 2019 to inform the Hereford ICS. This comprises a broadscale 2D Tuflow model with structures represented using a combination of 2D flow constrictions and isolated 1D elements within Estry. The model extends approximately 3.2 - 3.5km upstream of each watercourse from their confluence with the River Wye. The model / model outputs for the Withy, Norton and Red Brooks can be requested from Herefordshire Council to inform site-specific flood risk assessments.

[1] The Hereford ICS is an independent study commissioned by Herefordshire Council in 2019 that aims to improve understanding of flood risk and other water related impacts and opportunities within Hereford. This will provide an evidence base to inform proposed plans and policies and ensure sustainable development that manages risk and seeks to provide opportunity and betterment elsewhere.

1.2.6. The hydraulic modelling was completed in consultation with the Environment Agency. It has been agreed that the flood extents generated for the Yazor, Withy, Norton and Red Brooks for the 1 in 20 (5%), 1 in 100 (1%) and 1 in 1000 (0.1%) annual probability events can be used to inform the Flood Zone 1, Flood Zone 2, Flood Zone 3a and Flood Zone 3b[2] extents for this Level 2 SFRA, supported by anecdotal evidence of historic flooding. The mapped flood extents for the Yazor Brook (and therefore the Flood Zones used to inform this SFRA) have not taken the operation of the Yazor Brook Flood Alleviation Scheme (FAS) into account in order to provide a worst-case scenario. It is intended that the model outputs for the Yazor, Withy, Norton and Red Brooks will inform future updates of the Environment Agency's Flood Map for Planning although the programme for these updates is currently unknown. As discussed above, the Environment Agency is also planning a comprehensive review of the River Wye model although the programme is unknown.

1.2.7. The Level 2 SFRA has also been supplemented by consultation with the relevant sewerage authority, Dwr Cymru Welsh Water, to understand the availability and capacity of sewerage systems that could support development in Hereford.

1.2.8. The information provided within this Level 2 SFRA is the best available at the time of writing. More up to date information may be available to inform site-specific assessments and contact should always be made with the Environment Agency, Herefordshire Council and Dwr Cymru Welsh Water at an early stage of any development planning to ensure that the detailed site-based flood risk assessment is using the most current datasets. It is the developer's responsibility to ensure that the most up to date datasets are being used to inform their proposed development and that these are fit for purpose.

1.3 THE SEQUENTIAL AND EXCEPTION TESTS

1.3.1. The risk of flooding is most effectively addressed through avoidance, which in very simple terms means guiding future development away from areas at risk. The application of the Sequential and Exception Tests form the most important consideration in the allocation of land for development.

1.3.2. The aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. In summary, development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower probability of flooding. Development should be steered to Flood Zone 1 in the first instance, and only if there are no reasonably available sites located in Flood Zone 1 should sites be considered in Flood Zones 2 and 3.

[2] Flood Zone 1 is defined as land with an annual probability of flooding from fluvial sources of less than 1 in 1000 (0.1%). Flood Zone 2 is defined as land with an annual probability of flooding from fluvial sources of between 1 in 100 (1%) and 1 in 1000 (0.1%). Flood Zone 3a is defined as land with an annual probability of flooding from fluvial sources of greater than 1 in 100 (1%). Flood Zone 3b is defined as the functional floodplain where water has to flow or be stored in times of flood, typically representing areas that flood naturally during the 1 in 20 (5%) annual probability event or areas that are designed to flood (such as a flood attenuation scheme) in an extreme 1 in 1000 (0.1%) annual probability event. However, urban areas or areas that are located behind flood defences are not usually classified as functional floodplain.

1.3.3. Within Herefordshire, it is expected that the Sequential Test will also take into consideration risks associated with safe access and egress (for example, if a site is located in Flood Zone 1 and is a dry island surrounded by Flood Zone 3). It is also expected that the potential effects of climate change over the lifetime of the development are taken into consideration when applying the Sequential Test.

1.3.4. The process for applying the Sequential Test to inform the preparation of the Local Plan (and HAP) is illustrated in Figure 1.1, recreated from the NPPF Planning Practice Guidance.

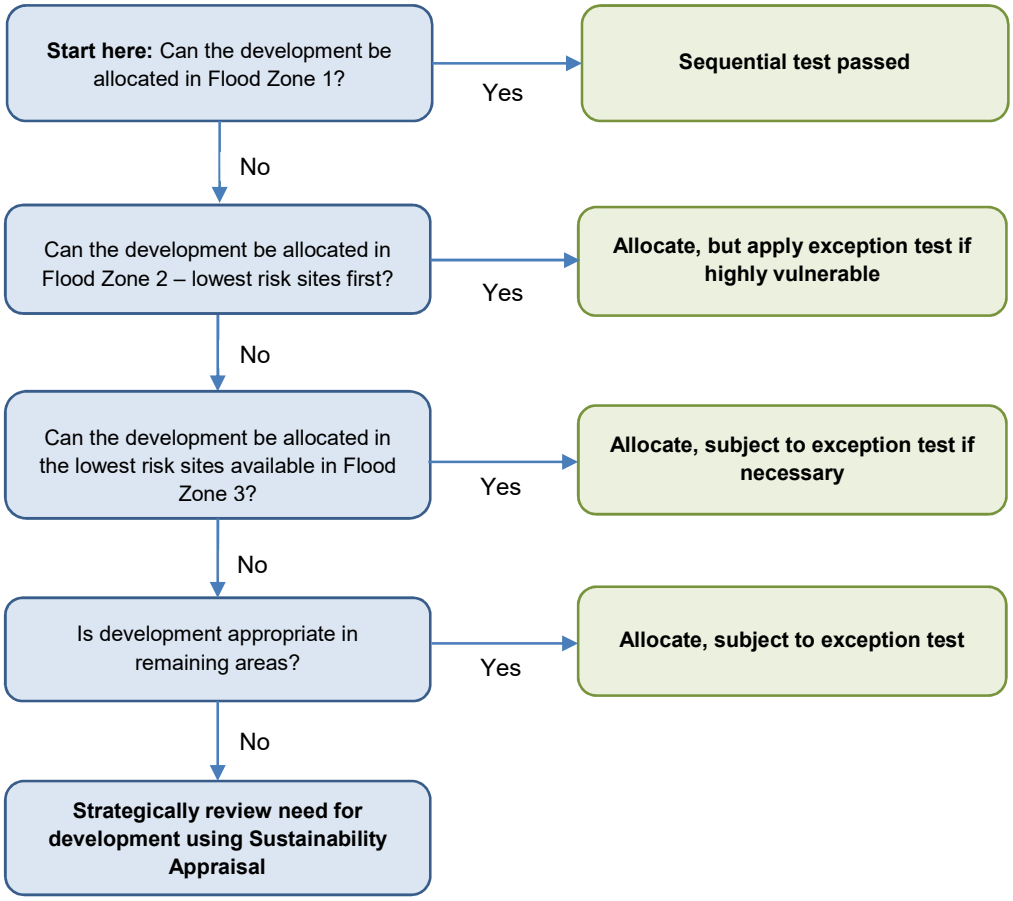


Figure 1.1 Application of the Sequential Test

1.3.5. In addition to the application of the Sequential Test, developments are expected to demonstrate that a sequential approach has been applied to the development layout to locate the most vulnerable areas of a development to those areas of the site that are at least flood risk. This also applies to sites that are located in Flood Zone 1 and to all sources of flood risk.

1.3.6. If following the application of the Sequential Test it is not possible for the development to be located in zones with a lower probability of flooding, the Exception Test must be applied as appropriate. Table 3 of the NPPF Planning Practice Guidance provides recommendations on the compatibility of different types of development based on their vulnerability classification within each of the mapped fluvial and tidal Flood Zones and summarises where the Exception Test will be required, as shown in Table 1.1.

Table 1.1 Flood risk vulnerability and flood zone compatibility

EA Flood Zone	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	✓	Exception test required	✓	✓
Zone 3a	Exception test required	✓	×	Exception test required	✓
Zone 3b	Exception test required	✓	×	×	×

✓ Development considered acceptable

× Development considered unacceptable

1.3.7. The majority of development proposed within the strategic and identified development sites comprises residential, employment and educational development. In accordance with guidance provided in the NPPF Planning Practice Guidance, residential and educational development would typically be classified as 'more vulnerable' and commercial or industrial development would typically be classified as 'less vulnerable'.

1.3.8. For the Exception Test to be passed:

- It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared; and
- A site-specific flood risk assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

1.3.9. Figure 1.2 summarises the application of the Exception Test in the preparation of a Local Plan, recreated from the NPPF Planning Practice Guidance.

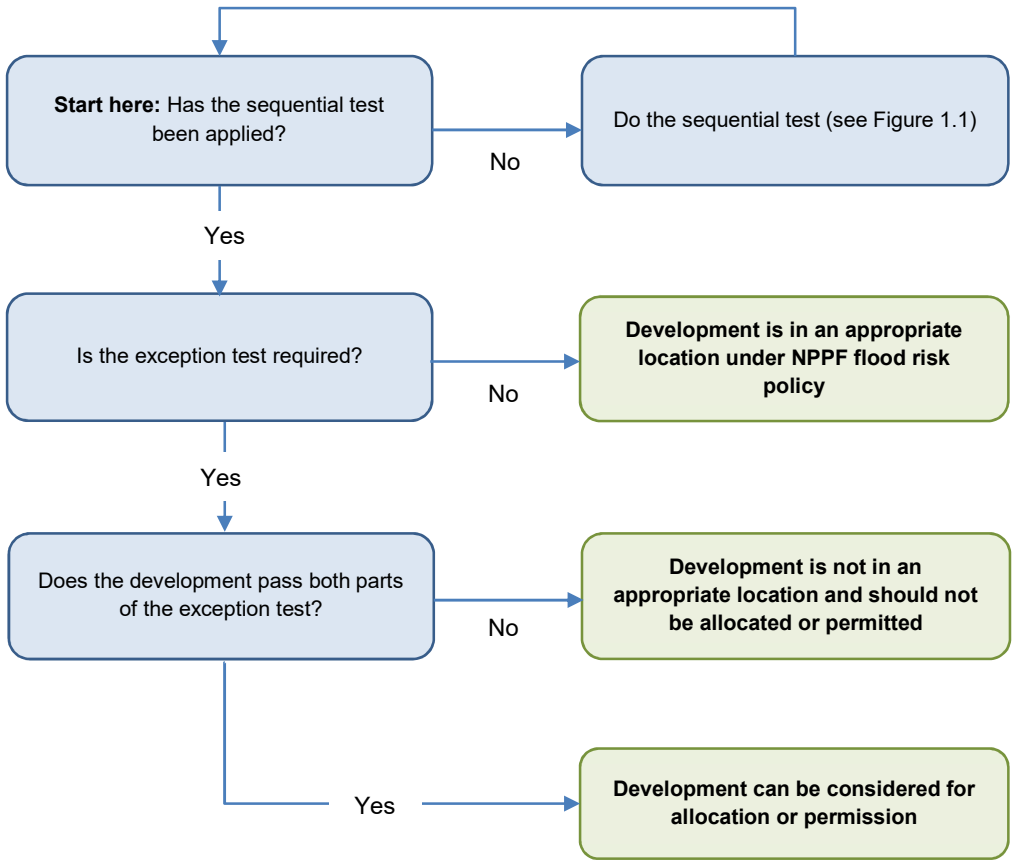


Figure 1.2 Application of the Exception Test

1.3.10. Within Herefordshire it is expected that even where a development passes the Exception Test and is considered acceptable in accordance with Table 1.1, the Sequential Test and sequential approach (as discussed above) must still be applied and summarised within the site-specific flood risk assessment.

1.4 DEVELOPMENT CONTROL

1.4.1. If after the application of the Sequential and Exception Tests the development is considered appropriate at the proposed location, identified flood risks can be managed through consideration of recommended development control policies. These recommendations are presented in detail in Section 6 of the Level 1 SFRA. A brief summary of key recommendations is provided below for reference for this Level 2 SFRA:

- All sources of flood risk must be considered. This includes flooding from main rivers, ordinary watercourses, surface water, groundwater emergence, the sewerage system, reservoirs and other artificial sources, as well as flooding that could be attributable to overland flow, blocked culverts, or temporary exceedance of drainage systems and failure of flood defence schemes.
- Consideration must be given to fluvial flood risks associated with smaller watercourses that may not be illustrated on the Environment Agency's Flood Map for Planning, typically watercourses with a small catchment of less than 3km^2.
- The assessment of fluvial flood risk must consider the potential effects of climate change that may occur over the design life of the development. This includes consideration of the 'design'

scenario and 'test' scenario as set out within Section 6.5 of the Level 1 SFRA. The climate change allowances considered applicable for each of the sites discussed in the detailed assessments of this Level 2 SFRA are presented in the relevant appendices.

- The design of surface water drainage systems must consider the potential effects of climate change that may occur over the design life of the development. This includes consideration of the 'design' scenario and 'test' scenario as set out within Section 6.5 of the Level 1 SFRA. All new drainage should be designed for the Central allowance category, and the resilience of the design tested for the Upper End allowance category.
- Developments should include appropriate flood resilience and resistance measures that may include but not be limited to:
  - Raised floor levels and other measures to prevent flood water ingress;
  - Designing buildings to recover quickly after flood water ingress;
  - Provision of safe access and egress routes, or provision of safe refuge;
  - Avoidance of high risk structures such as basements where these are not appropriate.

1.4.2. A site-specific flood risk assessment will be required to support any planning application that is located within:

- The medium risk Flood Zone 2 or high risk Flood Zone 3 taking the potential effects of climate change into account, and excluding benefits that may be offered by flood defences;
- The low risk Flood Zone 1 where the development is 1 hectare (ha) or greater in area; or
- The low risk Flood Zone 1 where the development is at risk of flooding from other sources of flooding (i.e. surface water, sewerage systems or reservoirs).

1.4.3. The site-specific flood risk assessment should identify and assess the risks of all forms of flooding to and from the development and demonstrate how these flood risks will be managed so that the development remains safe throughout its lifetime, taking climate change into account. Site-specific flood risk assessments for sites greater than 1ha in Flood Zone 1 and with no identified risks from other sources should focus on the sustainable management of surface water runoff generated by the proposed development and opportunities to reduce risk elsewhere.

1.5 SUSTAINABLE DRAINAGE SYSTEMS

1.5.1. Sustainable drainage systems, commonly referred to as SuDS, promote an improved approach to the management of surface water runoff that maximises the additional benefits that can be achieved when compared to traditional piped systems. The use of SuDS within Herefordshire is considered paramount to successful and sustainable development.

1.5.2. The Herefordshire Council SuDS Handbook provides detailed guidance on the expectations and use of SuDS within Herefordshire. This document, along with a useful flood risk and drainage checklist of the information that developers are expected to submit as part of their planning application, is available on the Council's website.

1.5.3. It is expected that strategic development sites (and other large site allocations) will be exemplars of good SuDS design and, where practicable, go beyond the minimum design standards set out within Defra's Non-Statutory Technical Standards for Sustainable Drainage Systems, the Herefordshire Council SuDS Handbook and the Level 1 SFRA. This is likely to include, for example, further reduction in the rate and volume of runoff to rates and volumes to those more comparable with Qbar; further consideration of larger rainfall events that goes beyond consideration of just the 1 in

100 (1%) annual probability event; and the use of vegetated systems that promote infiltration, evapotranspiration and treatment even in impermeable soils.

1.5.4. The long term maintenance of surface water drainage systems is essential to their ability to manage flood risk and protect the natural water environment. The proposals for ongoing maintenance of the surface water drainage system need to be identified during the planning application. Ownership and adoption issues also need to be confirmed. For major developments, a Maintenance Plan will be required for all proposed drainage features that are not being adopted by Dwr Cymru Welsh Water and that are to be adopted and maintained by a third party management company. Appendix C of the Council's SuDS Handbook, available on the Council's website, contains information regarding the arrangements for maintenance and adoption of SuDS features.

1.6 CITY WIDE RECOMMENDATIONS

1.6.1. As discussed in Section 1.1, only those sites that are considered to be at notable flood risk and that have not been granted planning permission at the time of preparing this assessment have been subject to detailed assessment within this Level 2 SFRA. The remaining sites that have been identified in the HAP and that are not considered to be at notable flood risk are listed below for reference, with discussion of any other key considerations that have been identified by Herefordshire Council and review of likely drainage options. It is still important to note that these sites must consider flood risk as part of future planning applications in line with the Level 1 SFRA and generic recommendations discussed above. The submission will need to include a detailed drainage strategy and (if required) a site-specific flood risk assessment to support the planning application.

Table 1.2 Summary of strategic and identified sites not subject to detailed assessment

Site Reference	Flood Risk	Sequential and Exception Tests	Key Recommendations
North Hereford - Holmer West Strategic Urban Extension	Majority of site in Flood Zone 1. Ayles Brook flows along southern site boundary. Overland flow route / ditch within west of site.	Planning permission has been granted. Site allocation passes the Sequential Test with development located in low risk Flood Zone 1. Site allocation passes the Exception Test.	Development of site has taken overland flow and Ayles Brook into account. Greenfield site. Discharge to Ayles Brook with rate attenuated to Qbar. Finished floor levels located above estimated flood level.
North-west Hereford HAP sites - Thr19, Thr21, Thr22, Thr26 Thr28, Thr35 & Cre25	Sites in Flood Zone 1. Pockets of surface water flooding with minimal risk to site development. No other significant sources of flood risk.	Site allocations pass the Sequential Test and Exception Test.	Consideration to be given to surface water ponding. Greenfield sites. Infiltration may be possible although restricted by presence of SPZ. Direct discharge to Yazor Brook may be possible although likely to require passage through third-party land. Indirect discharge to Yazor Brook likely to be preferred via DCWW surface water network or highway drainage.

Site Reference	Flood Risk	Sequential and Exception Tests	Key Recommendations
South-west Hereford HAP site - Bel08	Sites in Flood Zone 1. No other significant sources of flood risk.	Site allocation passes the Sequential Test and Exception Test.	Greenfield site. Infiltration unlikely. Drainage likely to comprise direct discharge to River Wye.
South Hereford HAP sites - Stm01, Stm05, Stm17	Sites in Flood Zone 1. No other significant sources of flood risk.	Site allocations pass the Sequential Test and Exception Test.	Greenfield sites. Some infiltration may be possible. Alternatively, drainage could comprise direct discharge to Withy Brook and Norton Brook although likely to require passage through third-party land.
East Hereford HAP sites - Ayl16, Tup26 & Tup27	Sites in Flood Zone 1. Surface water flooding associated with overland flow route along site boundaries. No other significant sources of flood risk.	Site allocations pass the Sequential Test and Exception Test.	Consideration to be given to surface water overland flow routes. Greenfield site. Infiltration unlikely. Drainage likely to comprise direct discharge to minor tributaries of River Lugg or indirect discharge to River Lugg via DCWW surface water network.
Hereford Racecourse HAP sites - Thr29 & Thr37	Sites in Flood Zone 1. No other significant sources of flood risk.	Site allocations pass the Sequential Test and Exception Test.	Greenfield sites. Infiltration may be possible. Alternatively, drainage could comprise discharge to Ayles Brook or indirect discharge to Yazor Brook via DCWW surface water network.
Central Hereford West HAP sites - Thr32, Stn05 & Stn21	Sites in Flood Zone 1. Surface water flooding may pose risk to access for Thr32. No other significant sources of flood risk.	Redevelopment of brownfield sites. Site allocations pass the Sequential Test and Exception Test.	Consider safe access and egress requirements. Brownfield sites. Likely to currently discharge to DCWW combined sewer network. Some infiltration may be possible. Alternatively, drainage could comprise indirect discharge to River Wye via DCWW surface water network.

Site Reference	Flood Risk	Sequential and Exception Tests	Key Recommendations
Central Hereford East HAP sites - Cen08, Cen22, Cen 27, Cen28, Cen30, Tup22, Tup25	Sites in Flood Zone 1. Pockets of low risk surface water flooding with minimal risk to site development. No other significant sources of flood risk.	Redevelopment of brownfield sites. Site allocations pass the Sequential Test and Exception Test.	Brownfield sites. Likely to currently discharge to DCWW combined sewer network. Infiltration unlikely. No known DCWW surface water network for majority of sites. Possible that suitable highways drainage network available but only acceptable following analysis of alternative options and network capacity. Possible that discharge to DCWW combined sewer network will be required. Consultation with HC and DCWW required.

1.7 DETAILED ASSESSMENT SUMMARY

1.7.1. Detailed assessments of the selected strategic and identified site options considered within the Level 2 SFRA are presented within the subsequent report appendices. Figure 1.3 below provides an overview of the location of the sites assessed within this report.

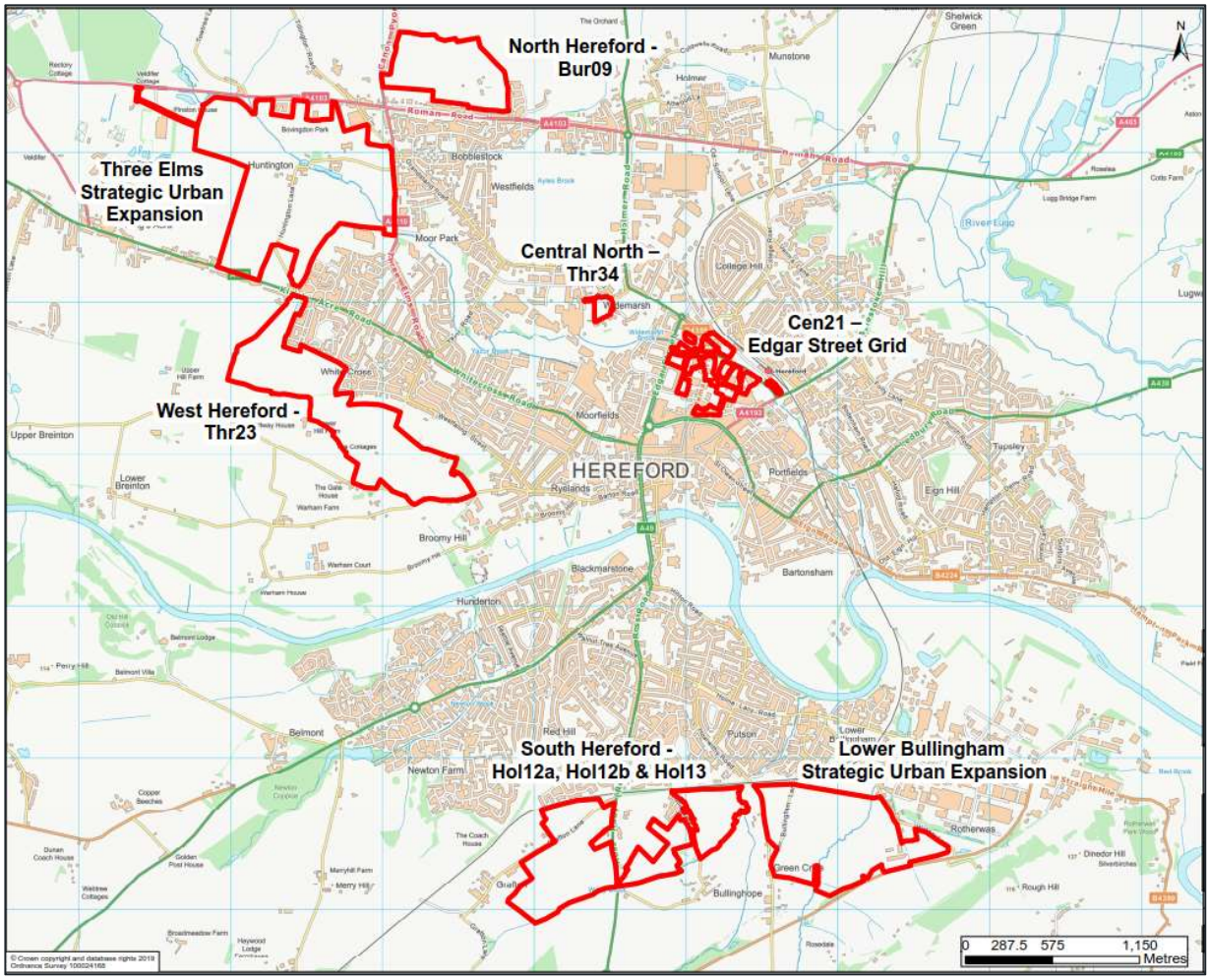


Figure 1.3 Location of strategic and identified sites

1.7.2. In summary, it is considered that all sites pass the Sequential Test and are appropriate for proposed development as set out within the Core Strategy and HAP site options. Where flood risks have been identified and the Exception Test is required, there are feasible mitigation measures that can be implemented to manage these risks without increasing flood risk elsewhere. A brief overview of the key requirements for future development is provided below

Table 1.3 Summary of strategic and identified sites subject to detailed assessment in this Level 2 SFRA

Site	Flood Risk	Sequential and Exception Tests	Key Recommendations
Three Elms Strategic Urban Expansion	Majority of site in Flood Zone 1. Yazor Brook and associated Flood Zone 2 and 3 passes through centre of site. No other significant sources of flood risk.	Site allocation passes the Sequential Test and Exception Test if development is located in low risk Flood Zone 1.	All development to be located outside of mapped fluvial flood extents up to the 1 in 100 (1%) annual probability event with 70% climate change allowance or the 1 in 1000 (0.1%) annual probability event, whichever is greater. Infiltration unlikely due to SPZ although building roof drainage may be appropriate. Surface water runoff more likely to be discharged to Yazor Brook. Recommend attenuation to Qbar greenfield runoff rate for all events. Maintain discharge during smaller events to assist with low flow issue in Yazor Brook. Treatment of runoff important. Opportunities to reduce flood risk elsewhere must be explored.
Lower Bullingham Strategic Urban Expansion	Majority of site in Flood Zone 1. Red Brook and associated Flood Zone 2 and 3 passes through centre of site. No other significant sources of flood risk.	Site allocation passes the Sequential Test and Exception Test if development is located in low risk Flood Zone 1.	All development to be located outside of mapped fluvial flood extents up to the 1 in 100 (1%) annual probability event with 70% climate change allowance or the 1 in 1000 (0.1%) annual probability event, whichever is greater. Infiltration to be promoted. If unviable, surface water runoff to be discharged to Red Brook. Recommend attenuation to Qbar greenfield runoff rate for all events. Consideration needs to be given to safe access and egress. Opportunities to reduce flood risk elsewhere should be explored.

Site	Flood Risk	Sequential and Exception Tests	Key Recommendations
Cen21 – Edgar Street Grid	Site located in Flood Zones 1, 2 and 3 attributable to Widemarsh and Ayles Brooks. Widemarsh Brook passes through centre of site. At significant risk of flooding from surface water and potentially high groundwater levels.	Regeneration of ESG important to economic growth of the city. Supported by construction of Yazor Brook FAS in 2012. Deemed to pass Sequential Test. Exception Test required. Development deemed to provide wider sustainability benefits. Independent study has concluded that appropriate mitigation can make development safe without increasing flood risk elsewhere. Likely to pass Exception Test although site-specific assessment required.	Plot levels to be raised. Finished floor levels minimum 600mm above 1 in 100 (1%) annual probability event with 35% climate change allowance flood level. Safe access and egress to be maintained. Buildings to remain dry in residual flood risk events. No increase flood risk to third parties in design or residual risk events. Infiltration unlikely. Attenuated discharge to Widemarsh Brook recommended where viable, either directly or via DCWW surface water network or highway drainage. Maximum discharge rate of either 5 l/s or Qbar recommended, whichever is lower, to assist with managing flood risk elsewhere.
South Hereford - Hol12a, Hol12b & Hol13	Majority of sites in Flood Zone 1. Withy Brook flows along southern site boundary. Fluvial flood risk within east of site Hol12b. Small area of surface water ponding in site Hol13. No other significant sources of flood risk.	Site allocations pass the Sequential Test and Exception Test if development is located in low risk Flood Zone 1.	All development to be located outside of mapped fluvial flood extents up to the 1 in 100 (1%) annual probability event with 70% climate change allowance or the 1 in 1000 (0.1%) annual probability event, whichever is greater. Infiltration unlikely to be viable. Surface water runoff likely to be discharged to Withy Brook. Recommend attenuation to Qbar greenfield runoff rate for all events. Consideration needs to be given to safe access and egress. Site Hol12b offers significant opportunities to reduce flood risk elsewhere that are recommended to form part of allocation requirement.

Site	Flood Risk	Sequential and Exception Tests	Key Recommendations
West Hereford - Thr23	Site located in Flood Zone 1. Significant surface water flood risk from overland flow in north of site.	Site allocation passes the Sequential Test and Exception Test.	Consideration must be given to overland flow surface water flood risk, with opportunity to provide betterment to existing properties adjacent to north of site. Infiltration may be viable in parts of site although springs known to exist. Alternatively, surface water runoff likely to be discharged to DCWW surface water network or (for part of site) discharge to existing ditch to south. Recommend attenuation to Qbar greenfield runoff rate for all events.
North Hereford - Bur09	Site located in Flood Zone 1. Minor surface water flood risk from overland flow in west of site.	Site allocation passes the Sequential Test and Exception Test.	Consideration must be given to overland flow surface water flood risk, with opportunity to provide betterment to existing infrastructure to west of site. Infiltration unlikely to be viable. Surface water runoff likely to be discharged to Ayles Brook and DCWW surface water network. Recommend attenuation to Qbar greenfield runoff rate or 5l/s for all events.
Central North – Thr34	Site located in Flood Zone 2 attributable to Ayles Brook although flood extents highly indicative. Site not within functional floodplain. At risk of flooding from surface water.	Regeneration of urban brownfield site. Deemed to pass Sequential Test. Exception Test may be required for more vulnerable development if deemed to be in Flood Zone 3 when climate change considered. Unlikely to pass Exception Test if more vulnerable development proposed in Flood Zone 3.	Finished floor levels minimum 600mm above 1 in 100 (1%) annual probability event with 35% climate change allowance flood level. Buildings to remain dry in residual flood risk events. No increased flood risk to third parties in design or residual risk events. Infiltration unlikely. Attenuated discharge to Widemarsh Brook recommended via DCWW surface water network. Maximum discharge rate of 5 l/s recommended.

Appendix A

THREE ELMS

THREE ELMS (WESTERN URBAN EXPANSION)

Allocation Reference:	Three Elms (Western Urban Expansion)
Location:	West Hereford
River Catchment:	Yazor Brook
NPPF Flood Zone (majority of area):	Flood Zone 1
NPPF Flood Zone (worst case):	Flood Zone 3b

INTRODUCTION

The Three Elms strategic development site occupies an area of approximately 95ha and is located to the north-west of Hereford as illustrated in Figure A.1. The site comprises largely agricultural land and the small settlement of Huntington in the centre of the site. The site is bound by Roman Road (A4103) to the north, Three Elms Road (A4110) and Whitecross Hereford High School to the east, Kings Acre Road (A438) to the south and the Livestock Market to the west. The centre of Hereford is located approximately 2.7km to the south-east of the site. The Yazor Brook flows in a south-east direction through the centre of the site, broadly splitting the site into two halves. The Yazor Brook is classified as an ordinary watercourse and is therefore under the jurisdiction of Herefordshire Council as Lead Local Flood Authority (LLFA).

Topography within the Three Elms strategic development site is relatively flat with a gentle slope from both the north and south towards the Yazor Brook in the centre of the site. Ground levels in the north of the site vary between 74mAOD and 61mAOD and in the south of the site vary between 65mAOD and 61mAOD. The north of the site is steeper in comparison to the south of the site.

The Three Elms strategic development site is identified in the Core Strategy as part of the Western Urban Expansion (Three Elms). Policy HD5 of the Core Strategy sets out the vision for the strategic site that comprises the provision of a minimum of 1000 new homes, 10 hectares of employment land, a Park & Choose site, a 210-place primary school, the expansion of Whitecross Hereford High School, and a neighbourhood community hub. Policy HD5 also includes a number of flood risk related requirements for the development of this site namely:

- Sustainable drainage and flood mitigation solutions should form an integral part of the green infrastructure network.
- Opportunities to mitigate flood risk arising from the Yazor Brook for existing residents and businesses within the city should be explored.

Policy HD6 also discusses the provision of a linear park along the Yazor Brook.

At the time of preparing this assessment it is known that the following major development application has been made within the Three Elms strategic site boundary:

- Outline planning application for the entirety of the Three Elms strategic site comprising 1200 new residential dwellings, an employment area, new primary school and a community hub (reference P162920/F awaiting determination). The development proposes two construction phases: 580

new residential dwellings and the new primary school to be constructed in the first phase and the remaining 620 new residential dwellings and the employment area to be constructed in the second phase.

DESCRIPTION OF FLOOD RISK

FLUVIAL

The assessment of fluvial flood risk has been informed by the 1D-2D FMP-Tuflow hydraulic model of the Yazor Brook that was commissioned by Herefordshire Council in 2019 to inform the Hereford ICS as discussed in Section 1.2 of the Hereford City Level 2 SFRA. The Flood Zone classification discussed below does not take into account the Yazor Brook Flood Alleviation Scheme (FAS) (discussed below) that was constructed in 2012 to reduce flood risk in the city centre. The undefended scenario has been used to denote the likely worst case scenario.

The updated undefended fluvial modelling of the Yazor Brook indicates that the majority of the Three Elms strategic site is located within the low risk Flood Zone 1 where the annual probability of flooding from fluvial sources is less than 1 in 1000 (0.1%). Land adjacent to the Yazor Brook is located within the high risk Flood Zone 3 and the medium risk Flood Zone 2. Flood Zone 3 is defined as land where the annual probability of flooding from fluvial sources is greater than 1 in 100 (1%). Flood Zone 2 is defined as land where the annual probability of flooding from fluvial sources is between 1 in 100 (1%) and 1 in 1000 (0.1%). The mapped undefended fluvial flood extents are illustrated in Figure A.2.

It should be noted that the Flood Zones shown in Figure A.2 are different to the Flood Zones used in the Herefordshire Level 1 SFRA following the update of the hydraulic model. The extent of both Flood Zones 2 and 3 are slightly smaller in the updated hydraulic model, particularly within the eastern section of the site.

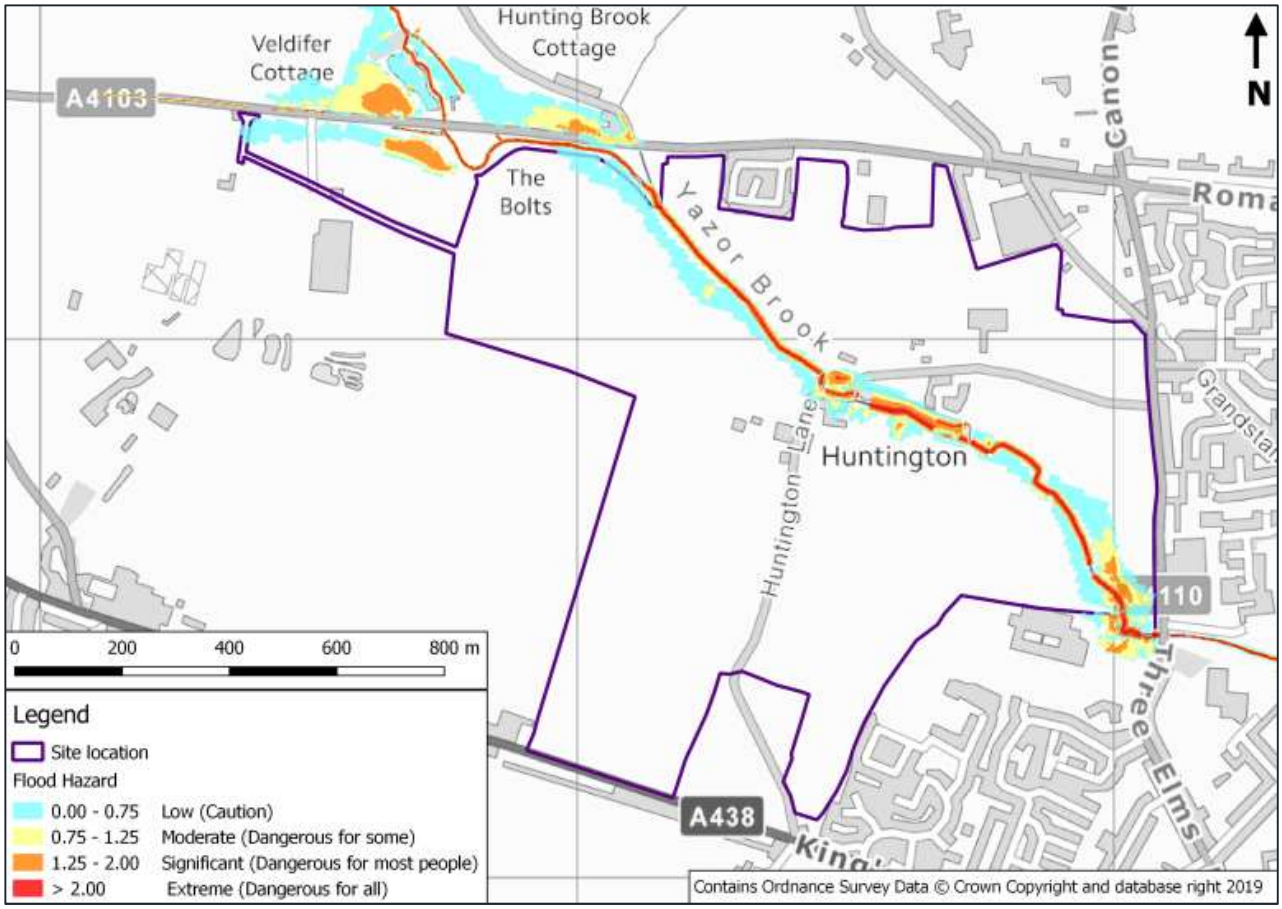
The Flood Zone 3b functional floodplain is defined as land where water has to flow or be stored in times of flood, typically represented by areas that flood naturally during the 1 in 20 (5%) annual probability event. The updated undefended fluvial modelling flood extent for 1 in 20 (5%) annual probably event indicates that flood flows exceed channel capacity along the watercourse through the site, although the flood extents are relatively small and constrained to land adjacent to the Yazor Brook. The mapped undefended functional floodplain extents are illustrated in Figure A.3.

The updated undefended fluvial modelling of the Yazor Brook has modelled the potential effects of climate change for a 35% and 70% increase in peak river flows for the 1 in 100 (1%) annual probability event. Mapped outputs of the climate change allowances are illustrated in Figure A.4. The mapping indicates that the extent of the 1 in 100 (1%) annual probability event with 70% climate change allowance is almost identical to the current extent of Flood Zone 2. Flooding during the 1 in 100 (1%) annual probability event with 35% climate change allowance is also increased, with flood waters overtopping the banks of the Yazor Brook at Pinston House in the west of the site and flowing overland parallel to the watercourse.

Figure A.5 illustrates the fluvial flood risk extents with the Yazor Brook FAS operational for the 1 in 100 (1%) annual probability event with a 35% and 70% climate change allowance. The FAS is located upstream of Hereford at Credenhill and diverts flood flows from the Yazor Brook to the River Wye via an overspill weir and c.1.4km long 2m diameter culvert that connects the two watercourses. The defended fluvial flood extents show a reduction in the areas indicated to be at risk of flooding

and removal of the overtopping flows at Pinston House, although there are still some out of bank flows adjacent to the Yazor Brook.

Flood hazard (a combination of depth and velocity) has been determined as part of the updated defended fluvial modelling of the Yazor Brook. Mapped output of flood hazard for the 1 in 100 (1%) annual probability event (with operational FAS) is illustrated in Insert A.1 below and includes a 35% climate change allowance. As shown in Insert A.1, the majority of the mapped flood hazard through the Three Elms site is classified as Low (Caution) with the exception of a small pocket at Huntington and in the south-east of the site that are classified as Significant (Dangerous for Most).



Insert A.1 – Yazor Brook flood hazard (depth and velocity) for Three Elms

SURFACE WATER AND MINOR WATERCOURSES

The Environment Agency's Risk of Flooding from Surface Water map indicates that the Three Elms strategic development site is generally at very low risk of surface water flooding as illustrated in Figure A.6. The flood extents along the Yazor Brook are broadly similar to the fluvial flood extents as previously discussed in the section above. The mapping indicates small areas of ponding in the centre and south of the site boundary which is assumed to correspond to local depressions in topography and not pose significant risk to future development.

GROUNDWATER

Review of the British Geological Survey (BGS) data indicates that the Three Elms strategic development site is underlain by Raglan Mudstone Formation comprising siltstone and mudstone

bedrock geology. Superficial deposits comprise Till that overlays Yazor Gravels. The Yazor Gravels between Credenhill and Three Elms Road are designated as a groundwater Source Protection Zone (SPZ) that serves the Heineken site in the centre of Hereford. The east of the site is located within Zone 1 (inner zone) which is defined as the 50 day travel time of pollutants to source with a 50m default minimum radius.

The BGS website provides a number of historic borehole records within and adjacent to the site boundary. These indicate groundwater levels that typically vary between approximately 6-10m below ground level although may be closer to surface in close proximity to the Yazor Brook and in the lower areas of the site. Whilst groundwater is likely to move freely within the Yazor Gravels, the Three Elms strategic development site is considered to be at low risk of groundwater flooding although consideration would need to be given to groundwater emergence that could affect unlined drainage systems or granular bedding on drainage systems.

OTHER SOURCES OF FLOOD RISK

Land adjacent to the Yazor Brook within the Three Elms strategic development site is classified as being at risk of flooding on the Environment Agency's Risk of Flooding from Reservoirs map. The extent is broadly similar to the fluvial flood extents previously described. The risk is attributable to a covered reservoir operated by Dwr Cymru Welsh Water located between Burghill and Portway approximately 3km upstream of the site. The reservoir is identified on OS mapping.

The Three Elms strategic development site is located on the outskirts of Hereford and there is sparse development surrounding the site. The site is not likely to be at significant risk of flooding from adjacent sewerage or drainage systems.

HISTORIC FLOOD RECORDS

Review of Herefordshire Council and Dwr Cymru Welsh Water historic flood records at the time of preparing this report indicate flooding at Huntington in November 2012 within the extent of the Three Elms site. The source of the event is not recorded but is likely to be attributable to the Yazor Brook.

A large number of flooding events have also been recorded downstream of the Three Elms site in the centre of Hereford. Three of these are stated to be attributable to flooding from the Widemarsh Brook (a downstream bifurcation of the Yazor Brook). The cause of the remaining events has not been recorded although are likely to be associated with the Yazor and Widemarsh Brooks.

PLANNING RECOMMENDATIONS

SPATIAL PLANNING AND DEVELOPMENT CONTROL

Development of the Three Elms strategic development site should be undertaken in accordance with the principles as set out within Section 1 of the Level 2 SFRA and Section 6 of the Level 1 SFRA. It is understood that proposed development within the Three Elms strategic development site will comprise a mix of more vulnerable development (such as residential and educational uses) and less vulnerable development (such as employment and retail uses).

The majority of the site is located within Flood Zone 1 and safe access and egress can be achieved. Given the size of the site it is recommended (and considered achievable) that all development (with the exception of access roads that may need to cross the Yazor Brook) can be located in Flood Zone 1 and outside of the extent of mapped fluvial flooding up to and including the 1 in 100 (1%) annual probability event with 70% climate change allowance or the 1 in 1000 (0.1%) annual

probability event, whichever is greater. Other sources of flooding as discussed above are not considered to pose risk to the development assuming that the recommendation to locate all development in Flood Zone 1 is adopted.

The site allocation is deemed to pass the Sequential and Exception Tests given that the majority of the site is at low risk of flooding, however a site-specific Flood Risk Assessment (FRA) prepared in accordance with the NPPF and supporting Planning Practice Guidance will be required. It is expected that the FRA is supported by detailed modelling of the Yazor Brook. The FRA should assess the risk of flooding associated with the Yazor Brook (including climate change allowances) and assess the risks associated with an increase in the rate or volume of site-generated surface water runoff. The site also offers opportunity to improve flood risk elsewhere. These aspects are discussed in greater detail below.

MANAGEMENT OF FLUVIAL FLOOD RISKS

The updated fluvial modelling of the Yazor Brook indicates that the majority of the Three Elms strategic development site would not be at risk during the 1 in 100 (1%) or 1 in 1000 (0.1%) annual probability events. As stated above, it is recommended that all development (including drainage systems but with the exception of access roads that may need to cross the Yazor Brook) are located outside of the undefended flood extents and taking climate change into account.

Finished floor levels of any new buildings should be raised a minimum of 600mm above the defended 1 in 100 (1%) annual probability event with an appropriate climate change allowance for the 'design event'. Finished floor levels should also be located above the 1 in 100 (1%) annual probability event with an appropriate climate change allowance for the 'test event' that considers both the defended and undefended scenarios. Recommended climate change allowances for the design event and test events are summarised below in Table A.1.

Table A.1 Climate change allowances

Development Classification	Design scenario	Test scenario
Less vulnerable	1 in 100 annual probability event with 35%CC with operational FAS	Highest of: 1 in 100 annual probability event with 70%CC with operational FAS; 1 in 1000 annual probability event with operational FAS; or 1 in 100 annual probability event with 35%CC with fully blocked FAS
More vulnerable	1 in 100 annual probability event with 35% with operational FAS	Highest of: 1 in 100 annual probability event with 70%CC with operational FAS; 1 in 1000 annual probability event with operational FAS; or 1 in 100 annual probability event with 35%CC with fully blocked FAS

Key access routes within the site should remain dry up to and including the 1 in 100 (1%) annual probability event plus 35% climate change allowance.

The development must not increase flood risk elsewhere. At minimum there should be no increase in flood risk up to the 1 in 100 (1%) annual probability event with 35% climate change allowance. Third-party impacts should also be tested for the residual risk events discussed above, noting that the acceptability of risks to third party land during these events will be assessed on a case-by-case basis (in consultation with Herefordshire Council and the Environment Agency) that takes the vulnerability of the land and the increase in risk into account.

If any development is required to be located in areas at risk during the 1 in 100 (1%) annual probability event plus 35% climate change allowance; 1 in 1000 (0.1%) annual probability event; or residual risk events discussed above, compensatory flood storage should be provided on a like-for-like basis, and ideally strive to provide betterment.

If a new crossing of the Yazor Brook is required to facilitate site access, this must be a clear span crossing and must demonstrate (via hydraulic modelling) that the crossing will not pose flood risk to the development or elsewhere as discussed above. A minimum 300mm freeboard to the soffit of the crossing should be maintained above the 1 in 100 (1%) annual probability event with 35% climate change allowance. Consideration should also be given to the residual risk events discussed above, noting that the road should remain safe during these events if it is considered important for access and egress during a flood event. Consideration must also be given to maintenance access and ecological requirements (including mammal passage) noting that a higher freeboard may be required.

If development of the Three Elms strategic development site is dependent on the construction of new strategic highway infrastructure, the potential implications of any essential auxiliary works should be taken into account in the assessment of flood risk and design of any required mitigation.

MANAGEMENT OF SITE GENERATED SURFACE WATER RUNOFF

The management of surface water runoff will be of particular importance for the Three Elms strategic development site given the historic flooding at Huntington and further downstream in the centre of Hereford. Drainage systems should be designed in accordance with the Herefordshire SuDS Handbook and Section 6 of the Level 1 SFRA, adhering to the following key principles:

- Applying the SUDS hierarchy to promote the infiltration of runoff to ground prior to the consideration of other measures;
- Controlling the rate and volume of runoff to ensure no increased flood risk for all events between the 1 in 1 (100%) and the 1 in 100 (1%) annual probability rainfall events;
- Promoting best practice vegetated and on-ground conveyance and storage features as much as practicable.

Methods for calculating runoff must be in accordance with the methods promoted within the CIRIA SuDS Manual (C753, published in 2015). It is expected that FEH methods and 2013 rainfall data are used in the calculations for existing and post-development scenarios. The calculation of pre-development runoff rates and volumes should not take the potential effects of climate change into account.

As discussed above the site is underlain by Till and Yazor Gravels superficial deposits with Raglan Mudstone Formation bedrock geology. Infiltration testing undertaken to support the Outline Planning Application for the Three Elms strategic development site indicated low infiltration potential within the Till. The permeability of the Yazor Gravels is likely to be high, although groundwater levels may be high (or seasonally high) in close proximity to the Yazor Brook and lower elevations of the

site. The Yazor Gravels between Credenhill and Three Elms Road are also designated as a groundwater SPZ and infiltration of surface water runoff into the SPZ (particularly from vehicular areas) is generally not supported by the Environment Agency, although this should be confirmed on a site-by-site basis and may be permitted in Zone 3 (outer zone) of the SPZ. Some discharge of roof water may also be permitted.

A controlled discharge to the Yazor Brook is likely to be the most viable option for surface water drainage for the majority of the Three Elms strategic development site. Attenuation of runoff will be of key importance and given the size and strategic importance of this site it is recommended that discharge is limited to Qbar or lower for all return period events (i.e. up to the 1 in 100 (1%) annual probability event and allowing for climate change) as much as practicable. Given the strategic importance of this site is also recommended that consideration is given to events larger than the 1 in 100 (1%) annual probability event – i.e. up to the 1 in 1000 (0.1%) annual probability event. Reducing runoff during larger return period events will mitigate increased downstream flood risk associated with the site's development and may also assist with reducing downstream flood risk attributable to the Yazor Brook.

Consideration must also be given to the performance of the drainage system (i.e. ensuring appropriate head to ensure correct function of flow controls) and the risk of water not being able to discharge as intended during periods of high water levels within the Yazor Brook.

Maintaining discharge during smaller events will, however, also be important as the Yazor Brook experiences difficulties with low flows that adversely affects water quality and hydromorphological conditions. Providing robust treatment of runoff will be important to prevent adverse effect to the quality of the Yazor Brook and assist in achieving the objectives of the Water Framework Directive.

It is expected that for a development site of this size best practice 'green' SUDS measures (i.e. vegetated conveyance and storage systems) are incorporated that promote attenuation (and infiltration where appropriate), treatment and biodiversity benefit throughout the development.

MANAGEMENT OF POTENTIALLY HIGH GROUNDWATER LEVELS

The risk of high groundwater levels must be considered in the drainage design, most notably the risk that high groundwater levels could reduce the effectiveness of infiltration systems or reduce the capacity of unlined attenuation/infiltration systems. If these systems are proposed, winter groundwater monitoring should be undertaken to better understand and mitigate these risks.

MANAGEMENT OF FOUL WATER

Foul water from the Three Elms strategic development site should be discharged to the public sewerage network that serves the city of Hereford. Dwr Cymru Welsh Water have confirmed that there is a public sewer that crosses the site. The Applicant should discuss their proposed development with Dwr Cymru Welsh Water to determine if this approach is acceptable and agree the need for any local improvements.

OPPORTUNITIES FOR BETTERMENT

Policy HD5 (Western Urban Expansion (Three Elms)) of the Core Strategy includes a number of flood risk related requirements for the development of this site. It states the following:

- Sustainable drainage and flood mitigation solutions should form an integral part of the green infrastructure network.

- Opportunities to mitigate flood risk arising from the Yazor Brook for existing residents and businesses within the city should be explored.

These requirements must be explored as part of the site's development.

As discussed above, the site also offers opportunity to reduce surface water runoff from the Three Elms strategic development site during larger rainfall events by limiting all site-generated surface water discharge to rates and volumes comparable to Qbar or lower. Whilst the benefits are likely to be small, these opportunities should be explored to reduce downstream fluvial flood risk associated with Yazor Brook.

The Hereford ICS commissioned by Herefordshire Council in 2019 considered options to reduce fluvial flood risk associated with the Yazor Brook by providing fluvial flood storage within the west of the Three Elms strategic development site. Modelling of the scheme indicated potentially significant betterment to downstream flood risk in the centre of Hereford, with potential for further benefit to improve the hydromorphological conditions of the Yazor Brook in the vicinity of the Three Elms site. It is recommended that this opportunity is discussed with Herefordshire Council during the development of the Three Elms strategic development site, noting that it is expected that this would be coupled with other opportunities for flood betterment within the remainder of the Three Elms site.

Appendix B

LOWER BULLINGHAM

LOWER BULLINGHAM (SOUTHERN URBAN EXPANSION)

Allocation Reference:	Lower Bullingham (Southern Urban Expansion)
Location:	South Hereford
River Catchment:	Red Brook / Norton Brook
NPPF Flood Zone (majority of area):	Flood Zone 1
NPPF Flood Zone (worst case):	Flood Zone 3b

INTRODUCTION

The Lower Bullingham strategic development site occupies an area of approximately 55ha and is located to the south of Hereford as illustrated in Figure B.1. The site currently comprises agricultural land and is bound by the B4399 (Gatehouse Road) to the south, Hoarwithy Road to the west, Watery Lane to the east and the railway line to the north. Lower Bullingham Lane passes through the west of the site. The Red Brook flows in a north-east direction through the centre of the site, broadly splitting the site into two halves. The Red Brook is classified as an ordinary watercourse and is therefore under the jurisdiction of Herefordshire Council as Lead Local Flood Authority (LLFA). Topography within the Lower Bullingham strategic development site slopes from south to north with levels typically ranging between 73mAOD to 52mAOD.

The Lower Bullingham strategic development site is identified in the Core Strategy as part of the Southern Urban Expansion (Lower Bullingham). Policy HD6 of the Core Strategy sets out the vision for the strategic site that comprises the provision of a minimum of 1000 new homes, 5 hectares of employment land, a Park & Choose site, a 210-place primary school, and a neighbourhood community hub. Policy HD6 also discusses the provision of green infrastructure corridors through the area to include strategic greenways along Red Brook and Norton Brook and links with Withy Brook, and creation of a country park. Although not included within the Core Strategy site boundary, it is understood that the country park will be located to the west of the main site, straddling the Norton Brook that will flow through the centre of the country park. The Norton and Withy Brooks are also classified as ordinary watercourses and are therefore under the jurisdiction of Herefordshire Council.

At the time of preparing this assessment it is known that the following major development application has been made within the Lower Bullingham strategic site boundary:

- Outline planning application for the entirety of the Lower Bullingham strategic site comprising up to 1300 new residential dwellings, employment uses, new primary school, a community hub and a Park & Choose (reference P194402/O, awaiting determination). The development also includes a country park located to the west of the site along the alignment of the Norton Brook.

DESCRIPTION OF FLOOD RISK

FLUVIAL

The assessment of fluvial flood risk has been informed by the 1D-2D Estry-Tuflow hydraulic model of the Withy, Norton and Red Brooks that was commissioned by Herefordshire Council in 2019 to inform the Hereford ICS as discussed in Section 1.2 of the Hereford City Level 2 SFRA. The mapped fluvial flood extents are illustrated in Figure B.2.

The fluvial modelling of the Withy, Norton and Red Brooks and subsequent Flood Zone classification indicates that the majority of the Lower Bullingham strategic site is located within the low risk Flood Zone 1. Land adjacent to the Red Brook is located within the high risk Flood Zone 3 and medium risk Flood Zone 2. Flood waters through the site are indicated to largely flow adjacent to the channel and be attributable to upstream out-of-bank flows, rather than direct flooding from the adjacent channel. The north of the site, close to the railway, is also indicated to be located within Flood Zone 2 attributable to flooding from the Withy Brook that flows east into the Lower Bullingham site when the banks of the watercourse are exceeded.

Flood incident reports indicate that flood waters from the Red Brook may exceed the channel capacity within the Lower Bullingham strategic development site and flow east to contribute to flooding in the Rotherwas Industrial Estate. The hydraulic model currently shows flooding in the Rotherwas Industrial Estate to be attributable to the ditch that flows past the City Spares site and parallel to Watery Lane, however the model may overestimate the capacity of the Red Brook as anecdotal evidence suggests the flooding is sensitive to the condition of the Red Brook channel, with the risk reduced if the channel is maintained in an enlarged and cleared state as it is represented in the hydraulic model. This highlights the need for ongoing maintenance of the watercourse in this area but also indicates that there may be some uncertainty with the current model representation. This must be considered in detail in any future development of the Lower Bullingham strategic development site, giving due consideration to potential flood risk to the development and to opportunities to improve flood risk to the Rotherwas Industrial Estate. The mapped fluvial flood extents illustrated in Figure B.2 summarises this uncertainty. Refinement of the hydraulic model is expected to support the planning application.

We also highlight that the current hydraulic model assumed that the ditch that flows past the City Spares site and parallel to Watery Lane connected into the wider Rotherwas drainage system, although it is now known that this ditch connects directly to Red Brook via a culvert. This is not considered likely to have a significant effect on the outputs of the hydraulic model as overtopping flows that exceeded the assumed size of the culverted ditch were modelled to discharge to the Red Brook, however future model refinement should include this amendment along with confirmation of the culvert size.

Anecdotal evidence indicates significant flooding of the B4399 at the road's crossing of the Norton Brook, immediately upstream of the proposed country park to the west of the main Lower Bullingham strategic development site. This is considered likely to be attributable to flood waters backing up behind the B4399 culvert and overtopping the road at a localised low point immediately east of the culvert. This flood mechanism is not indicated in the current hydraulic model and, as per above, it is expected that refinement of the model required to support any future planning application considers this flow path. The flood waters are reported to return to the Norton Brook downstream of the crossing although significant flooding of the B4399 occurs during this event

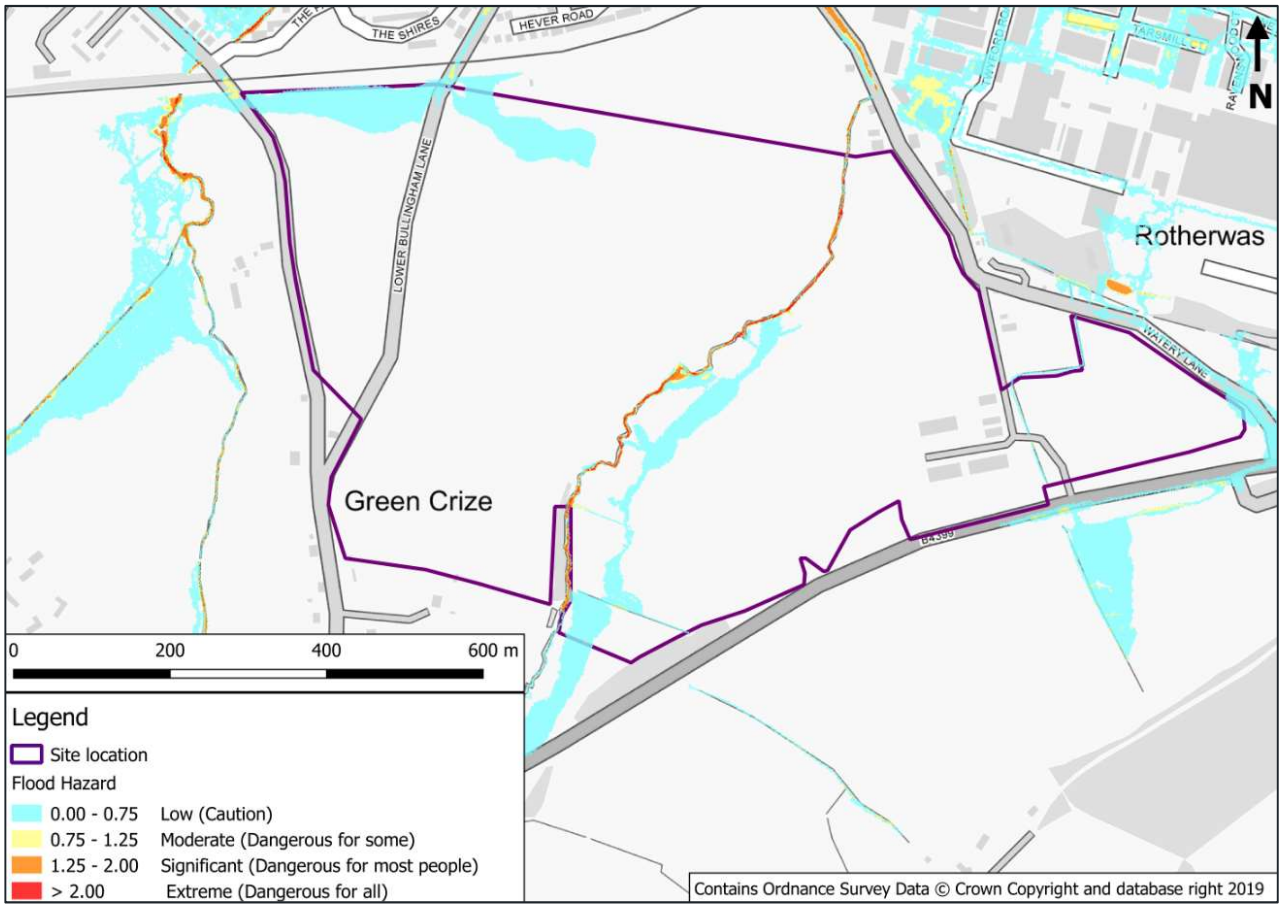
Flood flows within the country park to the west of the main Lower Bullingham strategic development site are largely contained within the river channel of Norton Brook although some relatively minor exceedance is predicted as indicated by the Flood Zone 2 and Flood Zone 3 mapped extents.

Land downstream of the site in the urban areas of Lower Bullingham and Rotherwas is indicated to be at significant risk of flooding from the Withy, Norton and Red Brooks and from the River Wye, although the influence of the Wye is not predicted to notably affect flooding within the Lower Bullingham strategic development site boundary.

The Flood Zone 3b functional floodplain is defined as land where water has to flow or be stored in times of flood, typically represented by areas that flood naturally during the 1 in 20 (5%) annual probability event. The fluvial modelling flood extent for 1 in 20 (5%) annual probably event indicates that flood flows are largely contained within the river channels, although exceed channel capacity in a small area at the very south of the Lower Bullingham site. The mapped functional floodplain extents are illustrated in Figure B.3.

The fluvial modelling of the Withy, Norton and Red Brooks has modelled the potential effects of climate change for a 35% and 70% increase in peak river flows for the 1 in 100 (1%) annual probability event. The modelling results indicate little change to mapped flood extents within the Lower Bullingham site boundary, although flood extents during the modelled 1 in 100 (1%) annual probability event with 70% climate change allowance increase to a similar extent to the present-day Flood Zone 2. Mapped outputs of the climate change allowances are illustrated in Figure B.4.

Flood hazard (a combination of depth and velocity) has been determined as part of the fluvial modelling of the Withy, Norton and Red Brooks. Mapped output of flood hazard for the 1 in 100 (1%) annual probability event is illustrated in Insert B.1 below and includes a 35% climate change allowance. As shown in Insert B.1, flood hazard within the Lower Bullingham site is classified as Low (Caution). The flood hazard immediately downstream of the site along Watery Lane is classified as Significant (Dangerous for most); this is supported by anecdotal evidence of recent flooding that occurred at this location in October 2019.



Insert B.1 – Red Brook flood hazard (depth and velocity) for Lower Bullingham

SURFACE WATER AND MINOR WATERCOURSES

The Environment Agency's Risk of Flooding from Surface Water map indicates that the Lower Bullingham strategic development site is generally at very low risk of surface water flooding as illustrated in Figure B.5. The flood extents along the Red Brook and in the north of the site from the Withy Brook are broadly similar to the fluvial flood extents as previously discussed in the section above.

The Environment Agency's Risk of Flooding from Surface Water map does however indicate a high risk of flooding along Hoarwithy Road, Lower Bullingham Lane and Watery Lane downstream of the site, and within the urban area of Lower Bullingham.

GROUNDWATER

Review of the British Geological Survey (BGS) data indicates that the Lower Bullingham strategic development site is underlain by Raglan Mudstone Formation comprising siltstone and mudstone bedrock geology. Superficial deposits comprise River Terrace Deposits comprising sand and gravel. The BGS website provides a number of historic borehole records adjacent to the site. These indicate that groundwater is likely to be in excess of 5m below ground level. Review of OS mapping indicates a number of springs in higher ground to the south of the site. These are likely to contribute to overland flow, fluvial and surface water flooding as discussed above but the risk of groundwater flooding affecting the site is likely to be low.

OTHER SOURCES OF FLOOD RISK

Review of the EA's Flood Risk from Reservoirs mapping indicates that the Lower Bullingham strategic development site is not located within an area deemed to be risk of flooding from reservoirs. Review of OS mapping also indicates no reservoirs or other large storage features at a higher elevation to the site that would pose flood risk in the event of failure.

The Lower Bullingham strategic development site is located on the outskirts of Hereford and there is sparse development surrounding the site. The site is not likely to be at significant risk of flooding from adjacent sewerage or drainage systems.

HISTORIC FLOOD RECORDS

Review of Herefordshire Council and Dwr Cymru Welsh Water historic flood records at the time of preparing this report indicates that Hoarwithy Road, Lower Bullingham Lane and Watery Lane regularly suffer from surface water flooding particularly at locations where the highway crosses under the railway. A large number of flood incidents have also been recorded downstream of the site in the urban area of Lower Bullingham, likely to be attributable to exceedance flows from the Red Brook and Withy Brook with influence from the River Wye.

Anecdotal evidence indicates significant and repeated flooding in the Rotherwas Industrial Estate immediately to the east of the Lower Bullingham strategic development site. This is reported to be attributable to out-of-bank flooding from the Red Brook within the site, flowing overland in an easterly direction towards the Rotherwas Industrial Estate. As discussed above, this is likely to be sensitive to the condition of the Red Brook channel, with the risk reduced if the channel is maintained in an enlarged and cleared state as it flows through the Lower Bullingham strategic development site.

As discussed above, anecdotal evidence also indicates significant flooding of the B4399 at the road's crossing of the Norton Brook, immediately upstream of the proposed country park. The road is reported to have become impassable for cars.

PLANNING RECOMMENDATIONS

SPATIAL PLANNING AND DEVELOPMENT CONTROL

Development of the Lower Bullingham strategic development site should be undertaken in accordance with the principles as set out within Section 1 of the Level 2 SFRA and Section 6 of the Level 1 SFRA. It is understood that proposed development within the Lower Bullingham strategic development site will comprise a mix of more vulnerable development (such as residential and educational uses) and less vulnerable development (such as employment and retail uses).

The majority of the site is located within Flood Zone 1. Given the size of the site it is recommended (and considered achievable) that all development (with the exception of access roads that may need to cross the Red Brook) can be located in Flood Zone 1 and outside of the extent of mapped fluvial flooding up to and including the 1 in 100 (1%) annual probability event with 70% climate change allowance or the 1 in 1000 (0.1%) annual probability event, whichever is greater. Other sources of flooding as discussed above are not considered to pose risk to the development assuming that the recommendation to locate all development in Flood Zone 1 is adopted (and taking into account potential risks to site access).

Consideration must be given to the availability of safe access and egress. The roads to the north (Hoarwithy Road, Lower Bullingham Lane and Watery Lane) are indicated to be at risk of flooding from fluvial and surface water sources. The primary access and egress route in the event that roads to the north are compromised is likely to be from the B4399 to the south of the site. However, this is indicated to be at risk of flooding from the River Wye to the east of the site and, as suggested by anecdotal evidence, also at risk of flooding from overtopping flows from the Norton Brook to the west of the site. It is therefore recommended that the planning application is accompanied by further consideration of the availability of safe access and egress, with the most viable solution likely to be addressing the flood risk to the B4399 at the crossing with Norton Brook.

The site allocation is deemed to pass the Sequential and Exception Tests, however a site-specific Flood Risk Assessment (FRA) prepared in accordance with the NPPF and supporting Planning Practice Guidance will be required. The FRA should assess the risk of flooding associated with the Red Brook, Withy Brook and Norton Brook (including climate change allowances) and assess the risks associated with an increase in the rate or volume of site-generated surface water runoff. It is expected that the FRA is supported by detailed modelling of the Red Brook, Withy Brook and Norton Brook, including the recommended updates to the Red Brook and Norton Brook to better reflect anecdotal flood records. The site also offers opportunity to improve flood risk elsewhere. These aspects are discussed in greater detail below.

MANAGEMENT OF FLUVIAL FLOOD RISKS

The fluvial modelling of the Withy, Norton and Red Brooks indicates that the majority of the Lower Bullingham strategic development site would not be at risk during the 1 in 100 (1%) or 1 in 1000 (0.1%) annual probability events. As stated above, it is recommended that all development (including drainage systems but with the exception of access roads that may need to cross the Red Brook) are located outside of these flood extents and taking climate change into account.

It is also recommended that the development takes into consideration the residual risk event, recommended to comprise the larger of a: 1 in 100 (1%) annual probability event with 70% climate change allowance or the 1 in 1000 (0.1%) annual probability event. It is recommended that development is located outside of the mapped residual risk flood extents.

Finished floor levels of any new buildings should be raised a minimum of 600mm above the 1 in 100 (1%) annual probability event plus 35% climate change allowance, and with no internal flooding of buildings during the residual risk flooding events listed above.

Key access routes within the site should remain dry up to and including the 1 in 100 (1%) annual probability event plus 35% climate change allowance. Consideration should also be given to existing flood risk to Hoarwithy Road, Lower Bullingham Lane, Watery Lane and the B4399 that are likely to provide key access and egress to the site as discussed above. The applicant should demonstrate that safe access can be achieved, ideally demonstrating a worst-case flood hazard of Low during the 1 in 100 (1%) annual probability event plus 35% climate change allowance. If this is not achievable, consultation with the Council's emergency planning team would be required to ensure that the risk is acceptable and that an appropriate management strategy is in place.

The development must not increase flood risk elsewhere. At minimum there should be no increase in flood risk up to the 1 in 100 (1%) annual probability event with 35% climate change allowance. Third-party impacts should also be tested for the residual risk events discussed above, noting that the acceptability of risks to third party land during these events will be assessed on a case-by-case

basis (in consultation with Herefordshire Council and the Environment Agency) that takes the vulnerability of the land and the increase in risk into account.

If any development is required to be located in areas at risk during the 1 in 100 (1%) annual probability event plus 35% climate change allowance or residual risk events discussed above, compensatory flood storage should be provided on a like-for-like basis, and ideally strive to provide betterment.

If a new crossing of the Red Brook is required to facilitate site access, this must be a clear span crossing and must demonstrate (via hydraulic modelling) that the crossing will not pose flood risk to the development or elsewhere as discussed above. A minimum 300mm freeboard to the soffit of the crossing should be maintained above the 1 in 100 (1%) annual probability event with 35% climate change allowance. Consideration should also be given to the residual risk events discussed above, noting that the road should remain safe during these events if it is considered important for access and egress during a flood event. Consideration must also be given to maintenance access and ecological requirements (including mammal passage) noting that a higher freeboard may be required.

As the ongoing maintenance of Red Brook at this location is important for managing flood risk to the site and not increasing flood risk downstream, it is recommended that this is considered as part of the ongoing management of the site and an appropriate planning condition included.

MANAGEMENT OF SITE GENERATED SURFACE WATER RUNOFF

The management of surface water runoff will be of particular importance for the Lower Bullingham strategic development site given the historic flooding downstream of the site in Lower Bullingham and Rotherwas. Drainage systems should be designed in accordance with the Herefordshire SuDS Handbook and Section 6 of the Level 1 SFRA, adhering to the following key principles:

- Applying the SUDS hierarchy to promote the infiltration of runoff to ground prior to the consideration of other measures;
- Controlling the rate and volume of runoff to ensure no increased flood risk for all events between the 1 in 1 (100%) and the 1 in 100 (1%) annual probability rainfall events;
- Promoting best practice vegetated and on-ground conveyance and storage features as much as practicable.

Methods for calculating runoff must be in accordance with the methods promoted within the CIRIA SuDS Manual (C753, published in 2015). It is expected that FEH methods and 2013 rainfall data are used in the calculation of existing and post-development scenarios. The calculation of pre-development runoff rates and volumes should not take the potential effects of climate change into account.

As discussed above the site is underlain by River Terrace Deposits and Raglan Mudstone Formation bedrock geology. The permeability of the superficial deposits is likely to be high and therefore infiltration should be promoted as much as practicable (noting that unlined combined attenuation and infiltration features are also supported in lower permeability sites), although consideration should be given to the potential for high groundwater levels. If permeability testing indicates that infiltration is viable (in full or in part) it is recommended that over-winter groundwater monitoring is undertaken.

A controlled discharge to the Red Brook (or Norton Brook for the country park) is likely to be the most viable option for surface water drainage if infiltration cannot manage all site runoff. Attenuation of runoff will be of key importance and given the size and strategic importance of this site it is recommended that discharge is limited to Qbar or lower for all return period events (i.e. up to the 1 in 100 (1%) annual probability event and allowing for climate change) as much as practicable. Given the strategic importance of this site is also recommended that consideration is given to events larger than the 1 in 100 (1%) annual probability event – i.e. up to the 1 in 1000 (0.1%) annual probability event. Reducing runoff during larger return period events will mitigate increased downstream flood risk associated with the site's development and may also assist with reducing downstream flood risk attributable to the Red Brook.

Consideration must also be given to the performance of the drainage system (i.e. ensuring appropriate head to ensure correct function of flow controls) and the risk of water not being able to discharge as intended during periods of high water levels within the Red Brook.

It is expected that for a development site of this size best practice 'green' SUDS measures (i.e. vegetated conveyance and storage systems) are incorporated that promote attenuation (and infiltration where appropriate), treatment and biodiversity benefit throughout the development.

MANAGEMENT OF POTENTIALLY HIGH GROUNDWATER LEVELS

The risk of high groundwater levels must be considered in the drainage design, most notably the risk that high groundwater levels could reduce the effectiveness of infiltration systems or reduce the capacity of unlined attenuation/infiltration systems. If these systems are proposed, winter groundwater monitoring should be undertaken to better understand and mitigate these risks.

MANAGEMENT OF FOUL WATER

Foul water from the Lower Bullingham strategic development site should be discharged to the public sewerage network that serves Rotherwas and Lower Bullingham. The Applicant should discuss their proposed development with Dwr Cymru Welsh Water to determine if this approach is acceptable and agree the need for any local improvements.

OPPORTUNITIES FOR BETTERMENT

As discussed above, the site offers opportunity to reduce surface water runoff from the Lower Bullingham strategic development site during larger rainfall events by limiting all site-generated surface water discharge to rates and volumes comparable to Qbar or lower. Whilst the benefits are likely to be small, these opportunities should be explored to reduce downstream fluvial flood risk associated with the Red Brook.

Improved and regular maintenance of the Red Brook and associated structures may assist in reducing flood risk to the Rotherwas Industrial Estate.

The Hereford ICS commissioned by Herefordshire Council in 2019 considered options to reduce fluvial flood risk associated with the Withy, Norton and Red Brooks. The study highlighted the potential opportunities that could be delivered by the Lower Bullingham site to reduce and slow flood flows through the Red Brook and Withy Brook, for example by incorporating Natural Flood Management (NFM) measures such as leaky dams, enhancing the natural floodplain adjacent to these watercourses, or providing online or offline flood storage features. Sections of Norton Brook upstream of the country park have already undergone improvement works for meander creation

therefore further enhancement would complement these works. We recommend that opportunities are explored further as part of the Lower Bullingham strategic development site and associated country park, noting that this recommendation aligns well with Policy HD6 of the Core Strategy that discusses the provision of green infrastructure corridors and strategic greenways along Red Brook and Norton Brook. The introduction of NFM measures and flood storage solutions within the Lower Bullingham strategic development site and associated country park are promoted by this SFRA and we recommend consultation with Herefordshire Council and the Environment Agency during the development of the site to discuss these opportunities in greater detail.

Appendix C

CEN21 - EDGAR STREET GRID

CEN21 - EDGAR STREET GRID

Allocation Reference:	HAP Site Option Cen21 - Edgar Street Grid
Location:	Central Hereford
River Catchment:	Yazor Brook / Widemarsh Brook
NPPF Flood Zone (majority of area):	Flood Zone 2
NPPF Flood Zone (worst case):	Flood Zone 3b

INTRODUCTION

The Edgar Street Grid (ESG) regeneration area consists of 14 potential development plots (Cen21a to Cen21n) spread over an area of approximately 11ha in the centre of Hereford between Edgar Street in the west and Commercial Road in the east. The site is identified in the Core Strategy Policy HD2 as an area for regeneration of mixed use developments capable of accommodating 800 dwellings. The opening of the A465 Hereford City Link Road in December 2017 has released opportunities for growth in this area.

As stated within the Core Strategy, the city centre plays an important role in contributing to the economic, cultural and social performance of the wider city and highlights the importance of the ESG in meeting this vision. In additional to significant housing provision, the ESG regeneration area is part of the Core Strategy's aim to improve Hereford's status as a sub-regional shopping destination by enhancing and improving existing facilities and integrating new development into the historic centre.

The ESG is located in one of the lowest lying areas of Hereford with ground levels typically ranging from 53.5mAOD to 51.6mAOD. The Widemarsh Brook, a downstream bifurcation of the Yazor Brook, winds its way through the centre of the ESG. The watercourse is due to be realigned as part of the redevelopment of the ESG, noting that the realignment is due to be completed prior to the development of individual plots. The Yazor Brook and its downstream bifurcations are classified as ordinary watercourses and are therefore under the jurisdiction of Herefordshire Council as Lead Local Flood Authority (LLFA).

At the time of preparing this assessment it is known that the following major development application has been made within the ESG regeneration area site boundaries:

- Hybrid planning application for plot Cen21k (Station Approach) comprising a full planning application for student accommodation for 178 bedrooms and an outline planning application for a standalone ancillary commercial element (reference P183841/CD4, approved).

At the time of preparing this assessment the proposed development of Land fronting Station Approach (reference P181583/CD4) has also been approved with conditions. Whilst not located within one of the development plots identified in the Core Strategy, the site is located immediately adjacent to plot Cen21c and was considered in the Flood Mitigation Study discussed below. The development comprises a new health centre.

Given the strategic importance of the ESG to the continued regeneration and development of the city centre, Herefordshire Council commissioned the ESG Flood Mitigation Study[3] in 2019 that investigated flood risk to the area and options for mitigation that would enable sustainable development of the ESG. The findings of this study and the more recent analysis completed as part of the Hereford ICS (as discussed in Section 1.2 of the Hereford City Level 2 SFRA) are discussed below.

DESCRIPTION OF FLOOD RISK

The ESG Flood Mitigation Study considered flood risk from fluvial, surface water and groundwater sources. The study showed the ESG to be a focal point for flood risk in the centre of the city, with fluvial, surface water and groundwater influences contributing to the current extent of flooding. This is largely attributable to the low-lying topography in the area of ESG, the confluence of the Widemarsh and Ayles Brooks in the area and a lack of capacity in the existing watercourse features.

FLUVIAL

The ESG regeneration area is at risk of fluvial flooding from the Widemarsh Brook that flows from west to east through the centre of the area and from the Ayles Brook that flows into the area from the north, joining the Widemarsh Brook as it passes underneath Widemarsh Street. The Widemarsh Brook bifurcates from the Yazor Brook approximately 1.4km upstream of Edgar Street and flows largely within an engineered channel and culverts through the ESG. The Ayles Brook is largely in culvert as it flows beneath the Hereford Racecourse to the north to its confluence with the Widemarsh Brook.

Data overview

The assessment of fluvial flood risk attributable to the Widemarsh Brook has been informed by the 1D-2D FMP-Tuflow hydraulic model of the Yazor Brook and its downstream bifurcations that was updated to support the Hereford ICS. The Flood Zone classification discussed below does not take into account the Yazor Brook Flood Alleviation Scheme (FAS) that was constructed in 2012 to reduce flood risk in the city centre and support the development of the ESG. However, the operation of the FAS is taken into account in the assessment of the site's suitability for development and opportunities for appropriate mitigation.

The updated hydraulic model of the Yazor (and Widemarsh) Brook includes a representation of the proposed realignment of the Widemarsh Brook as it flows through the ESG regeneration area and the permanent attenuation basin for the City Link Road, although at the time of writing this report the detailed design of these features was still in progress. OS mapping and other indicative flood mapping (in particular the Environment Agency's Surface Water Flood Risk mapping) does not yet represent the new alignment of the Widemarsh Brook and so this must also be taken into consideration when assessing risks to the site.

The updated hydraulic model of the Yazor (and Widemarsh) Brook incorporates inflows received from the Ayles Brook at Widemarsh Street and likely overland flow from exceedance of the Ayles

[3] Hereford Edgar Street Regeneration Area: Flood Mitigation - Final Report issued in May of 2019

Brook culvert at Mortimer Road, but does not include full or detailed modelling of the Ayles Brook. The current fluvial flood extents for the Ayles Brook (which are the same as those illustrated on the Environment Agency's current Flood Map for Planning) are based only on broadscale JFLOW modelling. The mapped Flood Zone extents has 'stitched' together the fluvial flood extents taken from the updated hydraulic model of the Yazor (and Widemarsh) Brooks and the existing (estimated) JFLOW flood extents of the Ayles Brook. No other detailed mapping of the Ayles Brook is currently available and flood risk associated with this watercourse must therefore be assessed with caution.

Flood Zone classification

The mapped extent of Flood Zone 1, 2 and 3 is provided in Figure C.2. This is informed by the updated hydraulic model of the Yazor (and Widemarsh) Brook but does not take the operational FAS into account to provide a worst-case scenario. As discussed above, the updated model also incorporates inflows received from the Ayles Brook at Widemarsh Street and likely overland flow from exceedance of the Ayles Brook culvert at Mortimer Road, but the Flood Zones associated with the Ayles Brook are based on JFLOW modelling as used in the Environment Agency's current Flood Map for Planning.

Figure C.2 indicates that without the operation of the Yazor Brook FAS the majority of the ESG is located within the high risk Flood Zone 3 and medium risk Flood Zone 2 with flood waters entering the area from the west.

The Flood Zone 3b functional floodplain is defined as land where water has to flow or be stored in times of flood, typically represented by areas that flood naturally during the 1 in 20 (5%) annual probability event. The mapped Flood Zone 3b extents are illustrated in Figure C.3 although this has again 'stitched' together the flood extents taken from the updated hydraulic model of the Yazor (and Widemarsh) Brooks without the operation of the FAS and the existing (estimated) JFLOW flood extents of the Ayles Brook. The mapping indicates that plots Cen21a and Cen21i are located within Flood Zone 3b along with small pockets adjacent to the Widemarsh Brook.

Influence of the Yazor Brook FAS

As discussed above the Yazor Brook FAS was constructed in 2012 to reduce flood risk in the city centre and support the development of the ESG. The FAS is located upstream of Hereford at Credenhill and diverts flood flows from the Yazor Brook to the River Wye via an overspill weir and c.1.4km long 2m diameter culvert that connects the two watercourses. The weir is oversized compared with the culvert capacity which allows for partial blockage of the weir without compromising the scheme capacity. The scheme is maintained in an "operational" state and therefore does not require any active intervention. Development within the ESG should therefore take the operation of the FAS into account, whilst also giving due consideration to residual risks in the event that the FAS should fail.

Figure C.5 illustrates the fluvial flood risk in the ESG with the FAS in operation and considers the potential effects of climate change. This mapping has stitched together the following information:

- 1 in 100 (1%) annual probability flood extents for the updated hydraulic model of the Yazor (and Widemarsh) Brook with present-day, 35% climate change and 70% climate change scenarios run and mapped. Within the ESG the extent of the 1 in 100 (1%) annual probability event with 70% climate change scenario is the same at the present-day 1 in 1000 (0.1%) annual probability event (i.e. the same as the equivalent Flood Zone 2 with the FAS operational).

- Flood Zone 2 and 3 extents for the Ayles Brook that have been 'stitched' together with the Yazor Brook model extents. Review of the Ayles Brook hydrology indicates that the 1 in 1000 (0.1%) annual probability event flood flows are approximately 70% higher than the present-day 1 in 100 (1%) annual probability event flood flows. It has therefore been assumed for the purpose of this assessment that the current 1 in 1000 (0.1%) annual probability extent (i.e. Flood Zone 2) can be used to represent the likely 1 in 100 (1%) annual probability flood extent with 70% climate change allowance. There is no available mapping to indicate the likely extent of the 1 in 100 (1%) annual probability flood extent with 35% climate change allowance for the Ayles Brook.

With the FAS in operation, the updated hydraulic model indicates that fluvial flooding from the Widemarsh Brook occurs to the east of Edgar Street and within the green space between the Link Road and St Thomas Cantilupe Primary School in the 1 in 50 annual probability event and higher and affecting development plots Cen21a and Cen21i. This is indicated to be caused by constrictions in the channel passing underneath Widemarsh Street and by pooled flood waters from Widemarsh Brook in the playing fields at the Hereford Lads Club that overtop the disused railway embankment to the west of Edgar Street. The extent of fluvial flood risk from the Widemarsh Brook is predicted to increase between Edgar Street and Widemarsh Street (to the north and south of the watercourse) during the 1 in 100 (1%) annual probability event, encroaching to within the boundaries of development plot Cen21d. However, the extent of the 1 in 100 (1%) annual probability event is significantly reduced by the FAS.

Figure C.6 illustrates the fluvial flood risk in the ESG during the 1 in 20 (5%) annual probability event with the FAS in operation (i.e. the functional floodplain Flood Zone 3b). This mapping also stitches together the detailed hydraulic model outputs of the Yazor (and Widemarsh) Brook with the existing broadscale JFLOW mapping of the Ayles Brook flood extents. With the FAS in operation, the updated hydraulic model indicates that the ESG site would not be at risk of flooding from the Yazor or Widemarsh Brooks during the 1 in 20 (5%) annual probability event. However, plot Cen21a and small pockets adjacent to the Widemarsh Brook is still indicated to be at risk during this event from the Ayles Brook. In summary, mapped flood risk to the development plots with the operation of the FAS is as follows:

- Plot Cen21a indicated to be located in the extent of the 1 in 20 (5%) annual probability event (i.e. equivalent to Flood Zone 3b from the Ayles Brook, although noting that in accordance with the Level 1 SFRA urban areas may not be classified as 'functional floodplain');
- Plots Cen21a, Cen21d and Cen21i are indicated to be partially located in the extent of the 1 in 100 (1%) annual probability event (i.e. equivalent to Flood Zone 3a);
- Plots Cen21b, Cen21c, Cen21e, Cen21f, Cen21g and Cen21h are indicated to be partially located in the extent of the 1 in 1000 (0.1%) annual probability event (i.e. equivalent to Flood Zone 2); and
- Plots Cen21j, Cen21k, Cen21l, Cen21m and Cen21n are indicated to be located outside of the extent of the 1 in 1000 (0.1%) annual probability event (i.e. equivalent to Flood Zone 1).

As suggested above, flood risk is predicted to increase significantly when the potential effects of climate change are taken into consideration, with the extent of the 1 in 100 (1%) annual probability event with 70% climate change allowance increasing to an extent similar to the present-day 1 in 1000 (0.1%) annual probability event.

Residual risk and uncertainty

The greatest residual risk to the ESG is the failure of the Yazor Brook FAS. Whilst this has low chance of occurring, the risks to ESG could be significant. The flood extents presented in Figure C.2 and Figure C.3 indicate the likely risk during the 1 in 20 (5%), 1 in 100 (1%) and 1 in 1000 (0.1%) annual probability events should a full blockage of the FAS occur and this would be seen as an unlikely worst-case scenario.

Maintenance of the Widemarsh Brook is also a residual risk that requires consideration. The ESG Flood Mitigation Study highlights localised residual risks that will need to be taken into consideration during site development, for example sensitivity of channel roughness and culvert blockage risks that could occur if the watercourse is not maintained. It is important that riparian landowners are made aware of their responsibilities for channel maintenance and that this forms part of the future management strategy of the site.

The ESG Flood Mitigation Study included proposed ground raising and channel / culvert improvements within ESG. The proposed channel improvements, aside from the works at Canal Road, and ground raising have not yet been constructed and were to be completed as each separate section of the ESG development area was brought forward. Although unlikely, the development of the plots should consider the residual risk in the event that the proposed channel improvements or ground raising does not occur as currently expected (or that the phased nature of the site's development results in only part of the works being completed as sites are brought forward).

The broadscale mapping of the Ayles Brook also presents considerable uncertainty, particularly in the east of the ESG where overland flows from the Ayles Brook are predicted to pose greatest flood risk. The current mapped flood extents may limit the suitability of this land for development, particularly plot Cen21a that is indicated to be at risk during the 1 in 20 (5%) annual probability flood event from the Ayles Brook.

SURFACE WATER AND MINOR WATERCOURSES

Review of the EA's Surface Water Flood Risk mapping indicates significant surface water flooding within the ESG regeneration area in areas similar to those indicated to be at fluvial flood risk. Of notable difference however is the predicted high risk of flooding to site Cen21k and the medium to low risk of flooding to sites Cen21j, Cen21l and Cen21n. Mapped surface water flood extents are reproduced in Figure C.7. It is important to note that the EA's surface water flood mapping does not take the newly constructed A465 City Link Road (completed in December 2017) into account and, therefore, the mapped flood extents are likely to have been altered. The City Link Road may exacerbate surface water ponding to the north of the road by introducing a barrier to overland flow from the north, potentially exacerbating flood risk to development plots Cen21a, Cen21b and Cen21c, although updated modelling or assessment has not been undertaken.

It is considered likely that a large amount of the mapped surface water flood risk is attributable to the Ayles Brook as discussed in the fluvial flood risk section above. This is likely to be exacerbated by other surface water flows that could occur following exceedance of draining systems, noting that the ESG regeneration area is a natural low point in the city and therefore the likely destination of overland flow from the north and north-west. In addition to the mapped surface water flooding likely to be attributable to the Ayles Brook, the EA's Surface Water Flood Risk mapping also suggests significant overland flow from the College Hill area of Hereford that flows south towards the railway

line and railway station, crossing the Link Road in front of the station and continuing towards the ESG. Furthermore, review of the Dwr Cymru Welsh Water One Year and 50 Year Headroom datasets also indicates high and medium risk of flooding from sewers located to the south and east of the racecourse that would likely flow south towards ESG.

Model validation undertaken to inform the updated fluvial hydraulic modelling of the Yazor Brook suggests that historic flood records within the ESG development area are likely to have been exacerbated by surface water flows into the area and high and groundwater levels, as the modelled fluvial flood risks do not fully align with observed flooding events.

GROUNDWATER

The low-lying topography of the ESG regeneration area could make it vulnerable to groundwater flood risk. The site is underlain by gravels that are likely to be hydraulically connected to the River Wye. Review of historic borehole records indicate that groundwater has been struck between 1-2m below ground level in this area. An Environment Agency groundwater monitoring borehole is located in the playing fields at the Hereford Lads Club approximately 250m north-west of the site. Recent monitoring completed in January 2019 indicates a groundwater level at approximately 52.9m AOD to 52.6mAOD, approximately 2.5m below ground level, although historic records indicate that groundwater levels have risen sharply with the hydrograph showing a 'peaky' response to winter rainfall and groundwater levels rising to approximately 0.5 m below ground level during winter periods.

During prolonged flood events, high water levels in the River Wye could lead to high groundwater levels under ESG and potentially lead to groundwater emergence in permeable areas or affect the performance of drainage systems. Groundwater is also likely to be conveyed by the granular bedding and so the drainage design should consider the provision of clay stanks.

As per the assessment of surface water flood risk above, model validation undertaken to inform the updated fluvial hydraulic modelling of the Yazor Brook suggests that historic flood records within the ESG development area are likely to have been exacerbated by surface water flows into the area and high and groundwater levels, as the modelled fluvial flood risks do not fully align with observed flooding events.

A more comprehensive review of hydrological conditions within the ESG regeneration area is provided within the ESG Flood Mitigation Study. It is recommended that development of the ESG plots is informed by groundwater monitoring data requested from the Environment Agency. It is also recommended that additional groundwater monitoring data is obtained to improve understanding of the groundwater conditions in and around ESG.

OTHER SOURCES OF FLOOD RISK

Review of the EA's Flood Risk from Reservoirs mapping indicates that the ESG regeneration area is not located within an area deemed to be risk of flooding from reservoirs. Review of OS mapping also indicates no reservoirs or other large storage features at a higher elevation to the site that would pose flood risk in the event of failure.

As discussed above, review of the Dwr Cymru Welsh Water One Year and 50 Year Headroom datasets indicates high and medium risk of flooding from combined and surface water sewers located to the south and east of the racecourse that would likely flow towards ESG, and from the surface water sewer that flows through the centre of the ESG.

HISTORIC FLOOD RECORDS

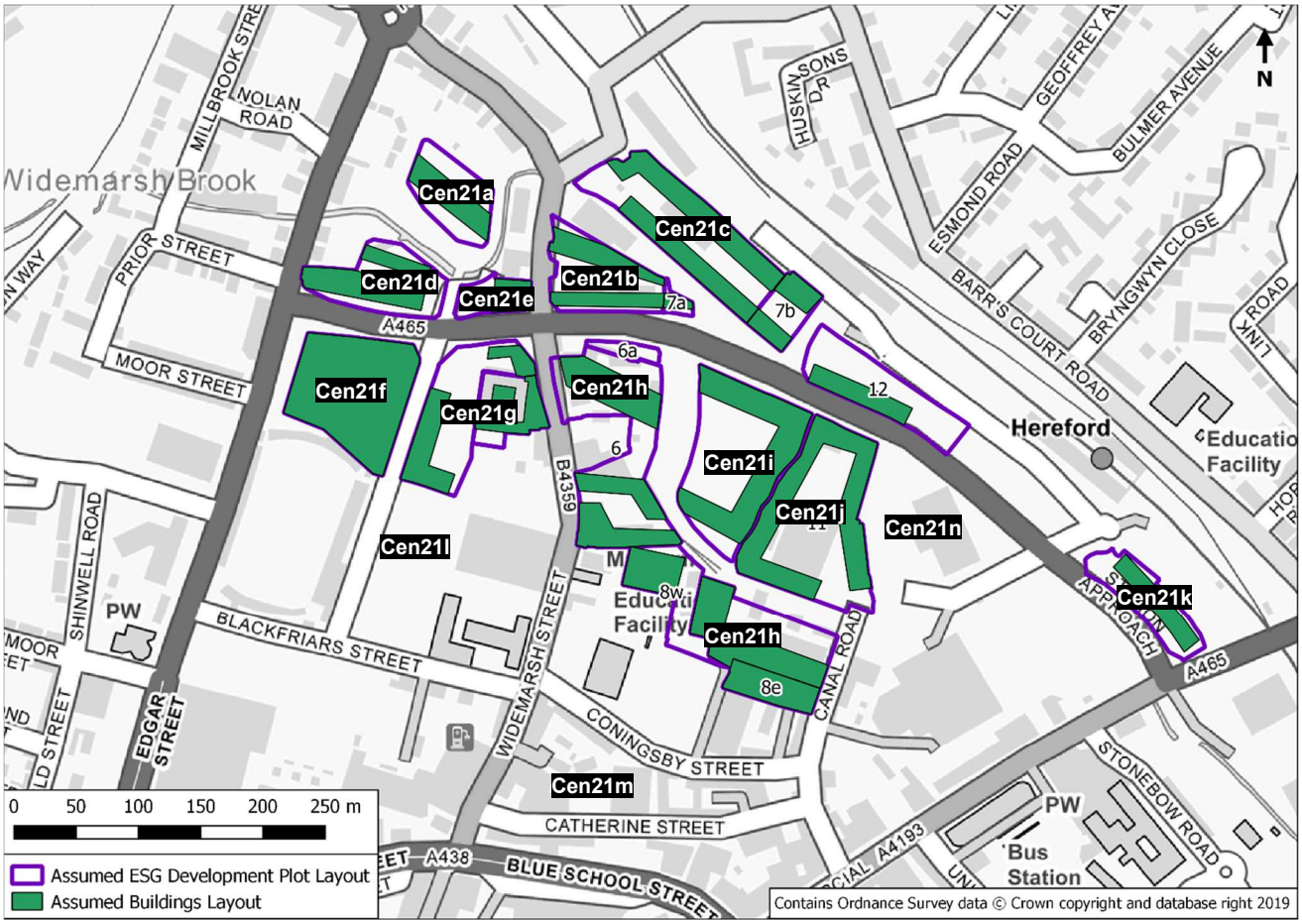
Review of Herefordshire Council and Dwr Cymru Welsh Water flood records indicate that a large number of flooding events have occurred within or in close proximity to the ESG regeneration area, particularly in the north-west. Three of these are stated to be attributable to flooding from the Widemarsh Brook but the cause of the remaining events has not been recorded. The most significant recent flooding event was recorded during the 2007 summer floods that inundated a large portion of the city centre[4].

ESG FLOOD MITIGATION STUDY

As discussed above, Herefordshire Council commissioned the ESG Flood Mitigation Study (completed in 2019) that investigated flood risk to the area and options for mitigation that would enable sustainable development of the ESG. This considered the operation of the Yazor Brook FAS and raising of development plot levels. The study assumed a development layout that differs slightly from the plot boundaries promoted by the Hereford Area Plan (HAP) that supports the Core Strategy (i.e. plots Cen21a to Cen21n). The development boundary and assumed development layout that was used in the ESG Flood Mitigation Study is illustrated in Insert C.1. The location of plot Cen21a to Cen21n has been added to assist with this Level 2 SFRA.

The ESG Flood Mitigation Study was also informed by the previous version of the Yazor Brook model prior to the subsequent updates that have informed the Hereford ICS and the assessment of fluvial flood risk as discussed above. The findings of the ESG Flood Mitigation Study are, however, still considered relevant to the initial assessment of mitigation options and viability of the area for future development.

[4] Further details of this event are provided in the Hereford – Summer 2007 Post Event Report completed on behalf of ESG Herefordshire Limited by Capita Symonds in December 2007.



Insert C.1 - ESG Flood Mitigation Study Assumed Development Layout

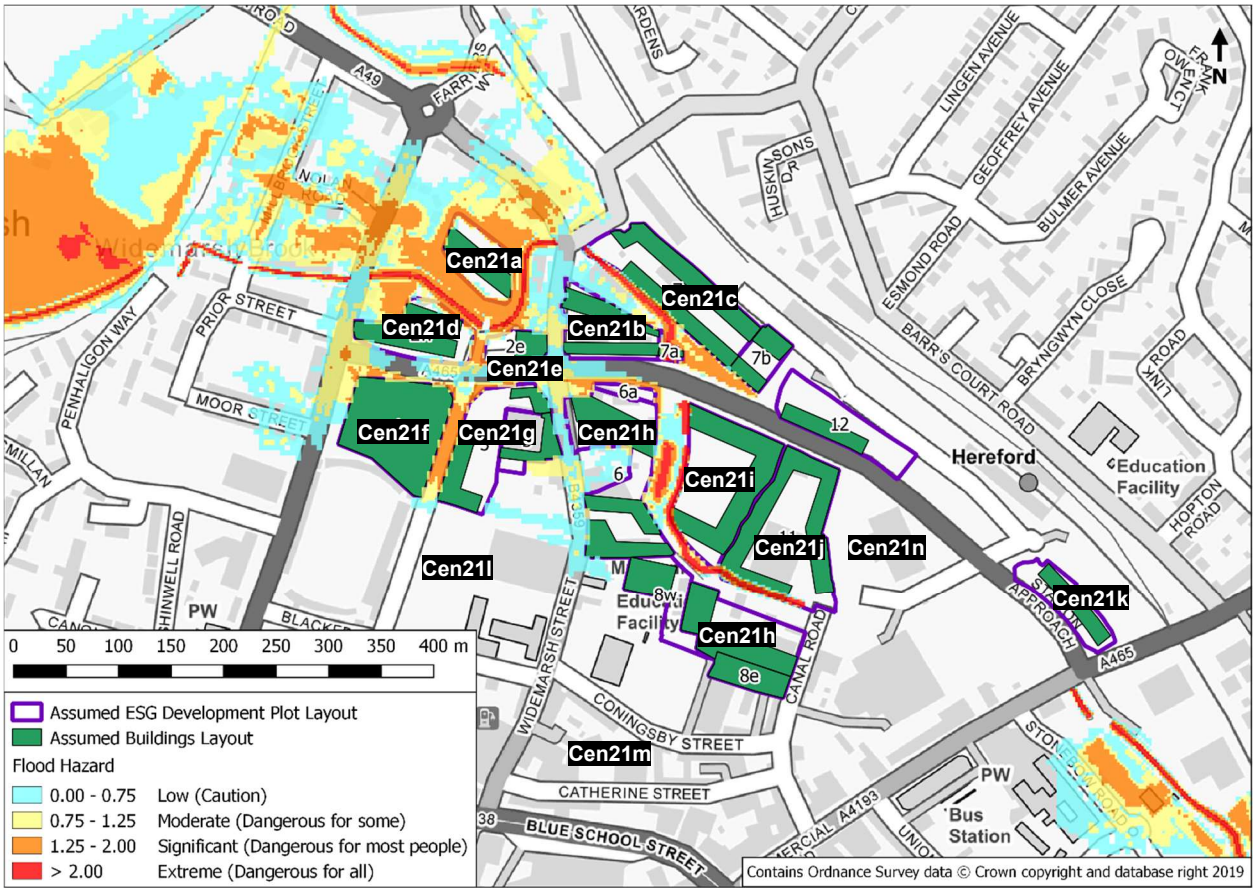
The study considered three key scenarios:

- The 'design' scenario that comprised the 1 in 100 annual probability event with 35% and 70% climate change allowances that are deemed to be the appropriate design events for 'more vulnerable' and 'highly vulnerable' developments respectively (as defined by the NPPF vulnerability classifications) and assumed the full operation of the Yazor Brook FAS.
- The 'residual risk' scenario to the plots that comprised the largest of the 1 in 100 annual probability event with 70% climate change allowance and the 1 in 1000 annual probability event with full operation of the Yazor Brook FAS, or the 1 in 100 annual probability event with 35% climate change allowance with complete blockage of the Yazor Brook FAS.
- The 'residual risk' scenario to third parties that comprised the largest of the 1 in 100 annual probability event with 70% climate change allowance and the 1 in 1000 annual probability event with full operation of the Yazor Brook FAS, or the 1 in 100 annual probability event with 35% climate change allowance with 50% blockage of the Yazor Brook FAS.

The purpose of the study was to assess the feasibility of raising ground levels for the assumed ESG development plots and building layouts so that no flooding to the development plots occurred during their respective 'design' events and no flooding within buildings occurred during the 'residual risk' event.

This testing compared the assumed development scenario with the existing flooding situation prior to the installation of the Yazor Brook FAS (as the FAS was constructed to support development within the ESG). Results showed that due to the significant reduction in flooding caused by the construction of the Yazor Brook FAS, the introduction of ground raising throughout ESG did not lead to significant increases in flood risk in the ESG or to third parties elsewhere. The study did however highlight the importance of maintaining overland flow routes throughout the ESG development area, as well as the importance of maintaining watercourse channels. The study also highlighted the residual risks associated with the current broadscale modelling of the Ayles Brook and therefore the uncertainty of flood mechanisms associated with this watercourse.

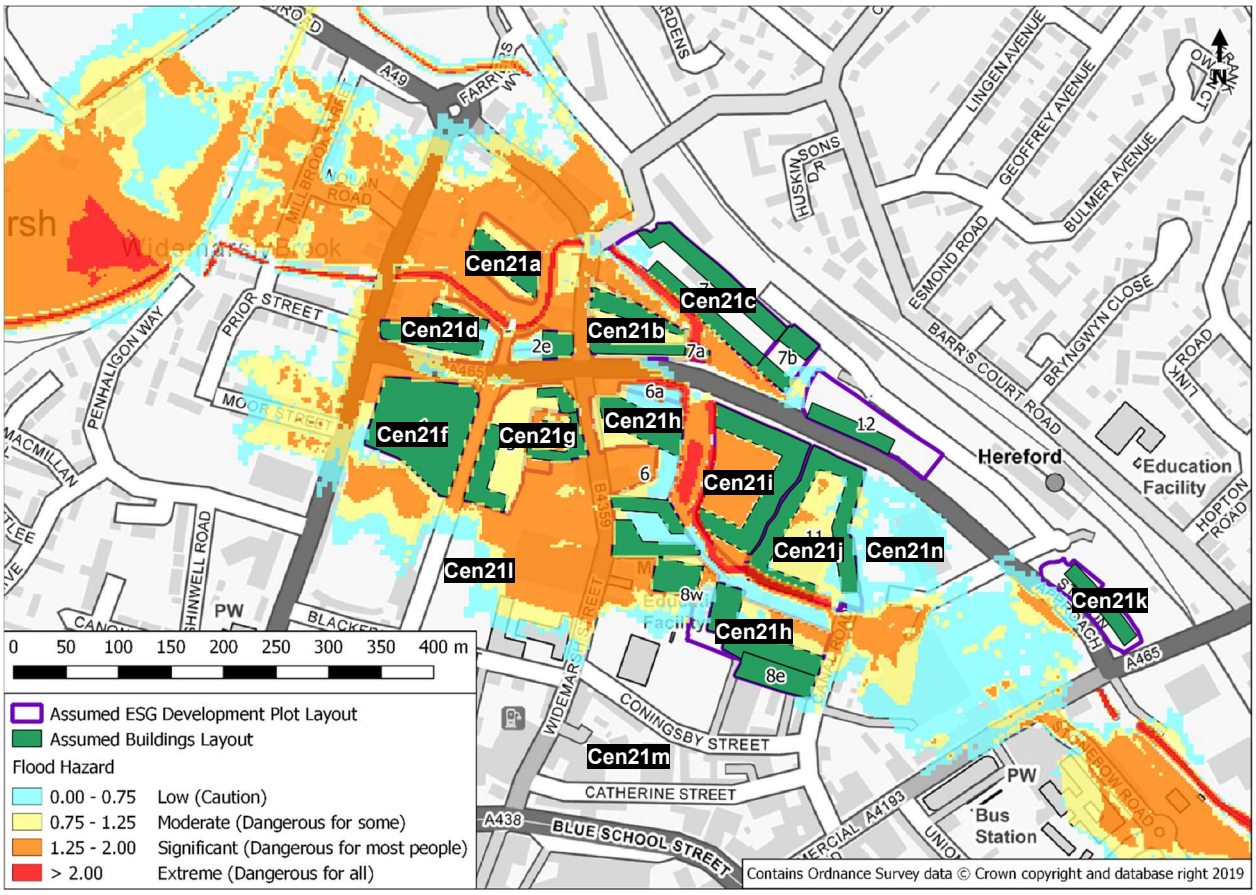
Flood hazard mapping of the assumed development plots, including assumed ground raising and an operational FAS, also showed that during the 1 in 100 (1%) annual probability event with 35% climate change allowance, dry or safe access could be achieved from all development plots with the exception of plot Cen21a), which is predicted to be surrounded by areas of Significant hazard (Dangerous for Most) as shown in Insert C.2. Early discussions for the development of this plot have mooted the potential for a raised footbridge / access route, although this will require further consideration during the development of the plot.



Insert C.2 - Assumed Development Scenario: Flood Hazard (100 annual probability +35%CC with operational FAS)

Testing of the 1 in 100 (1%) annual probability event with 35% climate change allowance and a completely blocked FAS showed that the majority of the plots are surrounded by Significant flood

hazard (Dangerous for Most) with areas of Extreme flood hazard (Dangerous for All) to the north / east of plot Cen21h as shown in Insert C.3. The peak flood depths around the inundated plots also exceed 300mm, limiting safe access to a number of properties. In this event safe refuge from flooding would need to be maintained within the buildings.



Insert C.3 - Assumed Development Scenario: Flood Hazard (100 annual probability +35%CC with a blocked FAS)

The predicted flood risk highlights the requirement to consider arrangements for flood warning, refuge and potential evacuation in development flood management plans. This is particularly apparent during extreme flood events, when safe access / egress is no longer possible for many of the plots, but is also a consideration in the 'design' event when alternative access/egress routes may need to be used or where highly vulnerable users may need assistance.

In addition to the assumed development plots and consideration of plot levels, the ESG Flood Mitigation Study considered robustness and sensitivity testing for scenarios including blockage of key culverts within the centre of the city, changes in channel roughness, changes in model hydrology and variations in development layout assumptions and phasing. Overall the tests show the development proposals to be robust against these variations. The majority of these tests showed no increase in third-party impacts and it is not expected that any of the scenarios tested would require changes to be made to the overall development flood mitigation strategy (i.e. to raise plot levels to above the 1 in 100 annual probability event with appropriate climate change allowances). It was however noted that changes in model hydrology caused an increase in third-party impacts to

the north of plot Cen21a. It is considered that this impact can likely be managed locally as part of a detailed flood risk assessment and mitigation strategy for this plot. It was also noted that the tested blockage scenarios and the increase of channel roughness in the Widemarsh Brook showed significant increase in flood depth, hazard and extent, thereby highlighting the need for regular inspection and, if necessary, maintenance of the channel and structures along the brook.

In summary, the assessments completed as part of the ESG Flood Mitigation Study demonstrated that development of the ESG regeneration area is feasible and that, with appropriate mitigation in the form of the Yazor Brook FAS and ground raising to improve the flood resilience of the proposed development plots, flood risk to the development and increased flood risk elsewhere can be appropriately managed. The assessment has also however highlighted the sensitivity of the ESG regeneration area to flood risk from multiple sources and careful consideration will need to be given to the management of these risks during future development of each of the plots.

UPDATES TO FLOOD MODELLING

Since the completion of the ESG Flood Mitigation Study there have been a series of updates to the Yazor Brook hydraulic model to support the Hereford ICS as discussed in Section 1 this Level 2 SFRA.

These updates to the model have led to reductions in the predicted flood extent associated with the Widemarsh Brook as it flows through the ESG regeneration area (principally attributable to assumed changes in the Yazor Brook hydrology) although the overall flood extent within the ESG is still uncertain as it will be affected by inflows and overland flows from the Ayles Brook that have not yet been modelled accurately. This uncertainty is not considered to change the conclusions drawn from the ESG Flood Mitigation Study although the updated modelling could potentially lead to a relatively minimal reduction in the amount of ground raising and mitigation required for each development plot in the ESG regeneration area.

PLANNING RECOMMENDATIONS

SPATIAL PLANNING AND DEVELOPMENT CONTROL

Development of the ESG regeneration area should be undertaken in accordance with the principles as set out within Section 1 of the Level 2 SFRA and Section 6 of the Level 1 SFRA. It is understood that proposed development within the ESG regeneration area will comprise more vulnerable development (such as residential) and less vulnerable development (retail/employment uses).

The operation of the Yazor Brook FAS reduces flooding within the ESG regeneration area although much of the area is still indicated to be at risk during the 1 in 100 annual probability event that is classified as Flood Zone 3a, or during the 1 in 1000 annual probability event that is classified as Flood Zone 2. No plots within the ESG regeneration area are indicated to be at risk of flooding from the Yazor and Widemarsh Brooks during the 1 in 20 annual probability event, however plot Cen21a is still indicated to be at risk from the Ayles Brook during this event.

In accordance with the NPPF, less vulnerable development is considered acceptable in Flood Zones 2 and 3a following successful application of the Sequential Test (discussed below). More vulnerable development is considered acceptable in Flood Zone 2 following successful application of the Sequential Test, but would usually only be acceptable within Flood Zone 3a following the successful application of the Exception Test.

Development would not usually be permitted in Flood Zone 3b where the annual probability of flooding is greater than 1 in 20 (5%). The ESG Flood Mitigation Study has indicated that land raising across ESG (including plot Cen21a) would not significantly increase flood risk elsewhere, however further assessment is required to fully understand the risk to this plot as the risk is indicated to be largely attributable to the Ayles Brook for which no detailed modelling is currently available. Development of plot Cen21a based on the current available information may need to be limited to water compatible development, although further assessment of the Ayles Brook and provision of an appropriate flood mitigation strategy could allow other forms of development to be progressed, particularly given the existing brownfield nature of this site and the strategic importance of the ESG regeneration area to Hereford.

A summary of how the NPPF is applied to each of the development plots is presented in Table C.1 below. This takes the operation of the FAS into account but has not yet considered the proposed ground raising as discussed in the ESG Flood Mitigation Study. The table does however provide guidance of the most appropriate uses of each plot based on the current flood risk.

Table C.1 – Recommended Development Vulnerability Allocation

Plot	Flood Zone	Water compatible	Less vulnerable	More vulnerable
Cen21a	Flood Zone 3b	Acceptable	Not acceptable	Not acceptable
Cen21b	Flood Zone 1 & Flood Zone 2	Acceptable	Acceptable	Acceptable
Cen21c	Predominantly Flood Zone 1	Acceptable	Acceptable	Acceptable
Cen21d	Flood Zone 2 & Flood Zone 3a	Acceptable	Acceptable	Exception Test required for 3a
Cen21e	Flood Zone 2	Acceptable	Acceptable	Acceptable
Cen21f	Flood Zone 1 & Flood Zone 2	Acceptable	Acceptable	Acceptable
Cen21g	Flood Zone 1 & Flood Zone 2	Acceptable	Acceptable	Acceptable
Cen21h	Flood Zone 1 & Flood Zone 2	Acceptable	Acceptable	Acceptable
Cen21i	Flood Zone 3a	Acceptable	Acceptable	Exception Test required
Cen21j	Flood Zone 1	Acceptable	Acceptable	Acceptable

Plot	Flood Zone	Water compatible	Less vulnerable	More vulnerable
Cen21k	Flood Zone 1	Acceptable	Acceptable	Acceptable
Cen21l	Flood Zone 1	Acceptable	Acceptable	Acceptable
Cen21m	Flood Zone 1	Acceptable	Acceptable	Acceptable
Cen21n	Flood Zone 1	Acceptable	Acceptable	Acceptable

To pass the Exception Test to be passed it must be demonstrated that:

- The development provides wider sustainability benefits to the community that outweigh flood risk; and
- The development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

The ESG regeneration area forms a pivotal role in the wider economic aspirations for the city centre as discussed in the Core Strategy and comprises the redevelopment of brownfield land. The development of the area has formed part of the Council's strategic planning for many years as demonstrated by the construction of the Yazor Brook FAS and therefore is considered to pass the Sequential Test. The development of the area has also been informed by the ESG Flood Mitigation Study that demonstrated that the proposed development plots could be made safe during the 1 in 100 (1%) annual probability event and allowing for appropriate climate change allowances without increasing flood risk to third-parties elsewhere. The ESG regeneration area is therefore considered likely to pass the Exception Test, although this will require review on a plot-by-plot basis once proposed flood management and mitigation measures are developed. Further discussion of recommended mitigation measures is provided below.

In accordance with the NPPF, highly vulnerable development would not be considered appropriate in Flood Zone 3a or Flood Zone 3b and would require the successful application of the Exception Test if located in Flood Zone 2. At the time of preparing this assessment there are no known highly vulnerable development proposals within the ESG regeneration area such as police stations, ambulance stations, fire stations or basement dwellings. It is recommended that no highly vulnerable development is located within Flood Zones 2 or 3.

A site-specific Flood Risk Assessment (FRA) will be required for all developments that come forward within the ESG regeneration area that are located within the mapped Flood Zone 2 or 3 (and taking a climate change into account), or that are greater than 1ha in Flood Zone 1, or that are located in an area identified to be at high or medium risk of surface water flooding. It should be noted that Herefordshire Council expect the effects of climate change to be considered when determining the extent of the Flood Zones, noting that it is expected that (at minimum) a 35% allowance is applied for less vulnerable development and a 70% allowance is applied for more vulnerable development. The FRA should address flood risks associated with the Widemarsh and Ayles Brooks and it is expected that sites that are likely to be at risk of fluvial flooding (including climate change allowances) are supported by detailed hydraulic modelling, including improved modelling of the Ayles Brook. The FRA must also assess surface water flooding attributable to overland flows, as well as demonstrate appropriate management of site-generated surface water runoff. Consideration

should also be given to risks associated with high groundwater levels. These aspects are discussed in greater detail below.

Sites that are assessed to be at significant risk of flooding (recommended to comprise a flood hazard of Moderate (Dangerous for Some) and above) to either the development plot or key access and egress routes should be discussed with the Council's emergency planning team to agree an appropriate management strategy for these sites. This may require additional gauges or alarms to be installed that would be a trigger for a Flood Evacuation Management Plan with financial contributions from developers of the ESG regeneration area.

Development of the ESG must also give consideration to asset ownership and maintenance responsibilities for the regular inspection and maintenance of the Widemarsh Brook and structures along the brook.

MANAGEMENT OF FLUVIAL FLOOD RISKS

As discussed, the ESG Flood Mitigation Study considered the flood events that should be used to inform the assessment and design of development within the ESG regeneration area and tested plot levels to enable safe and sustainable development. These recommendations take into consideration the vulnerability classification of the development as defined by the NPPF. Table C.2 details the respective events that each flood risk vulnerability classification should be tested against when assessing flood risk to the individual development plots within the site-specific FRA. Although no essential infrastructure, highly vulnerable or water compatible development is proposed, these classifications have also been included in Table C.2 for completeness. The events listed in Table C.2 assume operation of the Yazor Brook FAS unless specifically stated.

Table C.2 - Design and Residual Risk Events

Flood risk vulnerability classification	Design event	Residual risk event*
Essential infrastructure (Dependent on operational requirements**)	Typically the larger of: ▪ 100 annual probability +70% CC ▪ 1000 annual probability	Typically the larger of: ▪ 100 annual probability +70% CC ▪ 1000 annual probability ▪ 100 annual probability +35% CC with full FAS blockage
Highly vulnerable (Dependent on operational requirements**)	The larger of: ▪ 100 annual probability +70% CC ▪ 1000 annual probability	The larger of: ▪ 100 annual probability +70% CC ▪ 1000 annual probability ▪ 100 annual probability r +35% CC with full FAS blockage
More vulnerable	▪ 100 annual probability +35% CC	The larger of: ▪ 100 annual probability +70% CC ▪ 1000 annual probability ▪ 100 annual probability +35% CC with full FAS blockage

Less vulnerable	▪ 100 annual probability +35% CC	The larger of: ▪ 100 annual probability +70% CC ▪ 1000 annual probability ▪ 100 annual probability +35% CC with full FAS blockage
Water compatible	Variable assessment event, dependent on proposed development.	

**Local residual risk events (such as culvert blockage) should also be considered as appropriate to confirm any increased flood risk can be managed appropriately and no unacceptable consequences*

***Operational requirements may dictate that certain areas of a plot cannot be designed to be flood free. In this case an exception will be made to the above requirement. Operational requirements may also determine that the development must be more resilient to flood risk and a larger event used to inform plot development.*

When assessing the flood risk to individual development plots and hence determining the required ground raising for each, the above design and residual risk events should be matched with the design criteria detailed in Table C.3.

Table C.3 – Design Criteria

Design event	**Residual risk event** *Apply the same criteria as for the design event where technically and financially feasible*
Flooding to external areas of development plots acceptable (subject to other criteria) as summarised below	Flooding to external areas of development plots acceptable
Dry pedestrian access should ideally be maintained. Flood depths up to ~300mm or equivalent flood hazard up to and including Danger for Some may be acceptable	No specific criteria for access/egress (other criteria should mean that safe refuge is maintained) Exception is essential infrastructure / highly vulnerable development where operational requirements may dictate otherwise
Finished floor levels minimum 600mm above flood level. A smaller freeboard may be acceptable where site constraints mean this is impractical. Typically only acceptable where ground floor uses are 'less vulnerable' and appropriate resilience and management measures can be implemented. To be assessed on a case by case basis as part of site specific FRA.	Buildings remain dry in all residual risk events Flooding of buildings may be acceptable where site constraints mean this is impractical. Typically only acceptable where ground floor uses are 'less vulnerable' and appropriate resilience and management measures can be implemented. To be assessed on a case by case basis as part of site specific FRA.
No increase in flood risk to third parties	No increase in flood risk to third parties

At minimum, external areas within each development plot should be designed such that flooding does not occur for events up to and including the following design events:

- Essential infrastructure: 1 in 100 (1%) annual probability + 35% CC (unless operational requirements dictate otherwise)

- Highly vulnerable: 1 in 100 (1%) annual probability + 35% CC
- More vulnerable: 1 in 20 (5%) annual probability + 35% CC
- Less vulnerable: 1 in 20 (5%) annual probability + 35% CC
- Water compatible: Dependent on requirements of proposed development

When assessing the potential impact of a development to third parties, the appropriate residual risk event should be assessed as the largest of the following:

- 1 in 100 annual probability +70% CC;
- 1 in 1000 annual probability;
- 1 in 100 annual probability +35% CC with 50% FAS blockage.

Site-specific hydraulic modelling will be required for individual development plots located within Flood Zone 3, taking into consideration climate change allowances appropriate to the vulnerability of the development. The updated Yazor Brook 1D-2D FMP–Tuflow hydraulic model should be used for this assessment and can be requested from Herefordshire Council (for a charge) although it is the developer's responsibility to ensure that the model is up to date and fit for purpose at the time of undertaking the assessment. Of particular note at the time of preparing this SFRA is the need for detailed modelling of the Ayles Brook.

In addition to the standard NPPF requirements for the completion of a site-specific FRA, the FRA should also consider the following:

- Interactions with other sources of flooding, primarily those associated with surface water and groundwater flooding;
- The current state of the surrounding development area at the time of preparing the site-specific FRA;
- The potential future phasing of the ESG regeneration area, how the proposed plot may affect future development in the area and how future phasing may differ from the assumptions made during the ESG Flood Mitigation Study;
- The impact of development on overland flow routes;
- Consideration of local residual risk events, such as channel roughness and culvert blockage; and
- Emergency measures in the event of residual flood risk of the proposed plot. This may need to be completed in consultation with the Council's emergency planning team.

As the FAS and the proposed ground raising are intended to work in conjunction as part of the flood mitigation strategy for the ESG regeneration area, the assessment of post development flood risk should be made against the previous flood risk prior to the construction of the FAS.

Any new development must consider maintenance responsibilities and requirements of the Widemarsh Brook and, ideally, set new development back from the watercourse to facilitate maintenance. A minimum corridor of 4m between the watercourse and new development is considered appropriate.

MANAGEMENT OF SITE GENERATED SURFACE WATER RUNOFF

The outline drainage strategy for ESG was considered during the development of the new Link Road and realignment of the Widemarsh Brook. The high groundwater levels and potential contamination risks in this area suggest that infiltration will be unsuitable. For those plots that border the Widemarsh Brook a direct connection to the brook could be sought with discharge limited to an attenuated rate, noting that a minimum rate of 2l/s would be considered viable if an appropriate

overflow to the brook is provided and hydraulic performance of the drainage system can be achieved. Where a direct connection to the brook is not viable, it is recommended that surface water runoff is discharged to the new highway drainage network at an attenuated rate that in turn discharges runoff to the Widemarsh Brook. A minimum discharge of 5l/s is likely to be considered acceptable for development plots that are not located adjacent to the brook although this will need to be agreed with Herefordshire Council on a site-by-site basis. For all plots within the ESG regeneration area, it is also recommended that a maximum discharge rate of 5 l/s is applied to assist with managing flood risk elsewhere.

If neither discharge to the brook or the highway drainage network is viable, a connection to the Dwr Cymru Welsh Water combined network could be possible if no other options are available. Some of the sites within the ESG regeneration area are likely to have historically drained to the Dwr Cymru Welsh Water combined network. The redevelopment of these sites and redirection of surface water runoff to a new surface water network may therefore reduce pressure on the existing combined network.

MANAGEMENT OF MINOR WATERCOURSES AND OVERLAND FLOW

As discussed above, the ESG regeneration area is likely to be at significant risk of flooding from overland flow that will naturally drain towards the ESG given its low elevation. However, for most plots this is likely to be significantly less than the predicted fluvial flood risk attributable to the Widemarsh and Ayles Brooks and, as such, the mitigation measures proposed to manage fluvial flood risks will be adequate to also manage surface water flood risk. That said, this should be addressed separately within the site-specific FRA (also giving consideration to impacts associated with deflection of overland flow routes) and must also be considered in the design of the development's proposed drainage system to ensure overland flows do not discharge to the drainage system and thereby reduce system capacity.

Reference should be made to the recommendations of the ESG Flood Mitigation Study.

MANAGEMENT OF POTENTIALLY HIGH GROUNDWATER LEVELS

The risk of high groundwater levels must be considered in the development of the ESG regeneration area and drainage design, most notably the risk that this could reduce the effectiveness of infiltration systems or reduce the capacity of unlined attenuation/infiltration systems. Groundwater is also likely to be conveyed by the granular bedding and so the drainage design should consider the provision of clay stanks.

Appropriate mitigation may be required for isolated low spots where groundwater could emerge, such as ground raising, raised thresholds, sub-surface drainage, or management of overland flow paths. Building foundations could also result is a loss of groundwater storage and create a barrier to groundwater flow, which could locally increase groundwater levels and could lead to third party impacts if not properly mitigated. Groundworks and foundations should allow for the movement of subsurface water around deep structures and tanking to foundations. Similarly, if the soft made ground / alluvial fill is not removed prior to ground raising there could be a local rise in ground water levels, albeit temporary. Basement structures are not recommended for the ESG regeneration area.

Additional groundwater monitoring data should be obtained to improve understanding of groundwater conditions in and around the ESG regeneration area to inform future development.

Reference should be made to the recommendations of the ESG Flood Mitigation Study.

MANAGEMENT OF FOUL WATER

The ESG regeneration area is served by an existing Dwr Cymru Welsh Water foul water or combined network, therefore discharge to this network should be agreed in consultation with Dwr Cymru Welsh Water.

OPPORTUNITIES FOR BETTERMENT

The Yazor Brook FAS that was constructed to support development of the ESG development area provides significant betterment both within the ESG and throughout Hereford. Development of the ESG regeneration area could therefore support the ongoing maintenance and improvement of the Yazor Brook FAS via financial contributions, including improved flood warning, given the significance of the FAS to the viability of future development.

The Hereford ICS commissioned by Herefordshire Council in 2019 considered options to reduce fluvial flood risk associated with the Yazor and Widemarsh Brooks in conjunction with the existing Yazor Brook FAS. The study highlighted the potential opportunities to further reduce flooding in the centre of Hereford, for example by providing online or offline flood storage features in the upper and middle reaches of the Yazor Brook. The development of the ESG regeneration area may therefore offer opportunity to progress these options via financial contributions if these measures provide further betterment and assist with meeting the site's mitigation requirements.

As discussed above, it is likely that some of the sites within the ESG regeneration area historically drained to the Dwr Cymru Welsh Water combined network. The redevelopment of these sites and redirection of surface water runoff to a new surface water network may therefore reduce pressure on the existing combined network, although the benefits are likely to be small.

Attenuating surface water discharge to a maximum discharge rate of 2l/s to watercourses or 5 l/s to sewerage systems may also assist with managing flood risk elsewhere.

Improved and regular maintenance of the Widemarsh Brook and associated structures may assist in reducing flood risk both within the ESG development area and elsewhere. As discussed above it is important that riparian landowners are made aware of their responsibilities for channel maintenance and that this forms part of the future management strategy of the site.

Appendix D

SOUTH HEREFORD – HOL12A, HOL12B, HOL13

SOUTH HEREFORD – HOL12A, HOL12B & HOL13

Allocation Reference:	HAP Site Option Hol12a, Hol12b and Hol13
Location:	South Hereford
River Catchment:	Withy Brook
NPPF Flood Zone (majority of area):	Flood Zone 1
NPPF Flood Zone (worst case):	Flood Zone 3b

INTRODUCTION

The Hol12a, Hol12b and Hol13 identified site options occupy a collective area of approximately 56.4ha and are located to the south of Hereford as illustrated in Figure D.1. The sites currently comprise agricultural land with occasional properties and all are bound by the Withy Brook to the south. Both the Hol12b and Hol13 sites are bound by the railway line to the north. Ross Road and Bullingham Lane separate the site allocations, and Grafton Lane passes through the north of Hol13.

The Withy Brook flows in a north-east direction along the southern boundary of all sites, confluencing with the Norton Brook to the west of site Hol12b and also forming the eastern boundary of this site before passing beneath the railway line and discharging to the River Wye approximately 750m downstream of the railway. The Withy and Norton Brooks are classified as ordinary watercourses and are therefore under the jurisdiction of Herefordshire Council as Lead Local Flood Authority (LLFA).

Topography within the majority of sites Hol12a and Hol12b generally slopes towards the Withy Brook in the south and east, however runoff from part of site Hol12a may be intercepted by Bullingham Lane and channelled towards the railway. Topography within the south of siteHol13 also falls towards Withy Brook, although land to the north of Grafton Lane slopes towards the railway line. Levels within all three sites typically range between 75mAOD to 57mAOD.

The Hol12a, Hol12b and Hol13 sites are identified in the Hereford Area Plan (HAP) as part of the South West Hereford and South East Hereford sites. The HAP states that the sites have the following potential for development:

- Hol12a – Potential for 70 properties although expected that not all of the site will be developed due to other environmental constraints.
- Hol12b – Potential for 190 properties although expected that this will need to be located towards the north of the site due to visibility and ecological value of the southern edge.
- Hol13 – Potential for 155 properties although expected that the southern part of the site may be unsuitable for development due to other environmental constraints.

At the time of preparing this assessment it is known that the following major development application has been made within the Hol13 site boundary:

- Outline planning application for part of Hol13 (c.13ha of the eastern site extents to the north and south of Grafton Lane) for the construction of up to 300 dwellings with associated public open space and infrastructure (reference 193042, pending approval).

DESCRIPTION OF FLOOD RISK

FLUVIAL

The assessment of fluvial flood risk has been informed by the 1D-2D Estry-Tuflow hydraulic model of the Withy, Norton and Red Brooks that was commissioned by Herefordshire Council in 2019 to inform the Hereford ICS as discussed in Section 1.2 of the Hereford City Level 2 SFRA.

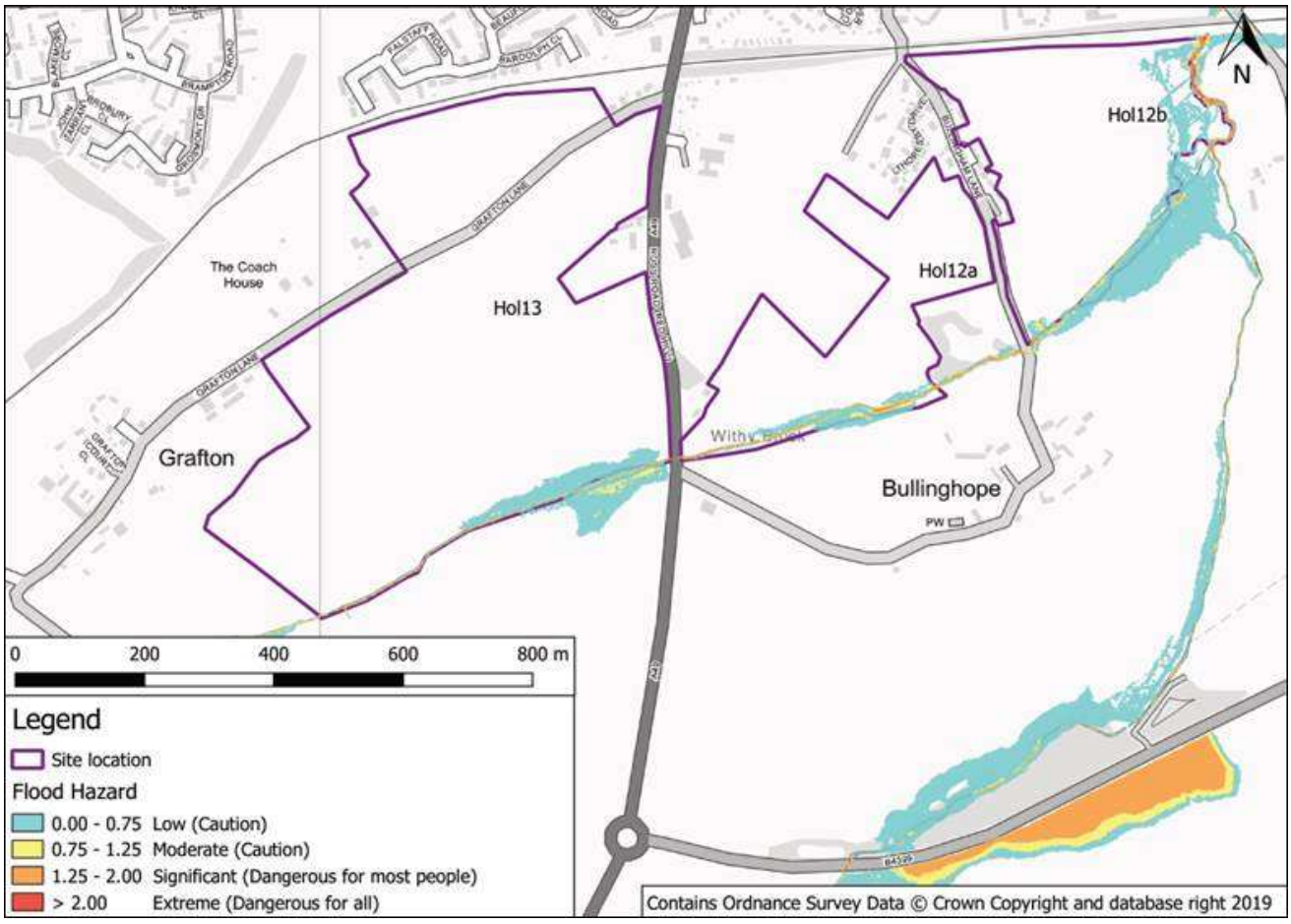
The fluvial modelling of the Withy, Norton and Red Brooks and subsequent Flood Zone classification indicates that the majority of the Hol12a, Hol12b and Hol13 sites are located within the low risk Flood Zone 1. Land adjacent to the Withy Brook is located within the high risk Flood Zone 3 and medium risk Flood Zone 2, with encroachment of the flood zones into the southern extent of the sites. More significant fluvial flood risk is indicated in the east of site Hol12b at the confluence of the Withy and Norton Brooks with land classified as Flood Zone 2. During extreme events, flows also break the right bank of the Withy Brook and flow east alongside the railway embankment, overtopping both Hoarwithy Road and Lower Bullingham Lane. Land downstream of the sites in the urban area of Lower Bullingham is indicated to be at significant risk of flooding from the Withy and Norton Brooks and from the River Wye, although the influence of the Wye is not predicted to notably affect flooding within the Hol12a, Hol12b and Hol13 site boundaries. The mapped fluvial flood extents are illustrated in Figure D.2.

Anecdotal evidence also indicates significant flooding of the B4399 at the road's crossing of the Norton Brook. This is currently not represented in the hydraulic modelling and considered likely to be attributable to flood waters backing up behind the B4399 culvert and overtopping the road at a localised low point immediately east of the culvert. The flood waters are reported to return to the Norton Brook downstream of the crossing although significant flooding of the B4399 occurs during this event.

The Flood Zone 3b functional floodplain is defined as land where water has to flow or be stored in times of flood, typically represented by areas that flood during the 1 in 20 (5%) annual probability event. The fluvial modelling flood extent for 1 in 20 (5%) annual probably event indicates that flood flows are largely contained within the river channels and pose little risk to the Hol12a, Hol12b and Hol13 sites, although land adjacent to the southern boundary of Hol12b is indicated to comprise functional floodplain. The mapped functional floodplain extents are illustrated in Figure D.3.

The fluvial modelling of the Withy, Norton and Red Brooks has modelled the potential effects of climate change for a 35% and 70% increase in peak river flows for the 1 in 100 (1%) annual probability event. The modelling results indicate little change to mapped flood extents within the Hol12a, Hol12b and Hol13 sites, although flood extents during the modelled 1 in 100 (1%) annual probability event with 35% climate change allowance pose greater risk to the east of site Hol12b and south of site Hol13, and flood extents during the modelled 1 in 100 (1%) annual probability event with 70% climate change allowance increase to a similar extent to the present-day Flood Zone 2. Mapped outputs of the climate change allowances are illustrated in Figure D.4. The climate change mapping also indicates that the probability of flood risk to sites adjacent to and downstream of site Hol12b (including the downstream urban area of Lower Bullingham) is likely to increase associated with an increase of flows within the Withy and Norton Brooks.

Flood hazard (a combination of depth and velocity) has been determined as part of the fluvial modelling of the Withy, Norton and Red Brooks. Mapped output of flood hazard for the 1 in 100 (1%) annual probability event is illustrated in Insert D.1 below and includes a 35% climate change allowance. As shown in Insert D.1, flood hazard within the Hol12a, Hol12b and Hol13 sites is classified as Low (Caution).



Insert D.1 – Withy and Norton Brooks flood hazard (depth and velocity) for Hol12a, Hol12b and Hol13

SURFACE WATER AND MINOR WATERCOURSES

The Environment Agency's Risk of Flooding from Surface Water map indicates that the Hol12a, Hol12b and Hol13 sites are generally at very low risk of surface water flooding as illustrated in Figure D.5. The flood extents along the Withy Brook are broadly similar to the fluvial flood extents as previously discussed in the section above.

The Environment Agency's Risk of Flooding from Surface Water map does however indicate a high risk of flooding in the north of site Hol13 indicating ponding of overland flow adjacent to the railway embankment. Ponding water at this location has also been confirmed during a site visit. It was thought that an existing culvert may present at this location to drain water beneath the railway line. This could not be identified during a site visit although it is possible that the culvert exists but has fallen into disrepair.

The Environment Agency's Risk of Flooding from Surface Water map also shows some ponding of water on Bullingham Lane where it passes under the railway line, noting that the road was locally lowered at this point during construction of the railway and a dip created. Recorded flooding events on Bullingham Lane beneath the railway line are reported to be attributable to surface water flooding where highway gullies are connected to a culvert beneath the road. The culvert conveys water from the railway bridge towards Winston Road and Hinton Road to the north-east of Bullingham Lane. The culvert will also pick up land drainage that flows off the fields to the south of the railway, noting that this may include part of the Hol12a site.

The Environment Agency's Risk of Flooding from Surface Water map also shows flooding to Hoarwithy Road and Lower Bullingham Lane to the east of site Hol12b, although the flooding to Hoarwithy Road and Lower Bullingham Lane is more likely to be attributable to fluvial flooding from the Withy Brook as discussed previously.

GROUNDWATER

Review of the British Geological Survey (BGS) data indicates that the Hol12a, Hol12b and Hol13 sites are underlain by Raglan Mudstone Formation comprising siltstone and mudstone bedrock geology. Isolated pockets of superficial gravel deposits overlay the bedrock geology although these are generally sparse within the site boundaries. The BGS website provides a number of historic borehole records adjacent to the site. These indicate that groundwater is likely to be in excess of 5m below ground level. Groundwater flooding is considered to present low risk.

OTHER SOURCES OF FLOOD RISK

Review of the EA's Flood Risk from Reservoirs mapping indicates that the Hol12a, Hol12b and Hol13 sites are not located within an area deemed to be risk of flooding from reservoirs. Review of OS mapping also indicates no reservoirs or other large storage features at a higher elevation to the site that would pose flood risk in the event of failure.

The Hol12a, Hol12b and Hol13 sites are located on the outskirts of Hereford and there is sparse development surrounding the site. The site is not likely to be at significant risk of flooding from adjacent sewerage or drainage systems.

HISTORIC FLOOD RECORDS

Review of Herefordshire Council and Dwr Cymru Welsh Water historic flood records at the time of preparing this report indicates that Hoarwithy Road and Lower Bullingham Lane regularly suffer from surface water flooding particularly at locations where the highway crosses under the railway. A large number of flood incidents have also been recorded downstream of the sites in the urban area of Lower Bullingham, likely to be attributable to exceedance flows from the Withy Brook with influence from the River Wye.

PLANNING RECOMMENDATIONS

SPATIAL PLANNING AND DEVELOPMENT CONTROL

Development of the Hol12a, Hol12b and Hol13 sites should be undertaken in accordance with the principles as set out within Section 1 of the Level 2 SFRA and Section 6 of the Level 1 SFRA. It is understood that proposed development within the Hol12a, Hol12b and Hol13 sites will comprise residential development.

The majority of the sites are located within Flood Zone 1. Given the size of the sites it is recommended (and considered achievable) that all development can be located in Flood Zone 1 and outside of the extent of mapped fluvial flooding up to and including the 1 in 100 (1%) annual probability event with 70% climate change allowance or the 1 in 1000 (0.1%) annual probability event, whichever is greater. Other sources of flooding as discussed above are not considered to pose risk to the development assuming that the recommendation to locate all development in Flood Zone 1 is adopted.

Development of the sites must demonstrate that safe access and egress can be achieved. This is of particular importance for access required from Hoarwithy Road and Bullingham Lane that are identified to be at risk of flooding, noting that recorded flooding events of Bullingham Lane indicate that the road may become impassable. Consideration should also be given to recorded flooding of the B4399 at the road's crossing of the Norton Brook, although this is unlikely to pose constraint to the site's development.

The site allocations are deemed to pass the Sequential and Exception Tests, however a site-specific Flood Risk Assessment (FRA) prepared in accordance with the NPPF and supporting Planning Practice Guidance will be required for all proposed developments that are 1ha or greater in area or that are deemed to be at flood risk from the Withy or Norton Brooks. The FRA should assess the risk of flooding associated with the Withy and Norton Brooks (including climate change allowances), as well as risks attributable to surface water overland flows and associated with an increase in the rate or volume of site-generated surface water runoff. The sites also offer opportunity to improve flood risk elsewhere. These aspects are discussed in greater detail below.

MANAGEMENT OF FLUVIAL FLOOD RISKS

The fluvial modelling of the Withy, Norton and Red Brooks indicates that the majority of the Hol12a, Hol12b and Hol13 sites would not be at risk during the 1 in 100 (1%) or 1 in 1000 (0.1%) annual probability events. As stated above, it is recommended that all development (including drainage systems) are located outside of these flood extents and taking climate change into account, noting that this will require the north-east of site Hol12b to be safeguarded for flood storage and a flood flow corridor to be maintained along the rest of the Withy Brook. As discussed in the 'opportunities for betterment' section below, land within the north-east of site Hol12b could also provide additional flood storage to benefit flood risk elsewhere, as identified by the Hereford ICS.

It is recommended that the development takes into consideration the residual risk event, recommended to comprise the larger of a: 1 in 100 (1%) annual probability event with 70% climate change allowance or the 1 in 1000 (0.1%) annual probability event. It is recommended that development is located outside of the mapped residual risk flood extents.

Finished floor levels of any new buildings should be raised a minimum of 600mm above the 1 in 100 (1%) annual probability event plus 35% climate change allowance, and with no internal flooding of buildings during the residual risk flooding events.

It is expected that access to site Hol12b would be made from Bullingham Lane to the west of the site and, as discussed above, the site-specific FRA must demonstrate that safe access and egress can be achieved. If access is required from Hoarwithy Road this could be problematic as this would require a new crossing of the Withy Brook and its (relatively extensive) floodplain at this location. Any new crossing must be a clear span crossing and must demonstrate (via hydraulic modelling) that the crossing will not pose flood risk to the development or elsewhere up to the 1 in 100 (1%)

annual probability event with 35% climate change allowance and maintain connection to the natural floodplain adjacent to the brook. A minimum 300mm freeboard to the soffit of the crossing should be maintained above the 1 in 100 (1%) annual probability event with 35% climate change allowance. Consideration should also be given to residual risk events discussed above, noting that the road should remain safe during these events if it is considered important for access and egress during a flood event. Consideration must also be given to maintenance access and ecological requirements (including mammal passage) noting that a higher freeboard may be required.

The development must not increase flood risk elsewhere. At minimum there should be no increase in flood risk up to the 1 in 100 (1%) annual probability event with 35% climate change allowance. Third-party impacts should also be tested for the residual risk events discussed above, noting that the acceptability of risks to third party land during these events will be assessed on a case-by-case basis that takes the vulnerability of the land and the increase in risk into account.

If any development is required to be located in areas at risk during the 1 in 100 (1%) annual probability event plus 35% climate change allowance or residual risk events discussed above, compensatory flood storage should be provided on a like-for-like basis, and ideally strive to provide betterment.

MANAGEMENT OF SITE GENERATED SURFACE WATER RUNOFF

The management of surface water runoff will be of particular importance for the Hol12a, Hol12b and Hol13 sites given the historic flooding downstream of the sites in Lower Bullingham. Drainage systems should be designed in accordance with the Herefordshire SuDS Handbook and Section 6 of the Level 1 SFRA, adhering to the following key principles:

- Applying the SUDS hierarchy to promote the infiltration of runoff to ground prior to the consideration of other measures;
- Controlling the rate and volume of runoff to ensure no increased flood risk for all events between the 1 in 1 (100%) and the 1 in 100 (1%) annual probability rainfall events;
- Promoting best practice vegetated and on-ground conveyance and storage features as much as practicable.

Methods for calculating runoff must be in accordance with the methods promoted within the CIRIA SuDS Manual (C753, published in 2015). It is expected that FEH methods and 2013 rainfall data are used in the calculation of existing and post-development scenarios. The calculation of pre-development runoff rates and volumes should not take the potential effects of climate change into account.

As discussed above the sites are underlain by Raglan Mudstone Formation bedrock geology with relatively sparse superficial deposits. It is therefore likely that infiltration of surface water runoff to ground will not be viable, although infiltration testing will be required to support future planning applications to confirm assumed conditions. Herefordshire Council will still promote unlined combined attenuation and infiltration features in lower permeability soils (if groundwater levels are sufficiently low) to maximise infiltration and treatment in smaller rainfall events. If permeability testing indicates that infiltration is viable (in full or in part) it is recommended that over-winter groundwater monitoring is undertaken.

A controlled discharge to the Withy Brook is likely to be the most viable option for surface water drainage if infiltration cannot manage all site runoff. Attenuation of runoff will be of key importance and given the size and strategic importance of these sites it is recommended that discharge is

limited to Qbar for all return period events (i.e. up to the 1 in 100 (1%) annual probability event and allowing for climate change) as much as practicable. Given the strategic importance of these sites is also recommended that consideration is given to events larger than the 1 in 100 (1%) annual probability event – i.e. up to the 1 in 1000 (0.1%) annual probability event. Reducing runoff during larger return period events will mitigate increased downstream flood risk associated with the sites' development and may also assist with reducing downstream flood risk attributable to the Withy Brook.

Consideration must also be given to the performance of the drainage system (i.e. ensuring appropriate head to ensure correct function of flow controls) and the risk of water not being able to discharge as intended during periods of high water levels within the Withy Brook.

The drainage of land within the north of site Hol13 could be problematic as site topography sheds surface water runoff towards the railway line. Review of the outline planning application submitted for part of site Hol13 (ref: 193042) proposed land raising adjacent to the railway to facilitate a gravity connection to the Withy Brook. This is a viable solution although must take into consideration the additional catchment area draining to the Withy Brook created by the proposed land raising.

It is expected that for development sites of this size best practice 'green' SUDS measures (i.e. vegetated conveyance and storage systems) are incorporated that promote attenuation (and infiltration where appropriate), treatment and biodiversity benefit throughout the development.

MANAGEMENT OF SURFACE WATER AND MINOR WATERCOURSES

The development of site Hol13 must give consideration to the mapped surface water ponding in the north of the site adjacent to the railway line, ensuring development is set back from this area and finished floor levels raised appropriately. Review of the outline planning application submitted for part of site Hol13 (ref: 193042) proposed land raising adjacent to the railway to facilitate a gravity connection to the Withy Brook. Whilst this would remove the risk from site Hol13, consideration must be given to any increased risk to the adjacent land caused by the proposed land raising. It may be necessary to maintain an area of sacrificial land within site Hol13 to provide storage for overland flows. If further site survey demonstrates the presence of a culvert beneath the railway that would drain the area of mapped flood risk, consideration must be given to the potential effects of land raising on the operation of this culvert.

Consideration should also be given to existing flood risk to Bullingham Lane that is likely to provide key access and egress to sites Hol12a and Hol12b. Ideally ponding of the road as it passes beneath the railway line should be less than 300mm, noting that the development of these sites may be able to contribute to reducing the depth of ponding.

MANAGEMENT OF POTENTIALLY HIGH GROUNDWATER LEVELS

The risk of high groundwater levels must be considered in the drainage design, most notably the risk that high groundwater levels could reduce the effectiveness of infiltration systems or reduce the capacity of unlined attenuation/infiltration systems. If these systems are proposed, winter groundwater monitoring should be undertaken to better understand and mitigate these risks.

Basement structures may be appropriate if long term groundwater monitoring demonstrates that groundwater levels do not rise to a level that would pose flood risk to these structures.

MANAGEMENT OF FOUL WATER

Foul water from the Hol12a, Hol12b and Hol13 sites should be discharged to the public sewerage network that serves existing properties to the south of the railway. A pumped discharge is likely to be required as the topography of these existing properties is higher than the general topography of the Hol12a, Hol12b and Hol13 sites. The Applicants should discuss their proposed developments with Dwr Cymru Welsh Water to determine if this approach is acceptable and agree the need for any local improvements.

OPPORTUNITIES FOR BETTERMENT

As discussed above, the Hol12a, Hol12b and Hol13 sites offer opportunity to reduce surface water runoff during larger rainfall events by limiting all site-generated surface water discharge to rates and volumes comparable to Qbar. Whilst the benefits are likely to be small, these opportunities should be explored to reduce downstream fluvial flood risk associated with the Withy Brook.

The Hereford ICS commissioned by Herefordshire Council in 2019 considered options to reduce fluvial flood risk associated with the Withy, Norton and Red Brooks. The study highlighted the potential opportunities that could be delivered by the development of the Hol12a, Hol12b and Hol13 sites (most notably site Hol12b) to reduce and slow flood flows from the Withy Brook.

The most notable option proposes the provision of significant fluvial storage at the confluence of the Withy and Norton Brooks within the east (and upstream) of site Hol12b. Hydraulic modelling indicated that this option could provide significant benefit to downstream flood risk in Lower Bullingham during frequent storm events, as well as reduce overland flows that flow east along the railway line and contribute to flooding to Hoarwithy Road and Lower Bullingham Lane. We recommend that the allocation of site Hol12b includes a requirement to consider opportunities to reduce downstream flood risk that could be delivered as part of the site's future development.

The Hereford ICS also identified opportunities for other improvements along the Withy Brook that could be delivered by development of the Hol12a, Hol12b and Hol13 sites, for example by incorporating Natural Flood Management (NFM) measures such as leaky dams or enhancing the natural floodplain adjacent to the watercourse. We recommend that these opportunities are explored further as part of the sites' development.

The drainage of land within site Hol12a may offer opportunity for betterment to existing flood risk at Bullingham Lane, particularly if runoff (including land drainage) can be intercepted and attenuated.

Appendix E

WEST HEREFORD – THR23

WEST HEREFORD - THR23

Allocation Reference:	HAP Site Option Thr23
Location:	West Hereford
River Catchment:	River Wye
NPPF Flood Zone (majority of area):	Flood Zone 1
NPPF Flood Zone (worst case):	Flood Zone 1

INTRODUCTION

The Thr23 identified site option occupies an area of approximately 64ha and is located in the west of Hereford as illustrated in Figure E.1. The site comprises largely agricultural land and two properties called The Cottages located to the east within the site boundary. The site is bound by the urban area of White Cross and Hereford Cemetery to the north and north- east, Breinton Road to the south and agricultural land to the west and north-west. The Broomy Hill conservation area is located to the south of the site and incorporates a section of the River Wye. The centre of Hereford is located approximately 2km to the east of the site. The nearest watercourse is the River Wye which is located approximately 1km to the south of the site.

Topography within the Thr23 site is relatively flat with a gentle slope from the centre of the site to the north-west and to the south-east. Ground levels in the centre of the site vary between approximately 81mAOD to 80mAOD, sloping towards approximately 70mAOD in the north-west and to approximately 71mAOD in the south-east.

The Thr23 site is identified in the Hereford Area Plan (HAP) as part of the South West Hereford sites. The HAP states that there is the potential capacity for 420 dwellings within the site, taking into account to the environmental constraints (landscape and archaeological) which mean only part of the site is suitable for development.

DESCRIPTION OF FLOOD RISK

FLUVIAL

Review of the Environment Agency's Flood Map for Planning indicates that the Thr23 site is located entirely within the low risk Flood Zone 1 where the annual probability of flooding from fluvial sources is less than 1 in 1000 (0.1%).

The nearest mapped flood zone to the site is associated with the River Wye that is located approximately 400m to south of the Thr23 site as illustrated in Figure E.2. The river flows in a west to east direction and is classified as a main river, and therefore under the jurisdiction of the Environment Agency. The Yazor Brook is located approximately 650m to the north of the site and flows in a south-easterly direction through the city to confluence with the River Wye close to the A49 crossing. The Yazor Brook is classified as an ordinary watercourse and is therefore under the jurisdiction of Herefordshire Council as Lead Local Flood Authority (LLFA). Neither of these

watercourses (The River Wye or Yazor Brook) pose a significant risk to the site or adjacent land, both now or in the future when climate change effects are considered.

SURFACE WATER AND MINOR WATERCOURSES

The Environment Agency's Risk of Flooding from Surface Water map indicates that the Thr23 site is generally at very low risk of surface water flooding as illustrated in Figure E.3. The mapping does however indicate significant ponding of overland flow in the north-west of the site to the south of King's Acre Road posing risk to the Fayre Oaks Park Home Estate. Topography to the south and south-west slopes towards this point and therefore overland flow from within and outside of the site boundary contributes to the mapped flood extent. This will need to be considered within the development proposals, noting that the development may offer opportunity for betterment. A flood defence ditch and storage area has been constructed in the field to the west of the Fayre Oaks Park Home Estate. An earth bund has also been constructed to the rear of dwellings to the south of Huntsman Drive, between the Thr23 site and the dwelling boundaries. The proposed layout of the Thr23 site (including its proposed access) will need to take these features into account including maintenance access. A 4m wide maintenance strip should be provided.

Review of the EA's Surface Water Flood Risk mapping also indicates the presence of an ephemeral watercourse within the east of the site that flows within a natural valley in the site's topography. The flow is indicated to enter Breinton Road and continue east, discharging into a Welsh Water sewer in Breinton Road.

GROUNDWATER

Review of the British Geological Survey (BGS) data indicates that the Thr23 site is underlain by Raglan Mudstone Formation comprising siltstone and mudstone bedrock geology. Superficial deposits comprise Till, although deep soakaway testing completed for a nearby development site indicated a gravel later at depth.

The very north of the site is designated as a groundwater Source Protection Zone (SPZ) that serves the Heineken site in the centre of Hereford. The site is predominantly located within Zone 2 (outer zone) which is defined by a 400 day travel time from a point below the water table.

In some areas of the Thr23 site rainwater is understood to become trapped forming a perched water table above the Raglan Mudstone. Springs are reported to sometimes form. Although there are no springs recorded on OS mapping, the name of Springfield Cottage located on Breinton Road at the south of the site suggests that historic springs are likely. Anecdotal reports also state that water continues to drain off the land long after a rainstorm has ended, which indicates that springs may be generating a base flow in ditches.

OTHER SOURCES OF FLOOD RISK

The Thr23 site is not located within an area deemed to be risk of flooding on the Environment Agency's Risk of Flooding from Reservoirs map. Review of OS mapping also indicates no reservoirs of other large storage features at a higher elevation to the site that would pose flood risk in the event of failure.

The Thr23 site is located on the western edge of the urban area of Hereford with existing urban development only located to the north at a lower elevation. The site is therefore not likely to be at significant risk of flooding from adjacent sewerage or drainage systems.

HISTORIC FLOOD RECORDS

Review of Herefordshire Council and Dwr Cymru Welsh Water historic flood records at the time of preparing this report indicate nine historic flooding incidents at the north of the site within the Fayre Oaks Park Home Estate that is indicated to be at surface water flood risk. The reported flood incidents all occurred in 2014 and although the source of the events is not recorded they are likely to be attributable to the overland flow route previously discussed. As discussed above, a flood defence ditch and storage area has been constructed to the west of the Fayre Oaks Park Home Estate to assist with managing this issue. Flooding could however occur to new development located within the area deemed to be at surface water flood risk, including risk to proposed access and egress routes that are likely to be located here.

PLANNING RECOMMENDATIONS

SPATIAL PLANNING AND DEVELOPMENT CONTROL

Development of the Thr23 site should be undertaken in accordance with the principles as set out within Section 1 of the Level 2 SFRA and Section 6 of the Level 1 SFRA. It is understood that proposed development within the Thr23 site will comprise residential properties.

The site is located within Flood Zone 1 and the majority of the site is not at significant risk from other sources of flooding. Safe access and egress can be achieved although risks from surface water flooding at the north of the site will need further consideration. The layout of the development must take the existing flood defence ditch and storage area located to the west of the Fayre Oaks Park Home Estate into account, noting that a 4m wide maintenance strip should be provided. Development of the Thr23 site must not increase risk to existing properties located within the Fayre Oaks Park Home Estate or White Cross areas.

All types of development are considered appropriate within Flood Zone 1 and the site allocation therefore passes the Sequential and Exception Tests. A site-specific Flood Risk Assessment (FRA) prepared in accordance with the NPPF and supporting Planning Practice Guidance will be required for any development greater than 1ha in area or that encompasses those areas deemed to be at significant surface water flood risk. The FRA should focus on flood risk associated with an increase in the rate or volume of site-generated surface water runoff and address flood risks associated with the overland flow routes. The FRA should demonstrate analysis of the surface water flood risks previously described; this could be informed by a watershed analysis to better define the surface water catchments and impacts to site development. The site may also offer opportunity for betterment to existing properties in the Fayre Oaks Park Home Estate and White Cross. These aspects are discussed in greater detail below.

MANAGEMENT OF SITE GENERATED SURFACE WATER RUNOFF

The management of surface water runoff will be of key importance for the Thr23 site given the site's sloping topography towards existing urban development and historic risk of flooding in to the north. Drainage systems should be designed in accordance with the Herefordshire SuDS Handbook and Section 6 of the Level 1 SFRA, adhering to the following key principles:

- Applying the SUDS hierarchy to promote the infiltration of runoff to ground prior to the consideration of other measures;
- Controlling the rate and volume of runoff to ensure no increased flood risk for all events between the 1 in 1 (100%) and the 1 in 100 (1%) annual probability rainfall events;

- Promoting best practice vegetated and on-ground conveyance and storage features as much as practicable.

Methods for calculating runoff must be in accordance with the methods promoted within the CIRIA SuDS Manual (C753, published in 2015). It is expected that FEH methods and 2013 rainfall data are used in the calculation of existing and post-development scenarios. The calculation of pre-development runoff rates and volumes should not take the potential effects of climate change into account.

As discussed above the site is underlain by Till superficial deposits with Raglan Mudstone Formation bedrock geology. Review of the Cranfield Soilscapes mapping indicates that the parts of the site that align with the Till superficial deposits are classified as freely draining soils. Infiltration of runoff to ground within the site (and particularly to the north) may therefore be viable and should be promoted in the first instance. Deep soakaway testing completed for a nearby development site indicated gravel at depth which may support infiltration if shallow geology is considered unviable. Onsite testing will be required to determine soil permeability and depth to the groundwater table throughout the site. If onsite testing concludes lower permeability soils and minimal risk associated with a high groundwater table, combined attenuation and infiltration features should be promoted to reduce runoff during small rainfall events and provide treatment.

Contamination risks are likely to be low given the greenfield nature of the site although consideration will need to be given to the cemetery to the north of the site. Consideration must also be given to the SPZ within the north of the site, noting that the Environment Agency may request no infiltration particularly from vehicular areas.

If discharge to ground cannot be achieved for all site runoff, it is possible that runoff from the west of the site can discharge to the Dwr Cymru Welsh Water surface water sewer network serving the existing White Cross residential development to the north. This system is understood to outfall to the Yazor Brook to the north. However, survey information indicates that the existing sewer is shallow in this location and that utility diversions may be required to achieve a connection here. Runoff from the east of the site may be able to discharge to the Dwr Cymru Welsh Water surface water sewer located in Breinton Road. This system is understood to outfall to the River Wye to the south-east. Any discharge to the public sewerage network will need to be agreed with Dwr Cymru Welsh Water.

To the east of the site, the Environment Agency's Detailed River Network dataset indicates that there is an existing small watercourse which starts to the south of Breinton Road and discharges to the River Wye. It may be possible to make a direct connection to this watercourse, although deep excavation may be required as topography rises towards the south before dropping back down towards the watercourse. Crossing of third party land and construction of a new outfall would also be required.

For any offsite discharge (i.e. to public surface water sewers or to the small watercourse to the south) attenuation and treatment of runoff will be important considerations. If possible it is recommended that all runoff is limited to the equivalent greenfield Qbar discharge rate or lower for all return period events, although a minimum discharge of 5l/s is likely to be acceptable given to residual risk to adjacent development and infrastructure should a blockage occur.

It is expected that for a development site of this size best practice 'green' SUDS measures (i.e. vegetated conveyance and storage systems) are incorporated that promote attenuation (and infiltration where appropriate), treatment and biodiversity benefit throughout the development.

MANAGEMENT OF MINOR WATERCOURSES AND OVERLAND FLOW

Consideration must be given to the overland flow routes within the north and east of the Thr23 site, demonstrating that these can be managed or maintained without posing flood risk to the proposed development and without increasing flood risk elsewhere.

With regard to the risk in the north of the site, this could pose significant risk to development in this area as evidenced by the historic flood records to properties immediately east of the area. Consideration will need to be given to safe access and egress. It is recommended that the development explores opportunities to actively manage this risk, for example by allocating sacrificial land suitable for surface water storage. Consideration must also be given to the risk of overland flows overwhelming the capacity of drainage systems, noting that it will not be acceptable to discharge overland flow to the public sewerage network.

As discussed above, the layout of the development must take the existing flood defence ditch and storage area located to the west of the Fayre Oaks Park Home Estate into account, noting that a 4m wide maintenance strip should be provided. Development of the Thr23 site must not increase risk to existing properties located within the Fayre Oaks Park Home Estate or White Cross areas. Hydraulic analysis such as a watershed analysis is also expected to demonstrate the effect of any proposed development on the operation of this ditch or to flood risk elsewhere. Consideration should also be given to residual flood risks associated with blockage of the ditch and storage area.

With regard to the risk in the east of the site, consideration will need to be given to the preferential flow of water through this area and how this can be managed as part of the future development layout. As per above, consideration must also be given to the risk of overland flows overwhelming the capacity of drainage systems.

It is recommended that a site walk-over is completed with the landowner to establish the presence of any known springs. As the site is developed, the presence of any springs will need to be logged.

MANAGEMENT OF FOUL WATER

Foul water from the Thr23 site should be discharged to the Dwr Cymru Welsh Water public sewerage network that serves Hereford. The Applicant should discuss their proposed development with Dwr Cymru Welsh Water to determine if this approach is acceptable and agree the need for any local improvements.

OPPORTUNITIES FOR BETTERMENT

Limiting all site-generated surface water discharge to rates and volumes comparable to the equivalent greenfield Qbar or lower may provide localised benefit. Whilst the benefits are likely to be small, these opportunities should be explored to reduce downstream fluvial flood risk both within sewerage systems and the receiving watercourses.

Appendix F

NORTH HEREFORD – BUR09

NORTH HEREFORD – BUR09

Allocation Reference:	HAP Site Option Bur09
Location:	North Hereford
River Catchment:	Yazor Brook / Ayles brook
NPPF Flood Zone (majority of area):	Flood Zone 1
NPPF Flood Zone (worst case):	Flood Zone 1

INTRODUCTION

The Bur09 identified site option occupies an area of approximately 29ha and is located to the north of Hereford as illustrated in Figure F.1. The site comprises largely agricultural land and a number of isolated residential properties. The site is bound by Roman Road (A4103) to the south, Canon Pyon Road to the west, and agricultural land to the north and east of the site. The centre of Hereford is located approximately 3.1km to the south-east of the site.

Topography within the Bur09 site is gently sloping from the north to the south, with the east of the site gently sloping south-east, and the west of the site gently sloping south-west. Ground levels range from approximately 89mAOD in the north to approximately 80mAOD in the south-west and 70mAOD in the south-east.

The Bur09 site option is identified in the Hereford Area Plan (HAP) as part of the North West Hereford sites. The HAP states that there is the potential capacity for 435 dwellings within the site, and notes potential for 500 dwellings if the landscape and transport issues identified within the HAP are addressed.

At the time of preparing this assessment it is known that the following major development application has been made within the Bur09 site boundary:

- Outline planning application for 3.7ha in the west of the Bur09 site comprising approximately 95 residential dwellings and a public open space (reference P191770/O, approved with conditions).

DESCRIPTION OF FLOOD RISK

FLUVIAL

Review of the Environment Agency's Flood Map for Planning indicates that the Bur09 site is located entirely within the low risk Flood Zone 1 where the annual probability of flooding from fluvial sources is less than 1 in 1000 (0.1%).

The nearest mapped Flood Zone to the site is associated with the Ayles Brook located approximately 360m to the south-east of the site as illustrated in Figure F.2. The watercourse flows in a north to south direction, passing beneath Roman Road in a box culvert and continuing south beneath the Hereford Racecourse in a 450mm diameter pipe (although the exact alignment of the watercourse in unknown). The Ayles Brook is classified as an ordinary watercourse and is therefore under the jurisdiction of Herefordshire Council as Lead Local Flood Authority (LLFA). The Yazor

Brook is located approximately 860m to the south-west of the site and is also classified as an ordinary watercourse. Neither of these watercourses (Ayles Brook or Yazor Brook) pose a significant fluvial flood risk to the Bur09 site, both now or in the future when climate change effects are considered, although both watercourses are known to pose significant fluvial flood risk to the centre of Hereford downstream of the Bur09 site.

SURFACE WATER AND MINOR WATERCOURSES

The Environment Agency's Risk of Flooding from Surface Water map indicates that the Bur09 strategic development site is generally at very low risk of surface water flooding as illustrated in Figure F.3. There are two small overland flow routes indicated on the Environment Agency's Risk of Flooding from Surface Water map that flow in a north to south direction across the site. The most notable of these is the flow route that passes through the west of the site, ponding within the site boundary before flowing across Canon Pyon Road and continuing south-west.

These overland flow routes will need to be considered within the development proposals, noting that the development may offer opportunity for betterment to downstream receptors.

GROUNDWATER

Review of the British Geological Survey (BGS) data indicates that the Bur09 site is underlain by Raglan Mudstone Formation comprising siltstone and mudstone bedrock geology. Superficial deposits to the west comprise Till and deposits to the east comprise hummocky glacial deposits, although review of boreholes records indicates that the bedrock is close to the surface.

Groundwater levels are not likely to be high within the Bur09 site and review of OS mapping indicates no groundwater springs. The Bur09 site is therefore considered to be at low risk of groundwater flooding.

OTHER SOURCES OF FLOOD RISK

The Bur09 site is not located within an area deemed to be risk of flooding on the Environment Agency's Risk of Flooding from Reservoirs map.

Review of OS mapping also indicates a large pond approximately 500m to the north of the site at Lyde Arundel that is at a slightly higher elevation (estimated to be c.95mAOD). The pond does not appear to be raised above adjacent ground level and review of topography indicates that exceedance flows would not pose risk to site Bur09.

The Bur09 site is located on the northern edge of the urban area of Hereford with existing urban development located at a lower elevation. The site is therefore not likely to be at significant risk of flooding from adjacent sewerage or drainage systems.

HISTORIC FLOOD RECORDS

Review of Herefordshire Council and Dwr Cymru Welsh Water historic flood records at the time of preparing this report indicate four historic flooding records along Roman Road adjacent to the Bur09 site. The dates or source of the events are not recorded but are considered likely to be attributable to the identified overland flow route discussed above.

PLANNING RECOMMENDATIONS

SPATIAL PLANNING AND DEVELOPMENT CONTROL

Development of the Bur09 site should be undertaken in accordance with the principles set out within Section 1 of the Level 2 SFRA and Section 6 of the Level 1 SFRA. It is understood that proposed development within the Bur09 site will comprise residential dwellings (more vulnerable).

The site is located within Flood Zone 1 and the majority of the site is not at significant risk from other sources of flooding. Safe access and egress can be achieved. All types of development are considered appropriate within Flood Zone 1 and the site allocation therefore passes the Sequential and Exception Tests.

A site-specific Flood Risk Assessment (FRA) prepared in accordance with the NPPF and supporting Planning Practice Guidance will be required for any development greater than 1ha. The FRA should focus on flood risk associated with an increase in the rate or volume of site-generated surface water runoff and address flood risks associated with the overland flow route in the west of the site. The site may also offer opportunity for betterment to existing properties along Roman Road. These aspects are discussed in greater detail below.

MANAGEMENT OF SITE GENERATED SURFACE WATER RUNOFF

The management of surface water runoff will be of key importance for the Bur09 site given the site's elevated position above existing urban development and the historic flood records along Roman Road. An increase in discharge could also increase downstream flood risk associated with the Yazor and Ayles Brooks. Drainage systems should be designed in accordance with the Herefordshire SuDS Handbook and Section 6 of the Level 1 SFRA, adhering to the following key principles:

- Applying the SUDS hierarchy to promote the infiltration of runoff to ground prior to the consideration of other measures;
- Controlling the rate and volume of runoff to ensure no increased flood risk for all events between the 1 in 1 (100%) and the 1 in 100 (1%) annual probability rainfall events;
- Promoting best practice vegetated and on-ground conveyance and storage features as much as practicable.

Methods for calculating runoff must be in accordance with the methods promoted within the CIRIA SuDS Manual (C753, published in 2015). It is expected that FEH methods and 2013 rainfall data are used in the calculation of existing and post-development scenarios. The calculation of pre-development runoff rates and volumes should not take the potential effects of climate change into account.

The permeability of the underlying bedrock and superficial deposits is likely to be low and offer limited opportunity for infiltration. Infiltration testing undertaken to the support the outline planning application submitted for land in the west of the Bur09 site indicated limited infiltration potential. Onsite testing for the remainder of the site will be required to determine soil permeability and depth to the groundwater table. If onsite testing concludes lower permeability soils and minimal risk associated with a high groundwater table, combined attenuation and infiltration features should be promoted to reduce runoff during small rainfall events and provide treatment.

If discharge to ground cannot be achieved all or part of site Bur09, discharge to the Ayles Brook at an attenuated rate should be promoted in the first instance for the natural catchment that drains to the Ayles Brook. It is recommended that discharge is limited to the equivalent Qbar or lower

greenfield runoff rate for all return period events up to the 1 in 100 year event and allowing for climate change effects to prevent increased flood risk downstream associated with the Ayles Brook and strive to provide betterment.

The proposed drainage strategy submitted to support the outline planning application for the west of site Bur09 proposes attenuated discharge to an existing Dwr Cymru Welsh Water surface water sewer located to the south of Roman Road. It is understood that this network discharges to the Yazor Brook approximately 1km south of the Bur09 site. Attenuation of discharge will therefore be important to prevent increased flood risk attributable to the sewerage network and Yazor Brook. It is recommended that development strives to attenuate runoff to the equivalent Qbar or lower greenfield runoff rate as much as practicable, although it is recognised that a minimum discharge of 5l/s may be required to prevent unacceptable risk of blockage to adjacent development.

Consideration must be given to the overland flow routes indicated by the Environment Agency's Risk of Flooding from Surface Water map, ensuring that the capacity of the drainage systems are not exceeded by overland flow, and ensuring that overland flow is not discharged into the public sewerage network. This matter will need to be discussed and agreed with Dwr Cymru Welsh Water before planning approval is granted.

It is expected that for a development site of this size best practice 'green' SUDS measures (i.e. vegetated conveyance and storage systems) are incorporated that promote attenuation (and infiltration where appropriate), treatment and biodiversity benefit throughout the development.

MANAGEMENT OF MINOR WATERCOURSES AND OVERLAND FLOW

Consideration must be given to the overland flow routes within the west and east of the Bur09 site, demonstrating that these can be managed or maintained without posing flood risk to the proposed development and without increasing flood risk elsewhere.

With regard to the risk in the west of the site, this could pose significant risk to new development and, potentially, elsewhere as evidenced by the historic flood records to Roman Road. It is recommended that the development explores opportunities to actively manage this risk, for example by defining an appropriate overland flow route through the site and allocating sacrificial land suitable for surface water storage. Property thresholds should also be raised close to this flow route and consideration given to safe access and egress at the entrance to the west of site Bur09. As discussed above, overland flow must not reduce the capacity of proposed drainage systems or be discharged to the public sewerage network.

The development may offer opportunity to reduce flood risk to Roman Road and it is recommended that this is actively considered as part of the design.

MANAGEMENT OF FOUL WATER

Foul water from the Bur09 strategic development site should be discharged to the public sewerage network to the south of the site that serves the city of Hereford. The Applicant should discuss their proposed development with Dwr Cymru Welsh Water to determine if this approach is acceptable and agree the need for any local improvements.

OPPORTUNITIES FOR BETTERMENT

The management of the mapped overland flow route that passes through the west of site Bur09 offers opportunity to reduce downstream flood risk that may be attributable to this flow route

although care must be taken to ensure that the overland flow (land drainage) is not discharged to the public sewerage network.

Limiting all site-generated surface water discharge to rates and volumes comparable to the equivalent greenfield Qbar or lower as far as practicable may also provide localised benefit. Whilst the benefits are likely to be small, these opportunities should be explored to reduce downstream flood risk both within sewerage systems and the receiving watercourses.

Appendix G

CENTRAL NORTH - THR34

CENTRAL NORTH – THR34

Allocation Reference:	HAP Site Option Thr34
Location:	Central North Hereford
River Catchment:	Widemarsh Brook
NPPF Flood Zone (majority of area):	Flood Zone 2
NPPF Flood Zone (worst case):	Flood Zone 2

INTRODUCTION

The Thr34 identified site option occupies an area of approximately 1.7ha and is located in the Widemarsh area of Hereford, just to the south of the Hereford Racecourse as illustrated in Figure G.1. The site is bordered by Grandstand Road to the east, a car park and Faraday Road to the west, and existing urban development to the north and south. The site is currently a derelict brownfield site. Topography of the site is flat at a level of approximately 56mAOD.

The nearest watercourses are the Widemarsh Brook located approximately 200m to the south of the site and the Ayles Brook located approximately 270m to the north and east of the site. The Widemarsh Brook bifurcates from the Yazor Brook approximately 1km upstream of site Thr34 and flows largely within an engineered channel and culverts to the north of the city centre, turning into the Eign Brook downstream of Commercial Road. The Ayles Brook is largely in culvert as it flows beneath the Hereford Racecourse to the north to its confluence with the Widemarsh Brook at Widemarsh Street. Both watercourses are classified as ordinary watercourses and are therefore under the jurisdiction of Herefordshire Council as Lead Local Flood Authority (LLFA).

The Thr34 site option is identified in the Hereford Area Plan (HAP) as part of the North West Hereford sites. The HAP states that there is the potential capacity for 100 dwellings within the site, although suggests that the site may be more suited to employment or mixed use development given the urban setting and adjacent land uses.

DESCRIPTION OF FLOOD RISK

FLUVIAL

The Thr34 site is located within the medium risk Flood Zone 2 where the annual probability of flooding from fluvial sources is between 1 in 100 (1%) and 1 in 1000 (0.1%). The mapped fluvial flood extents are shown in Figure G.2, noting that this map ‘stitches’ together detailed hydraulic modelling of the Widemarsh Brook with the Yazor Brook Flood Alleviation Scheme (FAS) not in operation and broadscale modelling of the Ayles Brook (discussed further below).

The assessment of fluvial flood risk attributable to the Widemarsh Brook has been informed by the 1D-2D FMP-Tuflow hydraulic model of the Yazor Brook and its downstream bifurcations that was updated to support the Hereford ICS as discussed in Section 1.2 of the Hereford City Level 2 SFRA. This modelling indicates that the Thr34 site is not at risk of fluvial flooding from the Widemarsh Brook even when the operation of the Yazor Brook FAS is not taken into consideration.

The source of the mapped fluvial flood risk is therefore deemed to be associated with the Ayles Brook. The detailed hydraulic model of the Widemarsh Brook (discussed above) incorporates inflows received from the Ayles Brook at Widemarsh Street but does not include detailed modelling of the Ayles Brook. The mapped flood extents attributable to the Ayles Brook are therefore based only on broadscale JFLOW modelling that has informed the Environment Agency's Flood Map for Panning. The mapped flood extents are therefore highly indicative and may be overestimated if the JFLOW modelling does not appropriately represent the existing culverts. However, it is likely that flooding from the Ayles Brook could occur when the capacity of the watercourse's culverts are exceeded (or blocked) and flooding enters the Thr34 site as overland flow.

Consideration has been given to the potential effects of climate change as illustrated in Figure G.4 (without FAS operation) and Figure G.5 (with FAS operation). Review of the detailed undefended hydraulic model of the Widemarsh Brook indicates that the Thr34 site would still not be at risk of flooding from the Widemarsh Brook during the 1 in 100 (1%) annual probability event with a 35% and 70% increase in peak river flow. As no modelling of the Ayles Brook is available, a qualitative approach has been applied that assumes the future 1 in 100 (1%) annual probability event with 70% climate change allowance would be similar to the current Flood Zone 2 – i.e. the current 1 in 1000 (0.1%) annual probability event. Review of estimated hydrology of the Ayles Brook indicates that the flows for the 1 in 1000 (0.1%) annual probability event are approximately 70% greater than the flows for the 1 in 100 (1%) annual probability event, thereby supporting this generalised approach. The site may therefore be at risk of flooding during the 1 in 100 (1%) annual probability event with 70% climate change allowance, although as discussed above the mapped flood extents may be overestimated if the JFLOW modelling does not appropriately represent the existing culverts.

Flood hazard mapping has not been prepared as there is no detailed modelling of the Ayles Brook, however an indicative flood hazard has been estimated from the Environment Agency's Flood Risk from Surface Water mapping. This suggests flood depths of up to 900mm during the low risk 1 in 1000 (0.1%) annual probability event and flood flow velocities of (generally) less than 0.25m/s, with an indication that water will pond within the site rather than flow through the site. The indicative flood hazard (taking into account a debris factor) is therefore likely to be Moderate (Danger for Some) to High (Danger for Most).

SURFACE WATER AND MINOR WATERCOURSES

Review of the Environment Agency's Risk of Flooding from Surface Water mapping indicates extensive but low risk of surface water flooding within the Thr34 allocate site in areas similar to those indicated to be at fluvial flood risk. Mapped surface water flood extents are reproduced in Figure G.6. It is considered likely that a large amount of the mapped surface water flood risk is attributable to the Ayles Brook as discussed in the fluvial flood risk section above.

GROUNDWATER

Review of the British Geological Survey (BGS) data indicates that the Thr34 site is underlain by Raglan Mudstone Formation comprising siltstone and mudstone bedrock geology, overlain by sand and gravel superficial deposits. An Environment Agency groundwater monitoring borehole is located in the playing fields at the Hereford Lads Club approximately 170m south-east of the site. Recent monitoring completed in January 2019 indicates a groundwater level at approximately 52.9m AOD to 52.6mAOD, approximately 2.5m below ground level, although historic records indicate that groundwater levels have risen sharply with the hydrograph showing a 'peaky' response to winter

rainfall and groundwater levels rising to approximately 0.5 m below ground level during winter periods.

Review of historic borehole logs available through the BGS also indicate that groundwater was struck approximately 3m below ground level approximately 100-150m to the west and south of the site, with borehole logs to the south of the site indicating that water levels rose to approximately 1.3m below ground level.

Groundwater emergence is considered unlikely to occur although could pose risk to below ground drainage systems and structures. It is recommended that monitoring data is requested from the Environment Agency to inform the development of the Thr34 site and its associated drainage systems.

OTHER SOURCES OF FLOOD RISK

Review of the Environment Agency's Flood Risk from Reservoirs mapping indicates that the Thr34 site is not located within an area deemed to be risk of flooding from reservoirs. Review of OS mapping also indicates no reservoirs or other large storage features at a higher elevation to the site that would pose flood risk in the event of failure.

Review of the Dwr Cymru Welsh Water One Year and 50 Year Headroom datasets indicates high and medium risk of flooding from combined and surface water sewers located to the south and east of the racecourse that may flow towards site Thr34 if their capacity is exceeded.

HISTORIC FLOOD RECORDS

Review of Herefordshire Council and Dwr Cymru Welsh Water flood records indicate no historic flooding events within or adjacent to the Thr34 site, however a number of historic flooding events have been recorded to south of the Hereford Racecourse (north of site Thr34) and to the east of Edgar Street (south-east of site Thr34). The events are likely to be attributable to the Ayles Brook, Widemarsh Brook and overland surface water flows.

PLANNING RECOMMENDATIONS

SPATIAL PLANNING AND DEVELOPMENT CONTROL

Development of the Thr34 site should be undertaken in accordance with the principles as set out within Section 1 of the Level 2 SFRA and Section 6 of the Level 1 SFRA. It is understood that proposed development within the Thr34 site will comprise a mix of residential (more vulnerable) and employment uses (less vulnerable).

Much of the site is indicated to be located in the medium risk Flood Zone 2 attributable to the Ayles Brook. Fluvial flood risk could increase when the potential effects of climate change are considered and, based on current data, the site is likely to be at risk during the 1 in 100 (1%) annual probability event with 70% allowance. Safe access and egress can be achieved although this would need further consideration as part of the site's development.

In accordance with the NPPF, less vulnerable development is considered acceptable in Flood Zones 2 and 3a following successful application of the Sequential Test. More vulnerable development is considered acceptable in Flood Zone 2 following successful application of the Sequential Test, but would usually only be acceptable within Flood Zone 3a following the successful application of the Exception Test that requires:

- Demonstration that the development provides wider sustainability benefits to the community that outweigh flood risk; and
- Demonstration that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Given the brownfield nature of the Thr34 allocation site and its urban location close to the centre of Hereford, it is recommended that the Thr34 site allocation passes the requirements of the Sequential Test for a mixed use development comprising more vulnerable and less vulnerable development classifications. However, it is unlikely that the site would be considered acceptable for more vulnerable residential development and pass the Exception Test unless detailed modelling demonstrates that the site is not at risk during the 1 in 100 (1%) annual probability event taking the potential effects of climate change into account for the 35% and 70% climate change allowances. If a mixed use development is sought, it is expected that a sequential approach will be taken to direct more vulnerable development to the lowest risk areas of the site, ideally located entirely in Flood Zone 1.

It is also recommended that the Thr34 site is only considered suitable for highly vulnerable development if detailed modelling demonstrates that the site is not at risk of flooding during the 1 in 100 (1%) annual probability event plus 35% and 70% climate change allowances or the 1 in 1000 (0.1%) annual probability event.

A site-specific Flood Risk Assessment (FRA) will be required to support development of the Thr34 site. The FRA should address flood risks associated with the Ayles Brook, as well as demonstrate appropriate management of site-generated surface water runoff and protection from surface water or sewerage overland flows. Hydraulic analysis is expected to support the site-specific FRA. Consideration should also be given to risks associated with high groundwater levels. These aspects are discussed in greater detail below.

MANAGEMENT OF FLUVIAL FLOOD RISKS

Further assessment will be required as part of the site-specific FRA to better determine the likely risk of flooding to the Thr34 site. In accordance with the recommendations set out in Section 6.5 of the Level 1 SFRA, this should be informed by detailed hydraulic modelling of the Ayles Brook to determine flood extents and hazard for a range of return period events and allowing for climate change effects.

Finished floor levels of any new buildings should be raised a minimum of 600mm above the 1 in 100 (1%) annual probability event plus 35% climate change allowance and with no internal flooding of buildings during the residual risk flooding events, recommended to be the larger of the 1 in 100 (1%) annual probability event plus 70% climate change allowance or the 1 in 1000 (0.1%) annual probability event. If this is not achievable, a lower freeboard may be acceptable for less vulnerable development although no internal flooding should occur during the 1 in 100 (1%) annual probability event plus 35% climate change allowance. Greater certainty of flood risk is also likely to be required than that promoted by the 'intermediate' approach discussed above.

The main roads serving this site (namely Grandstand Road, Holmer Road and Edgar Street) are indicated to be at risk of flooding, although as discussed above the flood risks from the Ayles Brook are highly indicative. Safe access during all events looks to be viable from Faraday Road to the

west of the site, although it is recommended that the provision of safe access and egress during a flood event is clarified in the site-specific FRA.

The development must not increase flood risk elsewhere. Given the urban setting of this site it is recommended that there should be no increase in flood risk up to the 1 in 100 (1%) annual probability event with 70% climate change allowance or the 1 in 1000 (0.1%) annual probability event.

If any development is required to be located in areas at risk during the 1 in 100 (1%) annual probability event plus 35% climate change allowance; 1 in 1000 (0.1%) annual probability event; or residual risk events discussed above, compensatory flood storage should be provided on a like-for-like basis, and ideally strive to provide betterment.

MANAGEMENT OF MINOR WATERCOURSES AND OVERLAND FLOW

As discussed above, the Thr34 site is likely to be at risk of flooding from surface water overland flow and, potentially, surrounding sewerage systems. However, much if this risk is likely to be attributable to fluvial flooding from the Ayles Brook and therefore the measures recommended above will assist with mitigating this risk. The management of other sources of overland flow is recommended to comprise raising of building threshold levels and consideration of flow routes through the site, ensuring that overland flows are not deflected into third parties.

Overland flows must also be considered in the design of the development's proposed drainage system to ensure overland flows do not discharge to the drainage system and reduce system capacity.

MANAGEMENT OF SITE GENERATED SURFACE WATER RUNOFF

Review of BGS data indicates that the Thr34 site is underlain by sand and gravel deposits that are likely to support infiltration of runoff to ground. Review of Cranfield Soilscapes mapping also describes the soils in this area as freely draining. However, review of historic borehole records indicate that groundwater levels may be too shallow to support infiltration and legacy contamination risks may also pose a constraint. Infiltration testing should be undertaken to support the planning application for the site (along with an assessment of groundwater levels and contamination risks) although it is considered likely that an alternative drainage strategy may be required.

Direct discharge of runoff from site Thr34 to the Widemarsh Brook located to the south of the site is unlikely to be viable as this would require crossing third party land. An existing Dwr Cymru Welsh Water surface water sewer is located immediately to the east of the site that discharges to the Widemarsh Brook approximately 300m downstream. Discharge to this sewer may therefore be viable following consultation with Dwr Cymru Welsh Water. It is recommended that a maximum discharge rate of 5 l/s is applied to assist with managing flood risk elsewhere whilst not introducing unacceptable risk in the event of blockage. Treatment of runoff prior to discharge is expected.

MANAGEMENT OF POTENTIALLY HIGH GROUNDWATER LEVELS

The risk of high groundwater levels must be considered in the drainage design, most notably the risk that this could reduce the effectiveness of infiltration systems or reduce the capacity of unlined attenuation/infiltration systems. It is recommended that groundwater monitoring data is requested from the Environment Agency to inform the development of the Thr34 site and its associated

drainage systems. Winter groundwater monitoring may also be required to better understand and mitigate these risks.

MANAGEMENT OF FOUL WATER

Existing Dwr Cymru Welsh Water foul water and combined sewers are located to the east and west of site Thr34 therefore discharge to this network should be agreed in consultation with Dwr Cymru Welsh Water.

OPPORTUNITIES FOR BETTERMENT

The site offers little opportunity for betterment elsewhere, however attenuating surface water discharge to a maximum discharge rate of 5 l/s may assist with reducing local flood risk.

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