FINAL

Cherwell Level 2 Strategic Flood Risk Assessment Addendum

Cherwell District Council

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1. Introduction

1.1 Planning Context

Cherwell District Council adopted the Cherwell Local Plan 2011-2031 (Part 1) in July 2015. The Council is now undertaking a Partial Review of the adopted Local Plan to help meet Oxford's unmet housing needs. Local Plan proposals have to undergo a Sustainability Appraisal (SA), which assists LPAs in ensuring their policies fulfil the principles of sustainability.

In May 2017, AECOM Infrastructure & Environment UK Ltd (AECOM) provided Cherwell District Council (CDC) with a Level 2 Strategic Flood Risk Assessment (SFRA) that was used by the Council to inform their choice of site allocations in the Proposed Submission Partial Review Plan July 2017.

The Cherwell Local Plan 2011 – 2031 (Part 1) Partial Review – Oxford's Unmet Housing Proposed Submission Plan includes three potential allocation sites which the Environment Agency has identified could potentially be impacted by fluvial flooding in the future. However, there is currently a limited understanding on how the flood risk within these specified areas will change over the lifetime of the proposed developments as a result of climate change.

The Environment Agency has therefore requested a more robust assessment of fluvial flood risk at the sites to provide confidence that the proposed land uses at the sites are likely to be deliverable, in respect to climate change. The aim of this addendum, therefore, is to provide a clarification of the fluvial flood risk posed to the three potential allocation sites, resulting from potential climate change.

1.2 Aim of this Level 2 SFRA Addendum

AECOM were commissioned in February 2018 to complete a further detailed assessment of the fluvial flood risks at the three potential allocation sites as part of an Addendum to the Level 2 SFRA. This Addendum will provide additional information to support the evidence base that will be used to inform the Examination of the Partial Review of the Cherwell Local Plan (2011-2031) Part 1: Oxford's Unmet Housing Need.

1.3 Study Area

Since completion of the original Cherwell Level 2 Strategic Flood Risk Assessment (SFRA) (May 2017), the Environment Agency has requested a more robust assessment of fluvial flood risks at the following three sites listed in Table 1-1.

Table 1-1: Level 2 SFRA Addendum Study Area – Potential Strategic Development Sites

SFRA Site ID Number	Settlement	Site Name	Area (Ha)	Table Number
PR6C	Kidlington	Land at Frieze Farm	29.9	Table 2-1
PR7A	Gosford	Land South East of Kidlington	32.2	Table 3-1
PR8	Begbroke	Land East of the A44	189.6	Table 4-1

CDC provided redline boundaries for each site in GIS format (Figure 1-1) which have been used to inform this assessment.

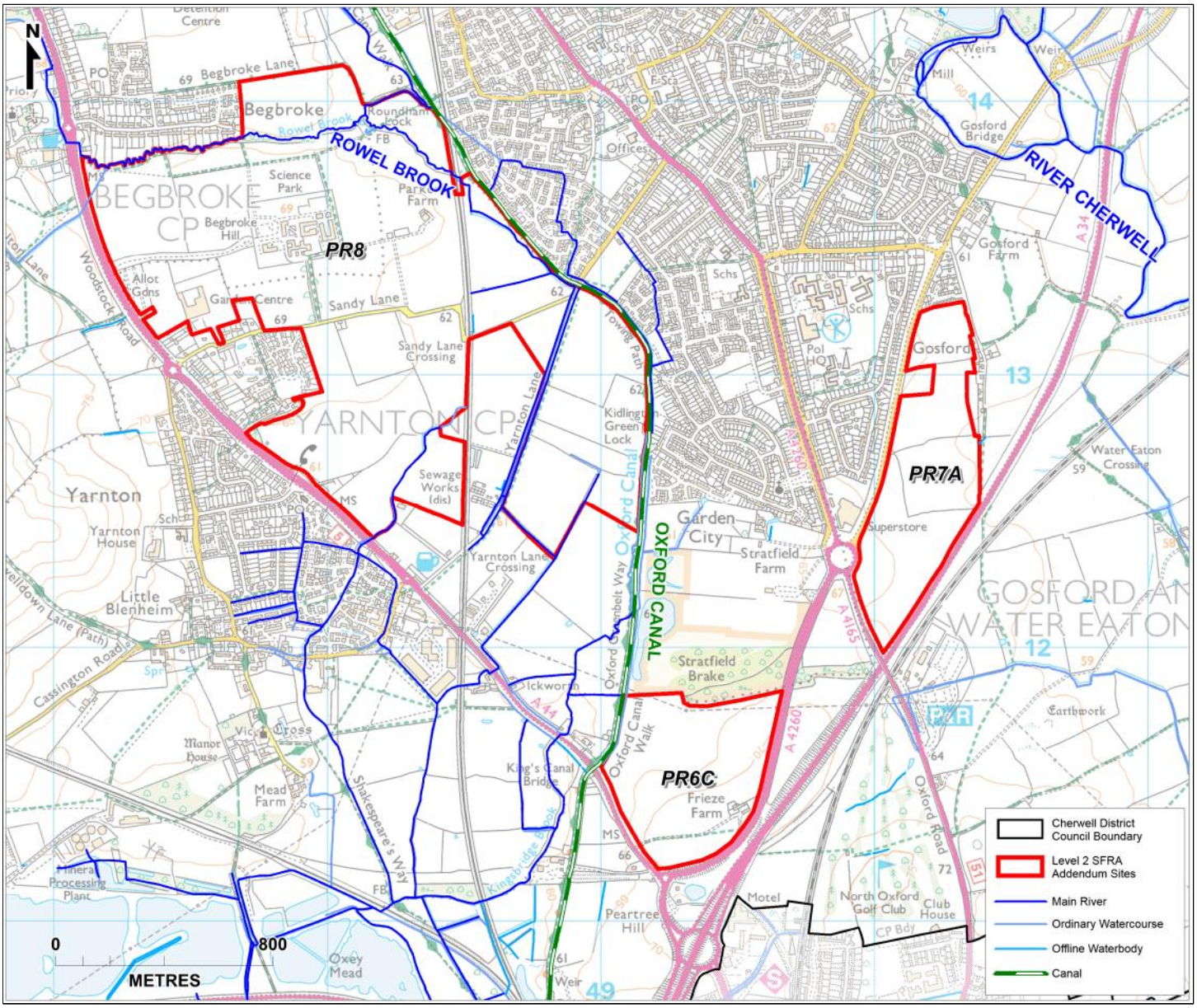

Figure 1-1: Location Plan of the Level 2 SFRA Addendum Sites– South of Kidlington

1.3.1 Hydrological Context

There are three key watercourses surrounding this area (Figure 1-1) which pose a fluvial flood risk to the proposed allocation sites. These include:

– **Rowel Brook;** flows eastwards then southwards alongside the Oxford Canal, along the northern and eastern borders of site PR8;

– **the Oxford Canal;** a 126 km long narrow canal which links Oxford with Bedworth. Within this study area the canal flows southwards along the northern and eastern boundaries of site PR8, and alongside the western boundary of site PR6C towards the centre of Oxford; and

– **the River Cherwell;** located in the north east of the study area, approximately 500 m north east, at its closest point to site PR7A.

1.4 Methodology

Level 2 assessments have been undertaken within Section 2 to Section 4 of this report for the sites listed in Table 1-1. The northern part of site PR7a, and site PR8 were the subject of Level 2 assessments in the Level 2 SFRA May 2017, (sites ID202 and ID20 respectively). These Level 2 assessments follow the same methodology and approach as detailed in Section 2 of the Level 2 SFRA (May 2017)[1] but examine ground levels in relation to modelled flood levels and, in the case of PR8, examine flow estimates in more detail, to further assess the likely impact of climate change.

In order to clearly communicate to developers what the requirements are for demonstrating the necessary evidence to pass the Exception Test in respect of climate change, this Level 2 SFRA Addendum aims to provide an update to the recommendations regarding future policies, best practice and master planning for development areas located in areas of flood risk.

1.4.1 Review of Flood Risk from All Sources

This method enables determination of the flood risk issues relative to the following sources of flooding and with regard to the vulnerability classification of the proposed land uses at the sites:

Rivers (Fluvial)

Land (Pluvial surface water and overland flow)

Groundwater

Sewers

Other artificial sources (Canals and Reservoirs)

A review was undertaken of the flood defence infrastructure (if any) and residual risks of flooding. Recommendations for strategic policies to be applied at the sites and requirements for site-specific Flood Fisk Assessments (FRAs) have also been updated.

1.4.2 Further Consideration of Climate Change

Guidance for the new climate change allowances is provided on the Environment Agency's website[2]. The anticipated changes in peak river flows and peak rainfall intensities for the Thames River Basin District (within which Cherwell is located) over three different timeframes (epochs) and for three different emissions scenarios are replicated in Table 2-2 and Table 2-3 of the Level 2 SFRA (May 2017) respectively.

Residential development is classified in Table 2 of the NPPF PPG as 'More Vulnerable' and therefore the risk posed by the 'Higher Central' allowance of the 2070 to 2115 time epoch (+35% in river flow) should be reviewed in relation to sites PR7A and PR8. The proposed golf course at PR6C is classified as 'Water Compatible' in Table 2 of the NPPF PPG, and therefore the 'Central' allowance (+25% in river flow) should be reviewed over this same time period epoch.

It is therefore possible that these new climate change predictions may infer an increase in the risk of fluvial flooding in certain areas of the sites further than the current modelled flood outlines have accounted for.

[1] AECOM (May 2017) Cherwell Level 2 SFRA. Available at: https://www.cherwell.gov.uk/downloads/download/367/cherwell-level-2-strategic-flood-risk-assessment-may-2017

[2] Environment Agency (February 2016) Flood risk assessments: climate change allowances. Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Modelled Flood Water Level Data (Received 2018)

Results from existing Environment Agency hydraulic models were requested and received from the Environment Agency for the watercourses within the vicinity of the proposed sites, (i.e. the River Cherwell, the Oxford Canal and Rowel Brook). These results included peak levels for a >=1% annual probability (AP) (1 in 100 year) event including a +20% allowance for climate change (+20% CC), and >=0.1% AP (1 in 1000 year) event events during the existing baseline scenario for the noted watercourses.

Hydrological Assessment

As the Environment Agency currently has only a broadscale JFLOW model for Rowel Brook alongside sites PR8 and PR6C, a new high level hydrological analysis was undertaken to assess if the flow estimate for the >=1% AP event plus a 35% allowance for climate change (+35% CC) is likely to be lower than that derived for the >=0.1% AP event.

The Environment Agency agreed that should this be demonstrated, this pragmatic approach would give greater confidence that the potential Flood Zone 3 (>=1% AP) +35% CC flood extent would not likely be larger than the extent of Flood Zone 2 that is currently adopted in the Level 2 SFRA as a proxy for this in the absence of more detailed modelling outputs. The Environment Agency could then have confidence that the number of houses proposed for development would likely be accommodated on proposed site PR8, and that the layout of any raised earthworks undertaken to construct the replacement golf course on proposed site PR6C was suitable.

This hydrological assessment involved applying the industry standard practice of ReFH2 and FEH Statistical methods and comparing the flood growth curve factors and flood frequency curve fittings (see a summary of the methodology adopted and results provided in Appendix A).

Peak Flood Level and Ground Level Comparison

The Environment Agency's modelled peak water levels were compared to the existing relative ground levels (meters above ordnance datum (mAOD)) within the three proposed allocation sites and across the wider local floodplain provided within detailed LiDAR digital terrain model (DTM) data[3].

As modelled flood extents and levels are not yet available for the >=1% AP +35% CC event, a high level assessment was then made of the relative impact of the potential further increases in flood water levels at the three sites. Consideration, based upon engineering judgement, was given to the potential extent this additional flow may inundate, relative to the modelled Flood Zone 2 outline (>=0.1% AP event).

The results of this analysis are summarised in the 'Sources of Flood Risk – River' rows in the Site Summary Tables in Sections 2, 3 and 4.

1.4.3 Flood Risk Mapping

Using the same GIS layers that were provided for the Level 2 SFRA, site overview maps as detailed in Appendix B were produced for this Level 2 SFRA Addendum to visually assist CDC in their consideration of flood risk at the proposed allocation sites to inform their decision making process.

[3] Environment Agency. 2018. **Light Detection and Ranging** (LiDAR) Composite DTM 1m. Available at: http://environment.data.gov.uk/ds/survey/#/survey

2. Assessment of Strategic Site on Land at Frieze Farm – PR6c

This Section details the Level 2 assessments for the potential strategic development site to the south of Kidlington. Flood risk mapping referred to in the tables is provided in Appendix B.

Table 2-1: Land at Frieze Farm (PR6c)

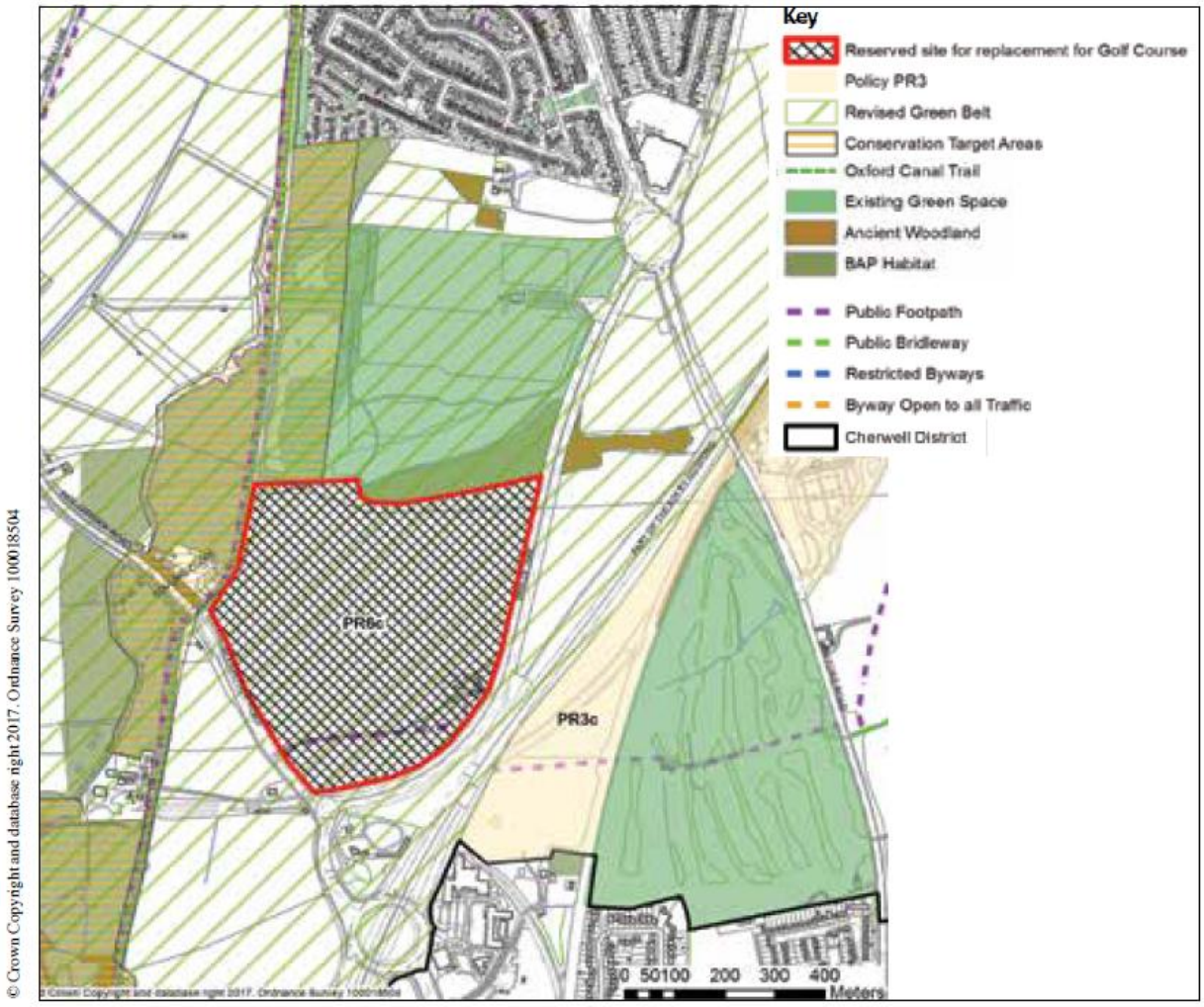

Figure Extracted from CDC Proposed Submission Plan - Summary Booklet (July 2017 – Updated)

Site Information	
Site Area	29.9 Ha
Existing Use and Topography	The Frieze Farm site lies approximately 500 m south of Kidlington, approximately 6 km north of the centre of Oxford. The A44 and the A4260 form the western and eastern/southern boundaries of the site respectively. The site is predominantly greenfield agricultural land with the exception of the Chronos Therapeutics development and associated road in the south of the site. The site is surrounded to the north and west by further greenfield agricultural land, with the North Oxford Golf Club located in the east. The Oxford Canal flows south alongside the western boundary of the site. The site topography generally slopes down from a maximum of approximately 70 mAOD in the south east to a minimum of 60 mAOD in the north west.
Proposed Use and Vulnerability Classification	Recreational (replacement Golf Course) classified by the NPPF PPG as 'Water-Compatible' development.

Sources of Flood Risk	
Rivers Fluvial)	The Oxford Canal flows southwards along part of the western boundary of the site and is similar in elevation to much of the land immediately adjacent within the site. A small proportion of land in the west of the site, adjacent to the Oxford Canal, is designated as being located in Flood Zone 3 (>=1% AP, 1 in 100 year, high risk) and Flood Zone 2 (>=0.1% AP, 1 in 1000 year, medium risk) (see Appendix B, Figure B.1). However, the vast majority of the site is situated within Flood Zone 1 (<0.1% AP, low risk). Rowel Brook (Main River) flows in a southerly direction further to the west of the canal, with other Main River tributaries of Kingsbridge Brook in close proximity. ***Comparison of Modelled Peak Flood Levels to Ground Levels in respect of Climate Change*** The hydrological assessment (see Appendix A) determined that the >=1% AP +35% CC peak flow is unlikely to be larger than the >=0.1% AP peak flow. The Environment Agency's JFLOW model for Rowel Brook and the Oxford Canal predicted peak water levels adjacent to the site for the >=1% AP +20% CC event as 59.53 mAOD and 59.57 mAOD respectively, however, no flood outline is currently available in this area for this event. Predicted peak water levels for the >=0.1% AP event are both 59.68 mAOD for Rowel Brook and the Oxford Canal. A review was made of these peak water levels in comparison to the ground levels within the site and local vicinity (see Appendix C, Figure C.1) and it was considered that the >=1% AP +35% CC peak flows would not likely inundate a greater degree of the site than illustrated by Flood Zone 2 locally along both Rowel Brook and the Oxford Canal respectively. Any potential small increase in water level is unlikely to result in vastly more extensive fluvial flooding of this site due to the steep rise in topography from 59 mAOD in the north west up to 70 mAOD in the south east of the site. The proportionally small area of relatively low lying land (≈59-60 mAOD) located in the north west of the site and a small band of land running along the western border of the site are considered to be at risk of fluvial flooding. Any additional flood water would instead proceed westwards following lower ground levels downstream of the site and west of the canal within the wider Rowel Brook/Kingsbridge Brook/Thames floodplain. The Environment Agency's Historical Flood Map (see Appendix B, Figure B.5) illustrates that the majority of the land south west of the site (that which surrounds the complex network of channels) has experienced fluvial flooding in the recent past. The Environment Agency's Flood Map does not however, detail any historical flood incidents east of the Oxford Canal, within approximately 1 km of the site.
Land (Pluvial)	The Environment Agency's updated Flood Map for Surface Water (uFMfSW) (see Appendix B, Figure B.4) illustrates that the majority of the land throughout the site is at a very low risk (<0.1% AP, 1 in 1000 year event) of surface water flooding. There is a high risk (>=3.33% AP, 1 in 30 year event) of surface water flooding along the western boundary of the site (i.e. the land adjacent to the Oxford Canal), encroaching approximately 50 m into the site. There is a low risk (>=0.1% AP, 1 in 1000 year event) surface water flow pathway which flows from the centre of the site towards this area of high risk of surface water ponding. In the south of the site, south of the Chronos Therapeutics development lies a narrow area which is shown to be at low, medium and high risk of surface water ponding alongside the A4260.
Groundwater	The Environment Agency's Areas Susceptible to Groundwater Flooding (AStGWF) map (see Appendix B, Figure B.2) illustrates that this site has a very low vulnerability to groundwater flooding (i.e. it is located within a 1 km grid square where <25% of the area is defined as having a susceptibility to groundwater emergence).
Sewers (Pluvial)	The Frieze Farm site is spread over two post code areas. The Thames Water (TW) DG5 register identifies 20-25 recorded incidents of foul sewer flooding within the post code area (OX5) and 0-5 within the adjacent post code area (OX2), covering the site between 2006 and 2016 (see Appendix B, Figure B.3).
Artificial Sources	The Oxford Canal runs alongside the boundary of the site and is elevated at similar ground levels to the site. In recent history the sole reported flooding incident occurred in January 2003, along the eastern and southernmost part of the site due to the capacity of the canal being exceeded and overtopping. The 'Risk of Flooding from Reservoirs' map on the Environment Agency's website illustrates that this site is not within the maximum modelled flood extent of a reservoir breach, and is therefore considered not at risk from reservoir flooding.

Flood Defence Infrastructure
There are no formal flood defences alongside the site.

Residual Flood Risk

The Oxford Canal potentially poses a residual risk of flooding to the site by overtopping.

Recommendations and SFRA Policies

The latest Environment Agency climate change allowances have not yet been taken into account in the current Flood Zone extents of the watercourses adjacent to the site. The SFRA policy for this site therefore follows a precautionary approach until more information is presented. No land raising or built development is permitted inside the combined modelled Flood Zone 2 (applied as a proxy for Flood Zone 3 +CC) and Flood Zone 3 envelope in the north west corner of the site. This supports the Environment Agency's current aspirations for the site. These Flood Zones however, should be refined/determined by more detailed hydraulic modelling undertaken as part of a site-specific FRA.

The proposed golf course is classified by the NPPF PPG as a 'water-compatible' development, and retaining this open space/recreation area will maintain a 'blue corridor' alongside the Oxford Canal and Rowel Brook that will prevent a net loss of floodplain storage, will not impede water flows and will not increase flood risk elsewhere. It should be designed to remain operational and safe for users in times of flood. It is therefore advised that any property construction associated with the golf course be constructed away from the north western region of the site.

As the area is primarily greenfield, any development within the area will increase surface water runoff (unless attenuated). A surface water management framework should be adopted as part of a masterplan to reduce surface water runoff to greenfield runoff rates and volumes from the developed site as required by the Environment Agency, and as such prevent any resultant increase in flood risk posed to downstream. NPPF states that SuDS should, where possible, mimic the natural drainage mechanism of an area. Infiltration is part of the natural drainage process. The Environment Agency advice indicates a presumption in favour of infiltration SuDS techniques being used wherever possible, as the District lies in an area of water stress.

Although the Oxford Canal is not designated an Environment Agency Main River, it is recommended that development does not encroach within a minimum of 8 m of the watercourse banks which is the Environment Agency's by-law distance for maintenance access along Main Rivers in the Thames Region. It is recommended that OCC, as the LLFA, should be contacted during the undertaking of an FRA to determine their requirements for any margin for maintenance either side of the local Ordinary Watercourses. This would be beneficial in terms of flood risk, wildlife habitat and amenity potential.

Limited sewer capacity will require consideration as part of any new development proposals.

Site Specific FRA Guidance

The latest climate change allowances have not yet been taken into account in the current modelled Flood Zone extents of watercourses adjacent to the site. A site-specific Level 3 FRA should therefore be undertaken to refine and determine in more detail, the risk of fluvial flooding across the site (maximum depths, velocities and hazard) within the NPPF PPG defined Flood Zones through new hydraulic modelling. These include Flood Zone 3B (20% AP, 1 in 20 year, functional floodplain), Flood Zone 3A (1% AP, 1 in 100 year), Flood Zone 3+CC (1% AP, 1 in 100 year plus the appropriate allowance for climate change depending on the proposed land use vulnerability) and Flood Zone 2 (0.1% AP, 1 in 1000 year). This modelling will be required to demonstrate, on the basis of fluvial flood risk, the suitability of the proposed locations of any buildings and earthworks.

The FRA should take into account the impact of the latest climate change allowances on all possible sources of flooding.

A site-specific FRA will be required to address surface water management for any development which exceeds 1 Ha applying consideration of surface water management options. It will be necessary as part of a site-specific FRA to quantify the volumes of surface water runoff to be discharged (subject to consultation with the LLFA and/or Environment Agency), and the suitability of the SuDS techniques to be incorporated to reduce the risk posed should be demonstrated.

A site-specific FRA should also demonstrate suitable provision for dry site access and egress, taking into account any requirements of the Cherwell emergency plan.

An agreement in principle from TW that foul drainage from the site will be accepted into their network should be obtained as part of any planning application for the site.

A site-specific FRA should consider the likelihood and impact of groundwater emergence. To investigate this and further understand SuDS suitability, the FRA should be informed by a suitable site GI.

3. Assessment of Strategic Site on Land South East of Kidlington – PR7a

This Section details the Level 2 assessments for the potential strategic development site to the south east of Kidlington. Flood risk mapping referred to in the tables is provided in Appendix B.

Table 3-1: Land South East of Kidlington (PR7a)

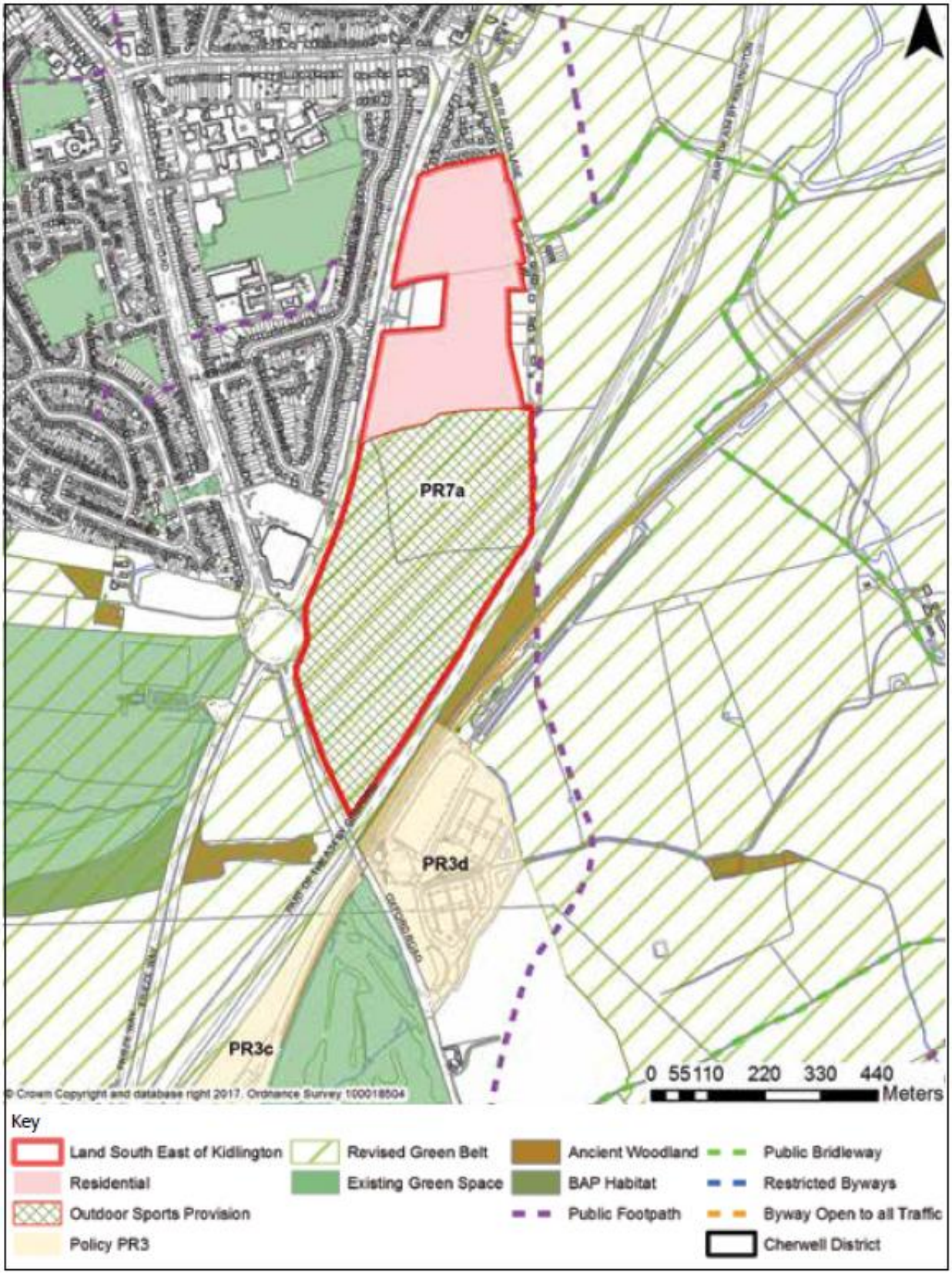

Figure Extracted from CDC Proposed Submission Plan - Summary Booklet (July 2017 – Updated)

Site Information	
Site Area	32.2 Ha
Existing Use and Topography	The land adjacent to Bicester Road, Gosford lies immediately to the east of Bicester Road. The A34 is situated to the east of the site, forming the eastern barrier to the lower half of the site. The site is currently used for agricultural farmland, with the exception of a small fraction of the site dedicated to the road of Water Eaton Lane. To the north and east of the site of the site there is a small scale residential development. The site is restricted from encompassing the whole area between Bicester Road and Water Eaton Lane due to the presence of Kidlington Cemetery in the west and residential properties, and their associated gardens, in the east. A review of the topography of the site identified that the there is a slight south east facing slope ranging from the maximum of 65 mAOD to a minimum of 61 mAOD.
Proposed Use and Vulnerability Classification	Residential development (230 new homes) classified by the NPPF PPG as 'More Vulnerable' development.
Sources of Flood Risk	
Rivers (Fluvial)	There are no Main Rivers flowing within close proximity to the site. The nearest Main River is the River Cherwell situated 0.7 km to the north and east of the site (see Appendix B, Figure B.1). There is a proportionally small area in the north east of the site that is located within Flood Zone 3 (>=1% AP, high risk), Flood Zone 3+CC (>=1% AP +20% CC, high risk) and Flood Zone 2 (>=0.1% AP, medium risk). Flood Zone 3+CC inundates the same extent as Flood Zone 2 in the immediate vicinity of the site. The rest of the site is defined as being at low risk from fluvial flooding. The majority of the site and area within it allocated for residential development is located within Flood Zone 1 (<0.1 % AP, 1 in 1000 year, low risk). ***Comparison of Modelled Peak Flood Levels to Ground Levels in respect of Climate Change*** The Environment Agency's River Cherwell SFRM (2008) model outputs predicted peak water levels during a >=1% AP +20% CC event range alongside the northern area of this site from 60.81 mAOD at the upstream extent and 60.61 mAOD at the downstream extent (see Appendix C, Figure C.2). The Environment Agency was unable to provide peak water levels used to determine the extent of Flood Zone 2 (>=0.1% AP event) in the locality, however, the Flood Map for Planning (Appendix B, Figure B.1) illustrates that these events both inundate the same extent within the site boundary. Should a >=1% AP +35% CC event peak flow be larger than the >=0.1% AP event peak flow, any potential small increase in water levels, towards for example a conservative level of 61 mAOD is unlikely to result in vastly more extensive fluvial flooding in northern/upstream area of the site due to the steep rise in topography from the east (≈60 mAOD) to the western areas of the site (≈65 mAOD). The 61 mAOD contour extends only marginally further into in the north eastern corner of the site and into the centre of the site along the eastern boundary. However due to the width of the floodplain here, it is unlikely that any additional flood water volume resulting from a 1% AP +35% flow would extend this far towards this region of the site, as any additional flood water would instead spread out following the lower ground levels within the wider, flatter floodplain to the north east and south east downstream of the site, reducing the potential resultant water level. Therefore any potential increase in flood water level above that of the >=0.1% AP event due to the latest climate change predictions would not likely inundate a significantly greater area of the site proposed for residential land use than as currently illustrated by Flood Zone 2 in the north east corner. The Environment Agency's Historical Flood Map illustrates no records of flooding at the site (see Appendix B, Figure B.5).
Land (Pluvial)	The Environment Agency's updated Flood Map for Surface Water (uFMfSW) (see Appendix B, Figure B.4) illustrates that the majority of the land throughout the site is at a very low risk (<0.1% AP, 1 in 1000 year event) of surface water flooding. There is potentially a high risk (>=3.3% AP, 1 in 30 year event) of surface water flooding within a very small area along the north eastern boundary. The extents depicted at medium risk (>=1% AP, 1 in 100 year event) and low risk (>=0.1% AP, 1 in 1000 year event) of surface water flooding is only slightly larger than this. In the central area of the site there are minor areas shown to be at low risk (>=0.1% AP) and medium risk

	(>=1% AP), with very small areas at high risk (>=3.33% AP) of surface water ponding encroach into the eastern boundary of the site alongside the A34.
Groundwater	The Environment Agency's Areas Susceptible to Groundwater Flooding (AStGWF) map (see Appendix B, Figure B.2) illustrates that the northern region of this site, north of Kidlington Cemetery, is situated in an area which is highly susceptible to groundwater flooding (i.e. within a 1 km grid square where >75% of the area is defined as having a susceptibility to groundwater emergence). The type of groundwater flooding the area is at risk from is due to permeable superficial deposits which tend to have a relatively high water table. The majority of the remainder of the site is situated in an area which has a medium susceptibility to groundwater flooding (i.e. within a 1 km grid square where >=50 <75% of the area is defined as having a susceptibility to groundwater emergence). The southernmost tip of the site is situated in an area which has a very low susceptibility to groundwater flooding (i.e. within a 1 km grid square where <25% of the area is defined as having a susceptibility to groundwater emergence).
Sewers (Pluvial)	The Thames Water (TW) DG5 register identifies 20 – 25 recorded incidents of foul sewer flooding within the post code area (OX2), covering the majority of the site, between 2006 and 2016 (see Appendix B, Figure B.3). The southern tip of the site is located in a different post code area (OX2), with the DG5 register reporting 0 – 5 sewer flooding incidents in this post code area.
Artificial Sources	The 'Risk of Flooding from Reservoirs' map on the Environment Agency's website illustrates that this site is not within the maximum modelled flood extent of a reservoir breach, and is therefore considered not at risk from reservoir flooding. The site is therefore not considered to be at risk of flooding from any artificial sources.

Flood Defence Infrastructure

There are no formal flood defences in place around this site.

Residual Flood Risk

There are no flood defences within close proximity to the site. Therefore, there is not considered to be any residual risk of flooding from breach failure at this site.

Recommendations and SFRA Policies

The latest Environment Agency climate change allowances have not yet been taken into account in the current Flood Zone extents of the watercourses adjacent to the site. The SFRA policy for this site therefore follows a precautionary approach until more information is presented. No land raising or built development is permitted inside the combined modelled Flood Zone 2 (applied as a proxy for Flood Zone 3 +CC) and Flood Zone 3 envelope which extends into the north eastern corner of the site. This will maintain a 'blue corridor' providing public open space/recreation area alongside the River Cherwell that will prevent a net loss of floodplain storage, will not impede water flows and will not increase flood risk elsewhere. This supports the Environment Agency's current aspirations for the site. These Flood Zones however, should be refined/determined by more detailed hydraulic modelling undertaken as part of a site-specific FRA.

As the area is primarily greenfield, any development within the area will increase surface water runoff (unless attenuated). A surface water management framework should be adopted as part of a masterplan to reduce surface water runoff to greenfield runoff rates and volumes from the developed site as required by the Environment Agency, and as such prevent any resultant increase in flood risk posed to downstream. The NPPF states that SuDS should, where possible, mimic the natural drainage mechanism of an area. Infiltration is part of the natural drainage process. The Environment Agency advice indicates a presumption in favour of infiltration SuDS techniques being used wherever possible, as the District lies in an area of water stress.

The Level 1 SFRA SuDS map illustrates that due to the underlying geological composition and groundwater vulnerability, infiltration SuDS techniques are unlikely to be suitable and development proposals for this area should seek to limit surface water runoff through the incorporation of attenuation SuDS techniques. Detailed site-specific analysis and ground investigation should be undertaken before the use of infiltration SuDS techniques is fully dismissed pending the outcome of any contamination assessment/remediation works.

Limited sewer capacity will require consideration as part of any new development proposals.

Site Specific FRA Guidance

The latest climate change allowances have not yet been taken into account in the current modelled Flood Zone extents of the River Cherwell adjacent the site. A site-specific Level 3 FRA should therefore be undertaken to refine and determine in more detail, the risk of fluvial flooding across the site (maximum depths, velocities and hazard) within the NPPF PPG defined Flood Zones through new hydraulic modelling. These include Flood Zone 3B (20% AP, 1 in 20 year, functional floodplain), Flood Zone 3A (1% AP, 1 in 100 year), Flood Zone 3+CC (1% AP, 1 in 100 year plus the appropriate allowance for climate change depending on the proposed land use vulnerability) and Flood Zone 2 (0.1% AP, 1 in 1000 year). This modelling will be required to demonstrate, on the basis of fluvial flood risk, the suitability of the proposed locations of any residential buildings and earthworks.

Once detailed modelling as part of an FRA is completed, should future development pressure and other sustainability objectives create the need to develop within the modelled Flood Zone 3 +35% CC (1% AP) envelope, then in accordance with the requirements of the NPPF PPG, evidence from the hydraulic modelling will be required to demonstrate to CDC, the LLFA[4] and the Environment Agency its suitability on the basis of fluvial flood risk (i.e. consideration of maximum depths, velocities and hazard) to satisfy the requirements of the Exception Test.

Appropriate mitigation measures would then need to be agreed with the Environment Agency and incorporated to protect 'More Vulnerable' residential development, for example minimum floor levels to adopt above the local 1% AP +35% CC maximum modelled flood level.

Within the modelled extents of Flood Zone 3 +35% CC (1% AP), any proposed building or landscaping earthworks should not increase the risk of flooding to surrounding areas (i.e. if land is to be raised, flood volume compensation on a 'level for level' and 'volume for volume' basis will be required elsewhere within the site boundary within a lower risk Flood Zone).

The FRA should take into account the impact of the latest climate change allowances on all possible sources of flooding.

A site-specific FRA should also demonstrate suitable provision for dry site access and egress, taking into account any requirements of the Cherwell emergency plan.

A site-specific FRA will be required to address surface water management for any development which exceeds 1 Ha applying consideration of surface water management options. It will be necessary as part of a site-specific FRA to quantify the volumes of surface water runoff to be discharged (subject to consultation with the LLFA and/or Environment Agency), and the suitability of the SuDS techniques to be incorporated to reduce the risk posed should be demonstrated.

An agreement in principle from TW that foul drainage from the site will be accepted into their network should be obtained as part of any planning application for the site.

A site-specific FRA should consider the likelihood and impact of groundwater emergence. To investigate this and further understand SuDS suitability, the FRA should be informed by a suitable site GI.

[4] Lead Local Flood Authority - Oxfordshire County Council

4. Assessment of Strategic Site on Land East of the A44 – PR8

This Section details the Level 2 assessments for the potential strategic development site in Begbroke. Flood risk mapping referred to in the tables is provided in Appendix B.

Table 4-1: Land East of the A44 (PR8)

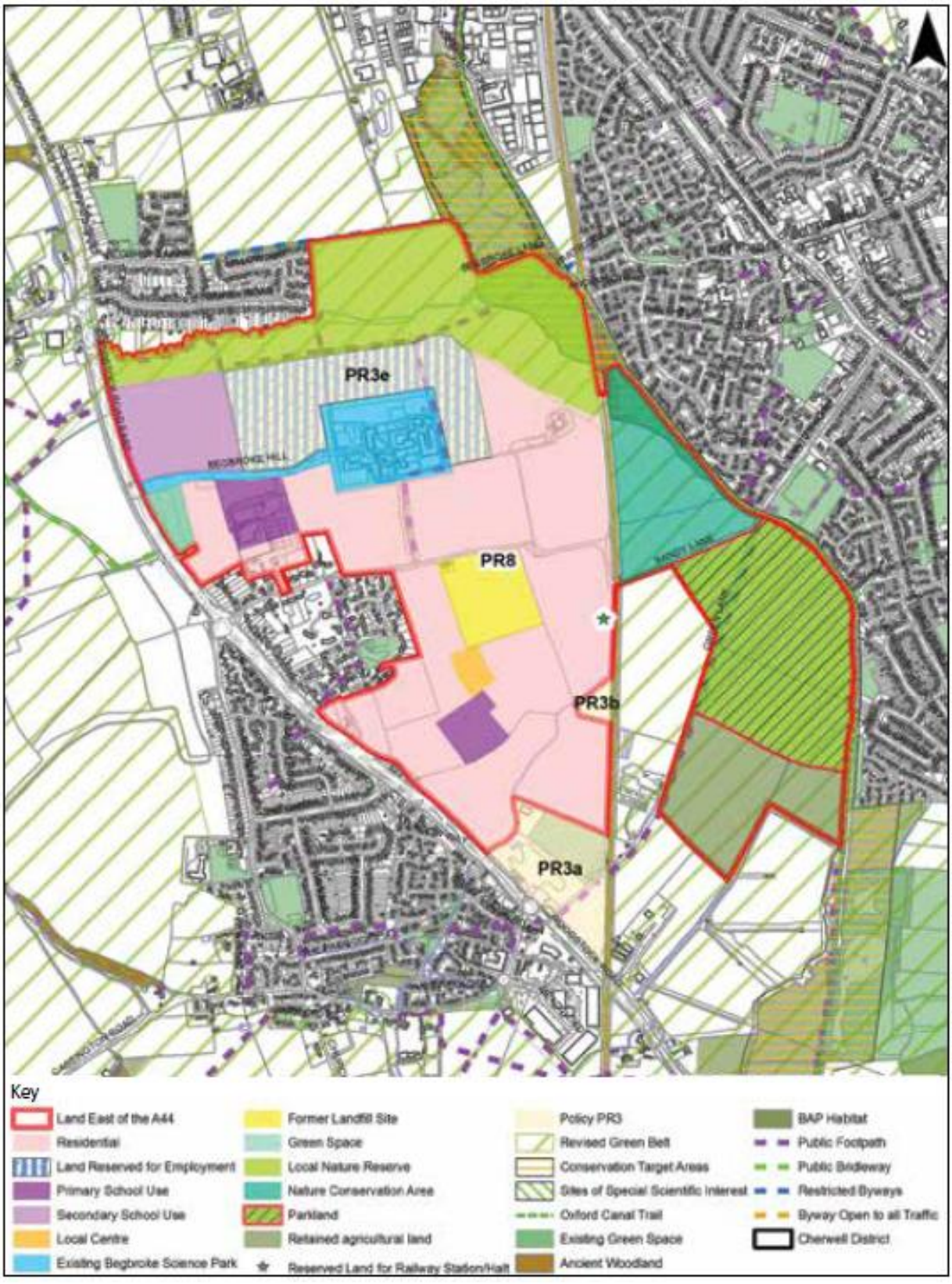

Figure Extracted from CDC Proposed Submission Plan - Summary Booklet (July 2017 – Updated)

Site Information	
Site Area	189.6 Ha
Existing Use and Topography	The Begbroke Science Park Site lies to the west of Kidlington, approximately 7 km north of Oxford city centre. It is bound on its western side by the A44 and on its eastern side by the Oxford Canal. The site is predominantly greenfield agricultural land with the exception of the science park itself (~8 Ha) and the railway line which cuts through the site; however there is a relatively large amount of residential development surrounding the site as well as London Oxford Airport and two business parks located north and south of the site. As well as the Oxford Canal, Rowel Brook flows eastwards across the northern perimeter of the site. In addition to these watercourses there are also several small agricultural drains located throughout the site. The topography generally slopes down to the east, from a maximum of 69 mAOD to a minimum of 60 mAOD. Roughly half of the site lies within 1m elevation of the Oxford Canal.
Proposed Use and Vulnerability Classification	Residential development (1950 new homes) classified by the NPPF PPG as 'More Vulnerable' development.
Sources of Flood Risk	
Rivers (Fluvial)	The Oxford Canal runs along the eastern boundary of the site and is lower in elevation compared to majority of the land within the site. Flood Zone 3 (>=1% AP, 1 in 100 year, high risk) is illustrated to inundate a large proportion of the eastern side of the site and either side of Rowel Brook in the north (see Appendix B, Figure B.1). The flatter areas within the south eastern area of the site are also partially inundated by Flood Zone 2 (>=0.1% AP, 1 in 1000 year, medium risk). The majority of the western region of the site lies within Flood Zone 1 (<0.1% AP, 1 in 1000 year, low risk). No flood outline is currently available in this area for the 1% AP +20% CC event. ***Comparison of Modelled Peak Flood Levels to Ground Levels in respect of Climate Change*** The hydrological assessment (see Appendix A) determined that the >=1% AP +35% CC event peak flow along Rowel Brook is unlikely to be larger than the >=0.1% AP peak flow, however, depending on which statistical approach was chosen as the preferred method, there was found to be the potential for the >=1% AP +35% CC event flows to be marginally larger (+7%). If, as part of a detailed modelling study undertaken as part of a site-specific FRA, these larger flows were adopted for use in the model, high level consideration was given to where the additional flood water may inundate as a precautionary approach. A review was subsequently made of the existing predicted peak water levels from the Environment Agency's broadscale JFLOW model for Rowel Brook and the Oxford Canal as follows in comparison to the ground levels across three areas within the site and the local vicinity (see Appendix C, Figure C.3): - **North of Begbroke Science Park along the northern boundary** - The peak water levels during a >=1% AP +20% CC event range from 66.64 mAOD at the A44 to 62.31 mAOD at the railway line. The peak water levels during a >=0.1% AP event range from 66.68 at the A44 to 62.34 mAOD at the railway line. Due to the relatively constrained topography in this area rising quickly to 64 mAOD+ in the vicinity of the proposed residential land use, if the potentially larger >=1% AP +35% CC event flows were modelled, it is considered reasonable to assume that they would not likely inundate a much greater degree of the site than illustrated by the current Flood Zone 2 outline; - **North of Sandy Lane and between the railway line and the Oxford Canal** - The >=1% AP +2020% CC event peak water levels range from 62.28 mAOD at the railway line to 60.97 mAOD at Sandy Lane), and the >=0.1% AP event peak water levels range from (62.32 mAOD at the railway line to 60.97 mAOD at Sandy Lane). Due to the relatively flat topography of this area (≈61–61.5 mAOD) and a wide margin of land not currently inundated by Flood Zone 2, if the potentially larger >=1% AP +35% CC event flows were larger flows were modelled, they may inundate a slightly greater area of the site proposed to be retained as green space. However, it would not likely proceed as far west as the area proposed for residential development (largely above 61.5 mAOD and restricted to the western side of the railway line) as the volume of flood water would have already spread out and levels would therefore reduce;

- **South of Sandy Lane and in the vicinity of the disused sewage treatment works -** In this area, the >=1% AP +20% CC event water levels range from of 60.97 mAOD at Sandy Lane to 59.97 mAOD at Yarnton Lane. The >=0.1% AP event peak water levels range from of 60.97 mAOD at Sandy Lane to 59.99 mAOD at Yarnton Lane.

  Due to the relatively flat topography of this region (60–61 mAOD), if the potentially larger >=1% AP +35% CC event flows were modelled they may inundate a slightly greater degree of the floodplain than illustrated by Flood Zone 2 within the eastern area of the site allocated for park land, greenbelt and agricultural land use.

  However, as any additional water would disperse across the lower levels of this wide floodplain either side of Yarnton Lane currently not inundated by Flood Zone 2, it is highly likely that this would be restricted to the east side of the railway line, outside of the area of the site proposed for residential land use (largely above 60.5 mAOD) as the volume of flood water would have already spread out and levels would therefore reduce.

Therefore any potential increase in flood water level above that of the >=0.1% AP event due to the latest climate change predictions would not likely inundate the area of the site proposed for residential land use.

The Environment Agency's Historical Flood Map (see Appendix B, Figure B.5) illustrates a small area in the east of the site, and further areas in the south eastern region of the site have experienced fluvial flooding. The mapping also indicates that there have been a further four reported incidents of fluvial flooding, from ordinary watercourses, within 200 m of the site.

Land (Pluvial)	The Environment Agency's updated Flood Map for Surface Water (uFMfSW) (see Appendix B, Figure B.4) illustrates that the majority of the land throughout the site is at a very low risk (<0.1% AP) of surface water flooding, especially those areas over 100 m from Rowel Brook. Along the banks of Rowel Brook, and the Oxford Canal north of Sandy Lane however, there are areas at a high risk (>=3.33% AP) of surface water flooding. There are several regions located throughout the site which are shown to be at a low (>=0.1% AP) to medium (>=1% AP) risk of surface water ponding, most notably in the southern area of of the site west of the disused sewage works and to the east of Yarnton Lane.
Groundwater	The Environment Agency's Areas Susceptible to Groundwater Flooding (AStGWF) map (see Appendix B, Figure B.2) illustrates that approximately half of the site is situated in an area which is highly vulnerable to groundwater flooding (i.e. within a 1 km grid square where >= 75% of the area is defined as having a susceptibility to groundwater emergence). This area spans east from the science park to slightly west of Kidlington Green Lock. Either side of this area, the site is situated within an area which has a medium susceptibility to groundwater flooding (i.e. within a 1 km grid square where >=50% - <75% of the area is defined as having a susceptibility to groundwater emergence), with the exception of a small area in the very north of the site, north of Rowel Brook, which has a very low susceptibility to groundwater flooding (i.e. within a 1 km grid square where <25% of the area is defined as having a susceptibility to groundwater emergence).
Sewers (Pluvial)	The Thames Water (TW) DG5 register identifies 20-25 recorded incidents of foul sewer flooding within the post code area (OX5) covering the site between 2006 and 2016 (see Appendix B, Figure B.3).
Artificial Sources	The Oxford Canal runs alongside the boundary of the site and is elevated at similar ground levels to the site. In recent history the sole reported flooding incident occurred in January 2003, along the eastern and southernmost part of the site due to the capacity of the canal being exceeded and overtopping. The 'Risk of Flooding from Reservoirs' map on the Environment Agency's website illustrates that this site is not within the maximum modelled flood extent of a reservoir breach, and is therefore considered not at risk from reservoir flooding.

Flood Defence Infrastructure

There are no formal flood defences alongside the site.

Residual Flood Risk

The Oxford Canal potentially poses a residual risk of flooding to the site by overtopping. In the south of the site there is the potential for the culvert beneath the A44 to restrict flow from the drain through the site, adding a potential risk of water backing up onto the site.

Recommendations and SFRA Policies

The latest Environment Agency climate change allowances have not yet been taken into account in the current Flood Zone extents of the watercourses adjacent to the site. The SFRA policy for this site therefore follows a precautionary approach until more information is presented. No land raising or built development is permitted inside the combined modelled Flood Zone 2 (applied as a proxy for Flood Zone 3 +CC) and Flood Zone 3 envelope which extends into the north eastern corner of the site. This will maintain a 'blue corridor' providing public open space/recreation area near Rowel Brook that will prevent a net loss of floodplain storage, will not impede water flows and will not increase flood risk elsewhere. This supports the Environment Agency's current aspirations for the site. This area however, should be determined by more detailed hydraulic modelling undertaken as part of a site-specific FRA.

As the area is primarily greenfield, any development within the area will increase surface water runoff (unless attenuated). A surface water management framework should be adopted as part of a masterplan to reduce surface water runoff to greenfield runoff rates and volumes from the developed site as required by the Environment Agency, and as such prevent any resultant increase in flood risk posed to downstream. The NPPF states that SuDS should, where possible, mimic the natural drainage mechanism of an area. Infiltration is part of the natural drainage process. The Environment Agency advice indicates a presumption in favour of infiltration SuDS techniques being used wherever possible, as the District lies in an area of water stress.

The Level 1 SFRA SuDS map illustrates that due to the underlying geological composition and groundwater vulnerability, infiltration SuDS techniques are unlikely to be suitable and development proposals for this area should seek to limit surface water runoff through the incorporation of attenuation SuDS techniques. Detailed site-specific analysis and ground investigation should be undertaken before the use of infiltration SuDS techniques is fully dismissed pending the outcome of any contamination assessment/remediation works.

Although Rowel Brook is not designated Environment Agency Main River, it is recommended that development does not encroach within a minimum of 8 m of the watercourse banks which is the Environment Agency's by-law distance for maintenance access along Main Rivers in the Thames Region. It is recommended that OCC, as the LLFA, should be contacted during the undertaking of an FRA to determine their requirements for any margin for maintenance either side of the local Ordinary Watercourses. This would be beneficial in terms of flood risk, wildlife habitat and amenity potential.

Limited sewer capacity will require consideration as part of any new development proposals.

Within the areas of this site which are designated as Flood Zone 3 there are small, sparsely distributed regions of land which are located within Flood Zone 1. In times of extensive fluvial flooding these regions may become surrounded by flood water, thus preventing access/egress to/from the site, these areas are called 'dry islands'. It is therefore suggested that development should not take place within these regions.

Site Specific FRA Guidance

The latest climate change allowances have not yet been taken into account in the current modelled Flood Zone extents of the watercourses adjacent to the site. A site-specific Level 3 FRA should therefore be undertaken to refine and determine in more detail, the risk of fluvial flooding across the site (maximum depths, velocities and hazard) within the NPPF PPG defined Flood Zones through new hydraulic modelling. These include Flood Zone 3B (20% AP, 1 in 20 year, functional floodplain), Flood Zone 3A (1% AP, 1 in 100 year), Flood Zone 3+CC (1% AP, 1 in 100 year plus the appropriate allowance for climate change depending on the proposed land use vulnerability) and Flood Zone 2 (0.1% AP, 1 in 1000 year). This modelling will be required to demonstrate, on the basis of fluvial flood risk, the suitability of the proposed locations of any residential buildings and earthworks.

Once detailed modelling as part of a FRA is completed, should future development pressure and other sustainability objectives create the need to develop within the modelled Flood Zone 3 +35% CC (1% AP) envelope, then in accordance with the requirements of the NPPF PPG, evidence from the hydraulic modelling will be required to demonstrate to CDC, the LLFA[5] and the Environment Agency its suitability on the basis of fluvial flood risk (i.e. consideration of maximum depths, velocities and hazard) to satisfy the requirements of the Exception Test.

Appropriate mitigation measures would then need to be agreed with the Environment Agency and incorporated to protect 'More Vulnerable' residential development, for example minimum floor levels to adopt above the local 1% AP +35% CC maximum modelled flood level.

Within the modelled extents of Flood Zone 3 +35% CC (1% AP), any proposed building or landscaping earthworks should not increase the risk of flooding to surrounding areas (i.e. if land is to be raised, flood volume compensation on a 'level for level' and 'volume for volume' basis will be required elsewhere within the site boundary within a lower

[5] Lead Local Flood Authority - Oxfordshire County Council

risk Flood Zone).

The FRA should take into account the impact of the latest climate change allowances on all possible sources of flooding.

A site-specific FRA will be required to address surface water management for any development which exceeds 1 Ha applying consideration of surface water management options. It will be necessary as part of a site-specific FRA to quantify the volumes of surface water runoff to be discharged (subject to consultation with the LLFA and/or Environment Agency), and the suitability of the SuDS techniques to be incorporated to reduce the risk posed should be demonstrated.

A site-specific FRA should also demonstrate suitable provision for dry site access and egress, taking into account any requirements of the Cherwell emergency plan.

An agreement in principle from TW that foul drainage from the site will be accepted into their network should be obtained as part of any planning application for the site.

A site-specific FRA should consider the likelihood and impact of groundwater emergence. To investigate this and further understand SuDS suitability, the FRA should be informed by a suitable site GI.

5. Summary

The Environment Agency has requested a more robust assessment of fluvial flood risk at the sites to provide confidence that the proposed land uses at the three Level 2 SFRA Addendum sites are likely to be deliverable, in respect to climate change. The aim of this Level 2 SFRA Addendum, therefore, is to provide a clarification of the fluvial flood risk posed to the three potential allocation sites, resulting from potential climate change

The Environment Agency's new climate change allowances have not yet been taken into account in the current modelled flood extents of adjacent watercourses. Therefore a high level assessment was made of the available modelled peak water levels in relation to ground level data to determine the potential impact of any increase in the flood risk posed to the sites resulting from the climate change predictions.

5.1 Conclusions

It is recommended that this Level 2 SFRA Addendum should be read in parallel with the Cherwell Level 2 SFRA (AECOM, May 2017) and the Cherwell Level 1 SFRA Update (AECOM, March 2017). These three reports accompany each other and give supplementary information for CDC and site developers.

5.1.1 Sites PR6c and PR8

The hydrological analysis demonstrated that three out of the four >=1% AP (1 in 100 year) flow estimates for Rowel Brook including a 35% allowance for climate change do not exceed the >=0.1% AP (1 in 1000 year) flow estimates. This provides reasonable confidence that if a larger 1% AP +35% CC event flow was modelled, the flood extent would unlikely extend further across the area of site PR8 allocated for residential development than the existing Flood Zone 2 extent, applied currently by CDC as a proxy outline for this event (see Appendix B, Figure B.1).

Although the fourth >=1% AP +35% CC flow estimate located at the downstream extent at the A40 is slightly larger when applying the FEH Statistical method, if this was to be adopted as the preferred method over the ReFH2 method for use in a hydraulic model, this marginal increase in flow (+7%) would not be expected to increase the flood extent of Flood Zone 2 dramatically. However, a review was made of the local ground levels against the Environment Agency's JFLOW modelled >=1% AP +20% CC event peak water levels, and against the >=0.1% AP event peak water levels that were used by the Environment Agency to determine the existing Flood Zone 2 extent alongside sites PR8 and PR6C. As a precautionary measure, a high level assessment of the potential impact of a slightly increased water level above that of the >=0.1% AP event was also made in relation to these relative ground levels. These ground/peak water levels are illustrated in Appendix C, Figures C.1 and C.3.

This provided reasonable confidence that if the >=1% AP event plus a 35% climate change allowance was modelled, the flood extent would unlikely extend significantly further across sites PR8 and PR6C than the extent of existing Flood Zone 2 (currently applied by CDC as a proxy for this event) as the additional water would likely disperse across the lower levels of the wider floodplain outside of the site boundary.

The latest climate change allowances would not therefore be likely to extend into the area of the site allocated to accommodate residential development in site PR8, or impact the potential golf course on site PR6C.

5.1.2 Site PR7A

At site PR7A, a review was undertaken of local ground levels at the site in comparison to the existing predicted peak water levels from the River Cherwell SFRM (2008) model for a 1% AP +20% CC event, and in comparison to the extent of the existing Flood Zone 2. As a precautionary measure, a high level assessment of the potential impact of a slightly increased water level above

that of the >=0.1% AP event was also made in relation to these relative ground levels. These ground/peak water levels are illustrated in Appendix C, Figure C.3.

This provided reasonable confidence that if a larger 1% AP +35% CC event was modelled, the flood extent would unlikely extend further across the area of site allocated for residential development than the existing Flood Zone 2 (currently applied by CDC as a proxy outline for this event) and once again, the additional water would likely disperse across the lower levels of the wider floodplain outside of the site boundary.

5.2 Recommendations

Recommendations and policies have been presented in the above tables for each of the three sites put forward for allocation from CDC.

As the latest climate change allowances have not yet been taken into account in the current modelled Flood Zone extents of adjacent watercourses, a site-specific Level 3 FRA should be undertaken to refine and determine in more detail, the risk of fluvial flooding across the site (maximum depths, velocities and hazard) within the NPPF PPG defined Flood Zones through new hydraulic modelling. These include Flood Zone 3B (20% AP, 1 in 20 year, functional floodplain), Flood Zone 3A (1% AP, 1 in 100 year), Flood Zone 3+CC (1% AP, 1 in 100 year plus the appropriate allowance for climate change depending on the proposed land use vulnerability) and Flood Zone 2 (0.1% AP, 1 in 1000 year). This modelling will be required to demonstrate, on the basis of fluvial flood risk, the suitability of the proposed locations of development within the site boundaries.

Appendix A – Hydrological Assessment Summary

Hydrological analysis using ReFH2 and FEH WINFAP software was undertaken to determine peak flow estimates at two locations along Rowel Brook;

1. the upstream extent of site PR8 at the A44, and
2. the downstream extent of site PR6C at the A40.

AECOM has undertaken this assessment in accordance with the Environment Agency's latest 'Flood Estimation Guidelines – Operational Instruction 197_08' (2015)[6].

Catchment Derivation

The catchment boundaries and catchment descriptors were exported from the FEH Web Service[7] and adjusted to more closely reflect the topography of the area, based on the 1m LiDAR available. It should be noted that the pre-existing LiDAR data was patchy in the north of the study area and therefore there are slight uncertainties with the upstream catchment boundaries.

Once adjusted, the overall differences in area between both the adjusted areas and the original FEH catchment areas were less than 10%, and therefore it was concluded that there were to be no adjustments to the catchment descriptors, with the exception of area.

The catchment area for Flow Estimate 1 'Upstream Extent at A44' was reduced from 3.95 to 3.90 km^2. The catchment area for Flow Estimate 2 'Downstream Extent at A40' was reduced from 13.2 to 12.45 km^2.

ReFH2

ReFH2[8] is the latest version of the Revitalised Flood Hydrograph (ReFH) model. The software enables the estimation of design flood hydrographs for both rural and urbanised catchments, using the latest methods which draw on both the FEH 1999 and 2013 rainfall models. As the URBEXT2000 values for both catchments were less than 0.25 and therefore, there was no need to apply the 'urban adjustment' method in the ReFH2.

Table A.1 illustrates the results of this ReFH2 hydrological analysis including the growth curve factors (multiplication factors of the 50% annual probability/1 in 2 year flow) used to devise peak flow estimates for greater magnitude/lower probability events.

Table A.1: ReFH2 Hydrological Analysis – Peak Flow Estimates

Annual Probability (%) (1 in Years)	Upstream Extent at A40		Downstream Extent at A44	
	Growth Curve Factors	Estimated Peak Flow (m^3/s)	Growth Curve Factors	Estimated Peak Flow (m^3/s)
50% (1 in 2 Year)	1	0.251	1	0.779
5% (1 in 20 Year)	2.112	0.529	1.935	1.507
1% (1 in 100 Year)	3.156	0.791	2.825	2.200
1%+35% for Climate Change	-	1.067	-	2.969
0.1% (1 in 1000 Year)	5.509	1.380	4.743	3.693

** both smaller than 0.1% annual probability flow*

[6] **Environment Agency (January 2015) Flood Estimation Guidelines - Technical guidance 197_08**
[7] **Centre for Ecology & Hydrology. 2017. Flood Estimation Handbook Web Service.** https://fehweb.ceh.ac.uk/
[8] Wallingford HydroSolutions. 2017. Revitalised Flood Hydrograph 2 (ReFH2). https://www.hydrosolutions.co.uk/software/refh-2/refh2_download/

These demonstrate that the 1% annual probability (1 in 100 year) flow estimates including a 35% allowance for climate change do not exceed the 0.1% annual probability (1 in 1000 year) flows.

FEH Statistical

WINFAP-v4[9] software and WINFAP-FEH v5[10] dataset (April 2017) were used to estimate peak flows and flood frequency curves for the ungauged catchments of interest using the latest FEH Statistical methods. Estimates of the QMED (50% annual probability/1 in 2 year) event flows were generated from the FEH Web Service catchment descriptors.

If a suitable hydrologically similar gauged 'donor catchment' is available, the starting QMED estimates can also be adjusted. However, the analysis determined that there were no such similar gauged catchments within the locality considered suitable for use on the catchments of interest to this study. Urban adjustments can also be made, where appropriate, and this was applied for the two estimates calculated at the downstream extent of the site.

A pooling group of similar gauged sites to each subject site was created based on comparison of the catchment descriptors. Growth curves (multiplication factors of the QMED) were derived by pooling data from observed/gauged catchments to devise peak flow estimates for greater magnitude/lower probability events.

Table A.2 illustrates the results of this FEH Statistical hydrological analysis.

Table A.2: FEH Statistical Hydrological Analysis – Peak Flow Estimates

Annual Probability (%) (1 in Years)	Upstream Extent at A40		Downstream Extent at A44	
	Growth Curve Factors	Estimated Peak Flow (m^3/s)	Growth Curve Factors	Estimated Peak Flow (m^3/s)
50% (1 in 2 Year)	1	0.211	1	0.778
5% (1 in 20 Year)	2.015	0.425	1.869	1.453
1% (1 in 100 Year)	2.99	0.631	2.338	1.818
1%+35% for Climate Change	-	0.852	-	2.454
0.1% (1 in 1000 Year)	5.203	1.097	2.946	2.291

** smaller than 0.1% annual probability flow*

** slightly larger than 0.1% annual probability flow*

These demonstrate that the 1% annual probability (1 in 100 year) flow estimate including a 35% allowance for climate change does not exceed the 0.1% annual probability (1 in 1000 year) flows for the upstream catchment extent, but at the downstream extent the 1% annual probability +35% for CC flow does exceed the 0.1% annual probability flow by a small amount (7%).

Summary

Three out of the four flow estimates demonstrate that the 1% annual probability (1 in 100 year) flow estimate including a 35% allowance for climate change does not exceed the 0.1% annual probability (1 in 1000 year) flows, providing reasonable confidence that if the latter event was modelled, the flood extent would unlikely extend further across sites PR8 and PR6C than the existing Flood Zone 2 extent used by CDC as a proxy for the latest climate change allowance.

Although the estimate at the at downstream extent at the A40 is slightly larger when applying the FEH Statistical method, if this was adopted as the final preferred method over the ReFH2 method for use in a

[9] **Wallingford HydroSolutions. 2017.** https://www.hydrosolutions.co.uk/software/winfap-4/

[10] **National River Flow Archive. 2016. WINFAP-FEH v5 data files** https://nrfa.ceh.ac.uk/winfap-feh-files

hydraulic model, this marginal increase in flow (+7%) would not be expected to increase the flood extent of Flood Zone 2 dramatically.

As a precautionary measure, the potential impact of a slightly increased water level above that of the 0.1% (Flood Zone 2) outline alongside sites PR8 and PR6C has been made in relation to the relative ground levels at the site in Table 4-1 and Table 2-1 respectively.

Appendix B – Level 2 Flood Risk Mapping

Table B.1: Flood Risk Mapping at Level 2 SFRA Potential Development Sites

Settlement Name	Site ID	Site Name	Description	Figure
Kidlington & Begbroke	PR6c PR7a PR8	Land at Frieze Farm Land South East of Kidlington Land East of the A44	Environment Agency Fluvial Flood Map for Planning	Figure B.1
			Environment Agency Area Susceptible to Groundwater Flooding (AStGWF)	Figure B.2
			Historical Total Reported Sewer Flooding Incidents (Thames Water DG5 2006-2016)	Figure B.3
			Environment Agency Risk of Flooding from Surface Water Map (uFMfSW)	Figure B.4
			Reported Historical Flooding Incidents	Figure B.5

B.1 Fluvial Flood Map for Planning - All Level 2 SFRA Addendum Sites

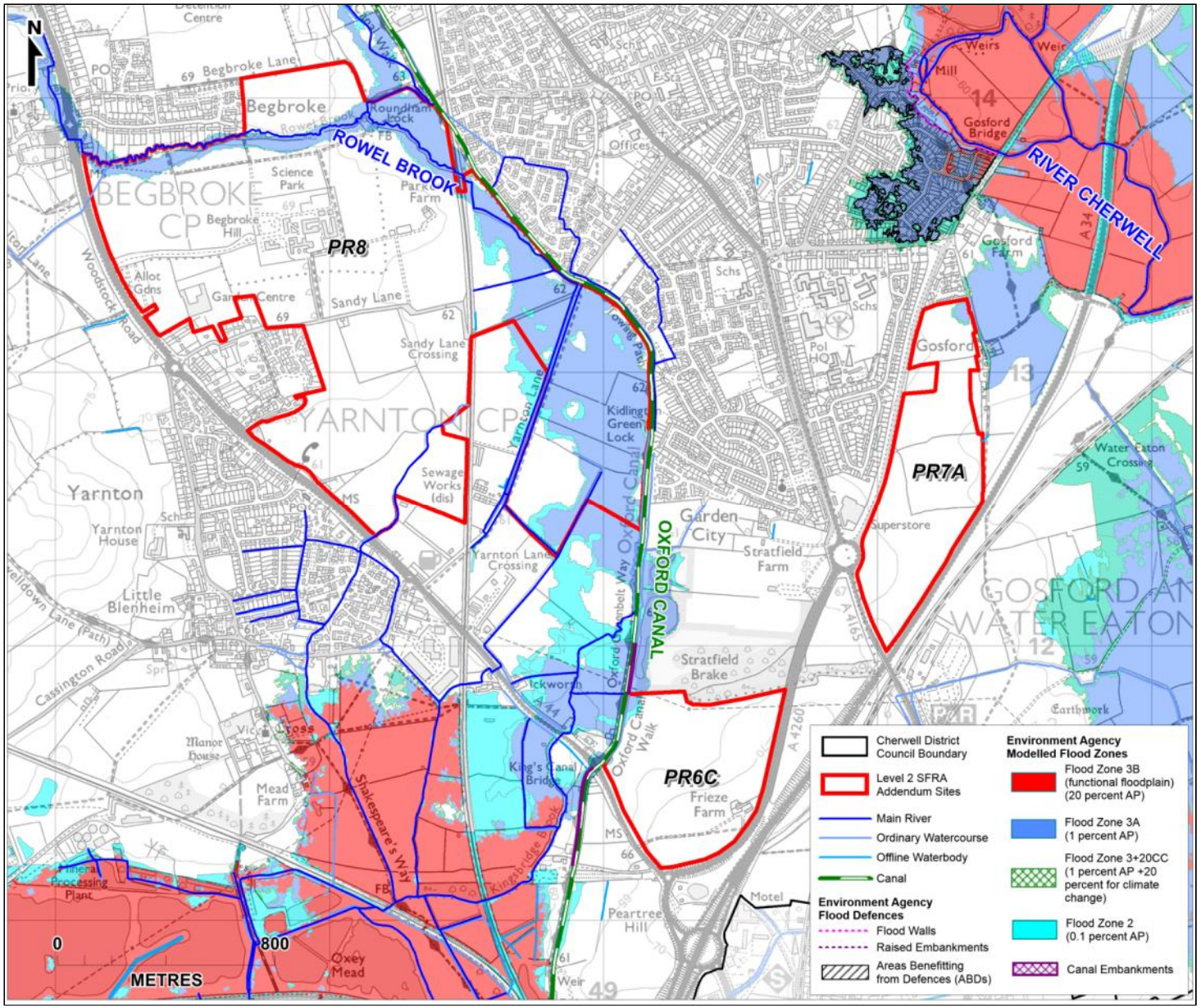

Figure B.1: Environment Agency Fluvial Flood Map for Planning – South of Kidlington

B.2 Areas Susceptible to Groundwater Flooding Map - All Level 2 SFRA Addendum Sites

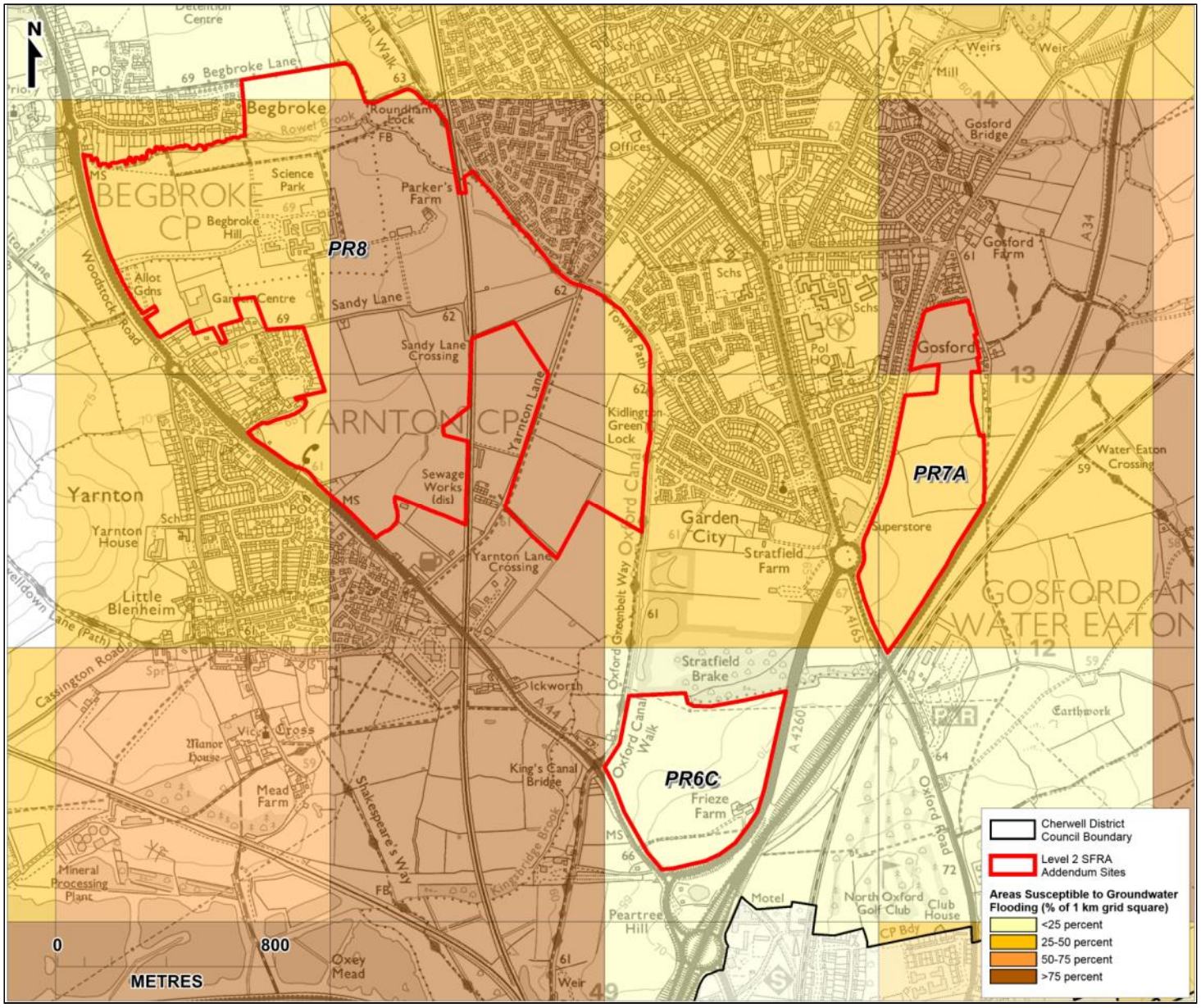

Figure B.2: Environment Agency Area Susceptible to Groundwater Flooding Map (AStGWF)

B.3 Historical Total Reported Sewer Flooding Incidents (TW DG5 2006-2016) - All Level 2 SFRA Addendum Sites

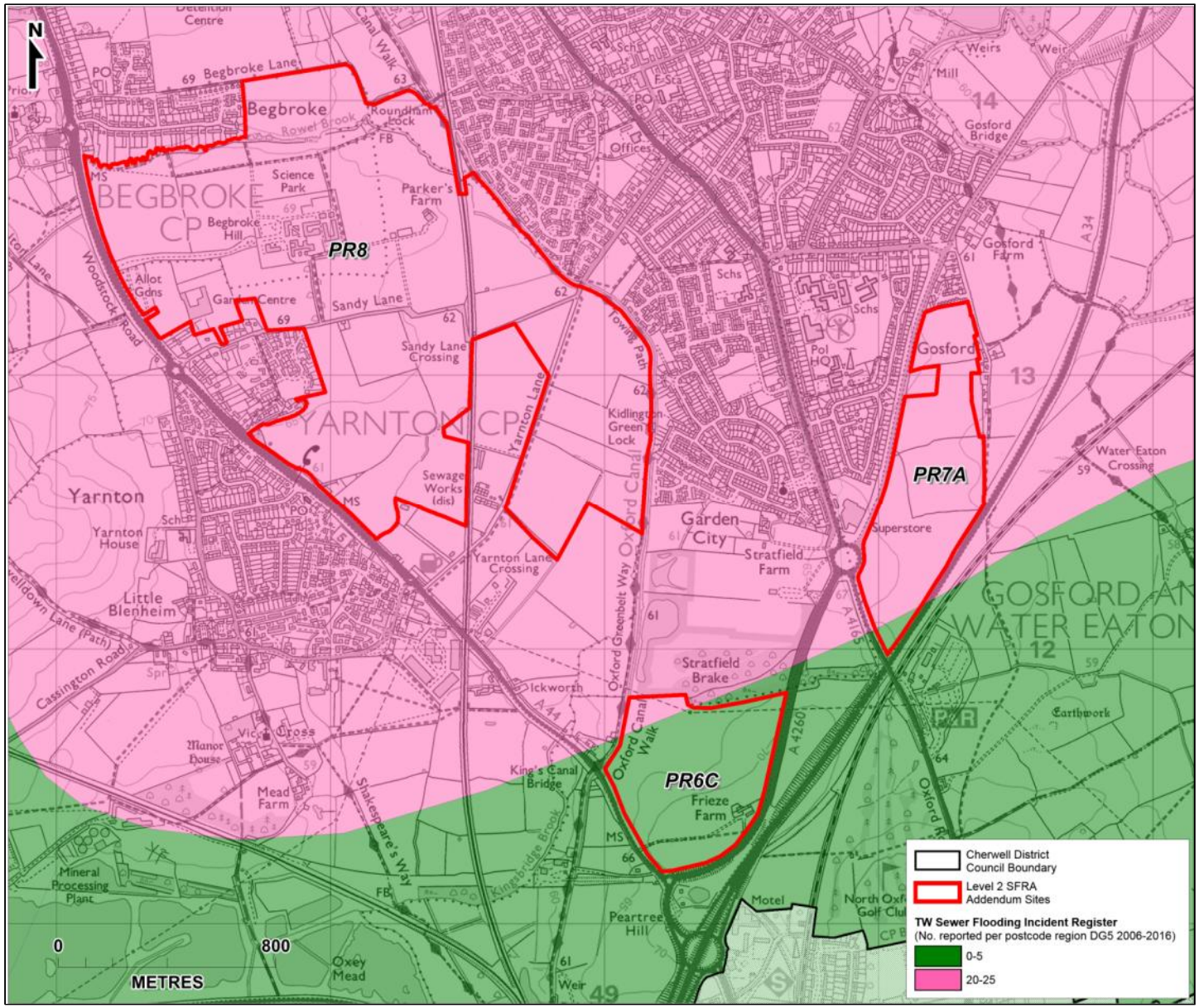

Figure B.3: Historical Total Reported Sewer Flooding Incidents (Thames Water DG5 2006-2016)

B.4 Risk of Flooding from Surface Water Map - All Level 2 SFRA Addendum Sites

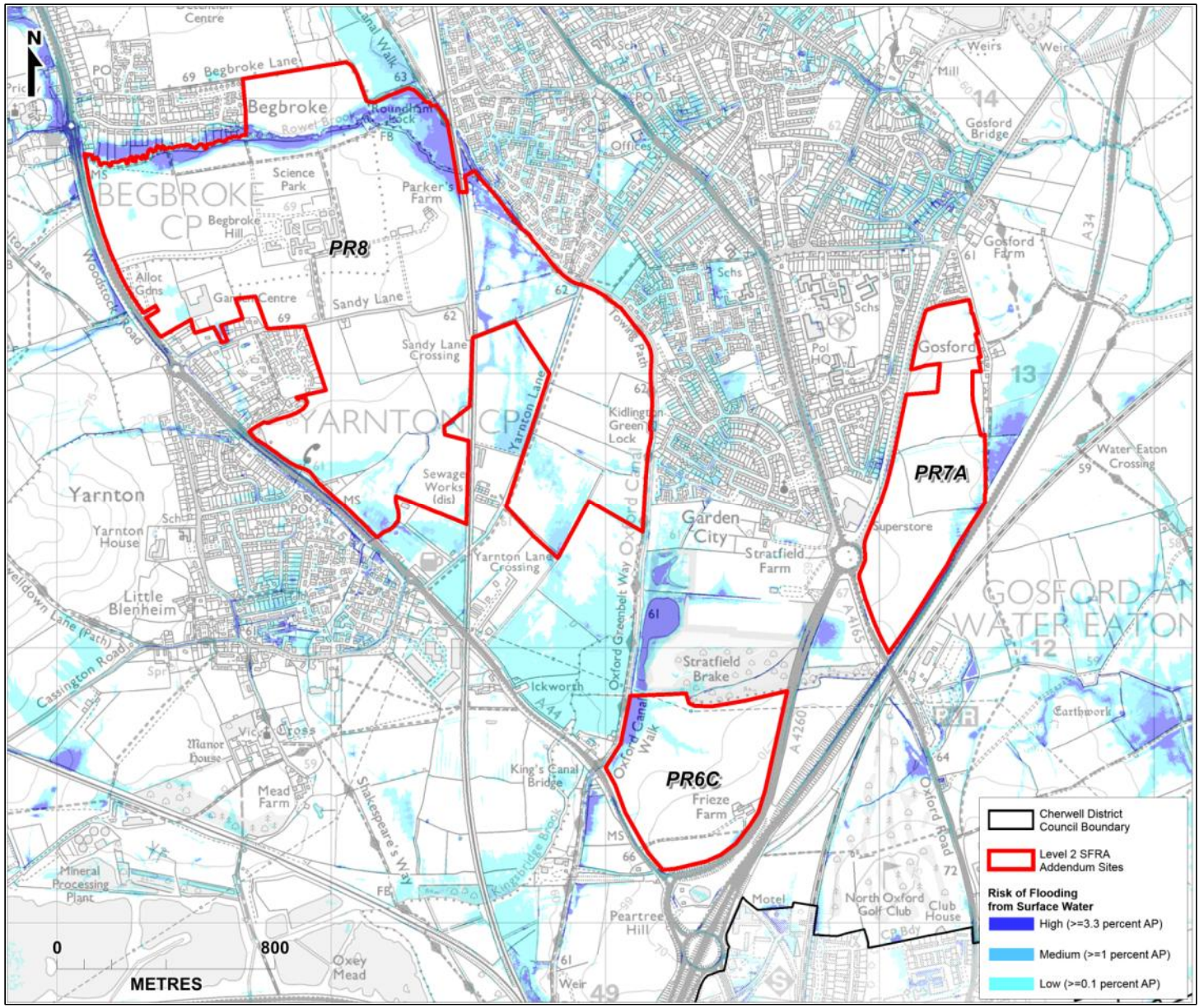

Figure B.4: Environment Agency Risk of Flooding from Surface Water Map (uFMfSW)

B.5 Historical Flooding Records - All Level 2 SFRA Addendum Sites

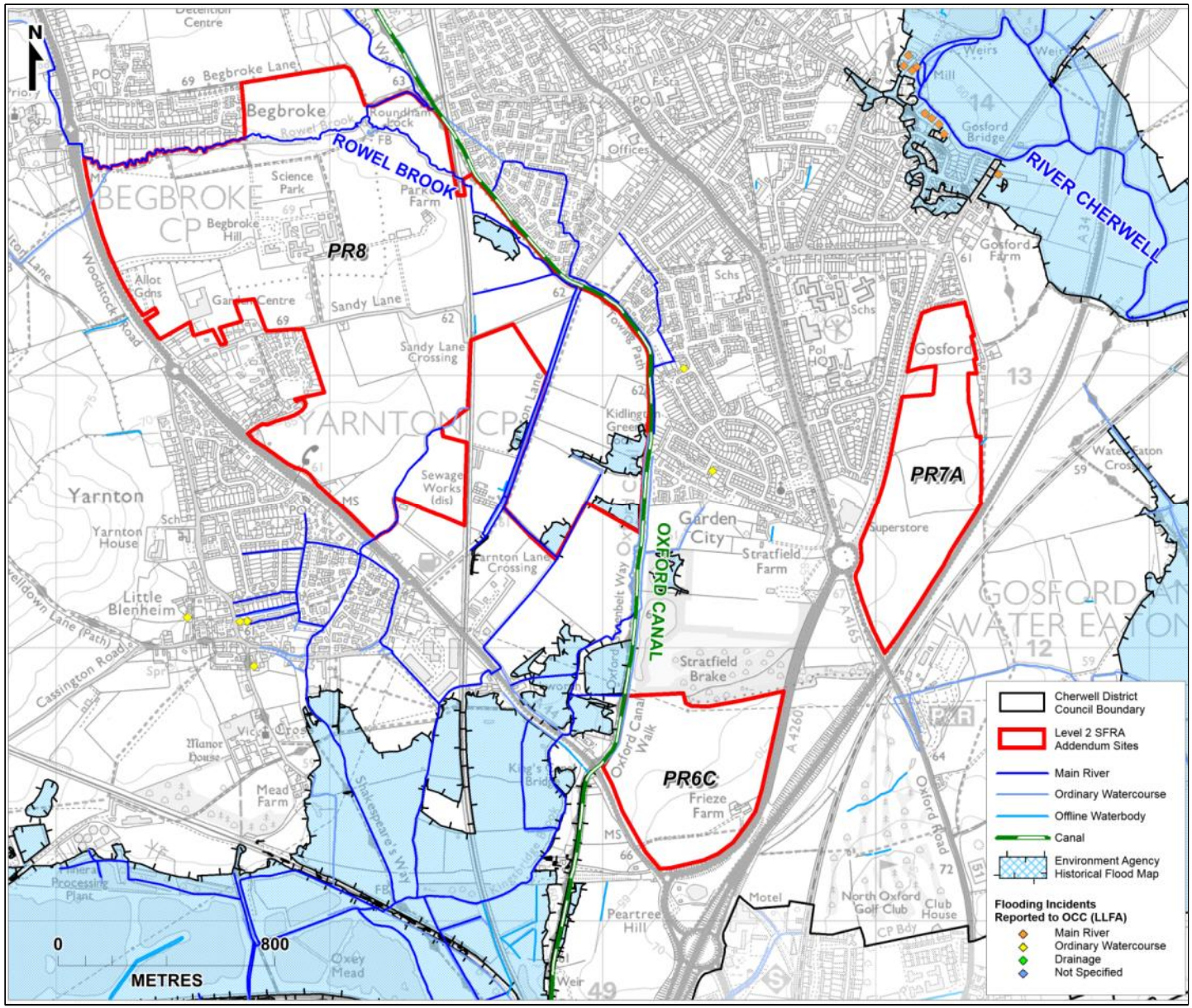

Figure B.5: Reported Historical Flooding Incidents

Appendix C – Modelled Flood Level & Contour Mapping

Table C.1: Modelled Flood Levels & Contour Mapping at Level 2 SFRA Potential Development Sites

Settlement Name	Site ID	Site Name	Description	Figure
Kidlington	PR6C	Land at Frieze Farm	Comparison of Contours with Modelled Water Levels along the Oxford Canal and Rowel Brook	Figure C.1
	PR7A	Land South East of Kidlington	Comparison of Contours with Modelled Water Levels along the River Cherwell	Figure C.2
Begbroke	PR8	Land East of the A44	Comparison of Contours with Modelled Water Levels along Rowel Brook	Figure C.3

C.1 Site PR6C - Contour Map vs Modelled Water Levels along the Oxford Canal and Rowel Brook

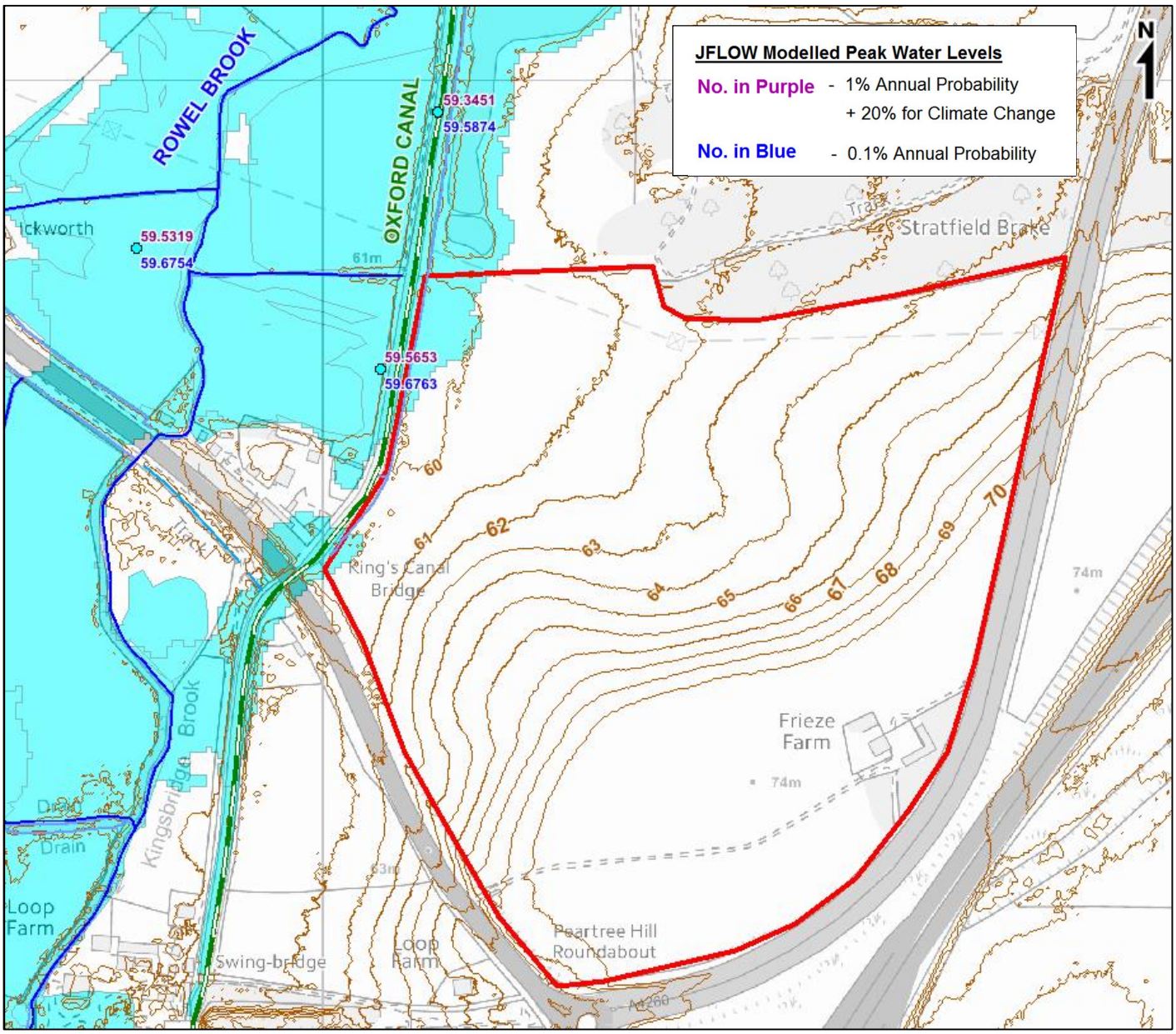

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Figure C.1: Comparison of Environment Agency Modelled Peak Water Levels and LiDAR Ground Levels within Site PR6C

C.2 Site PR7A - Site PR7A – Contour Map vs Modelled Water Levels along the River Cherwell

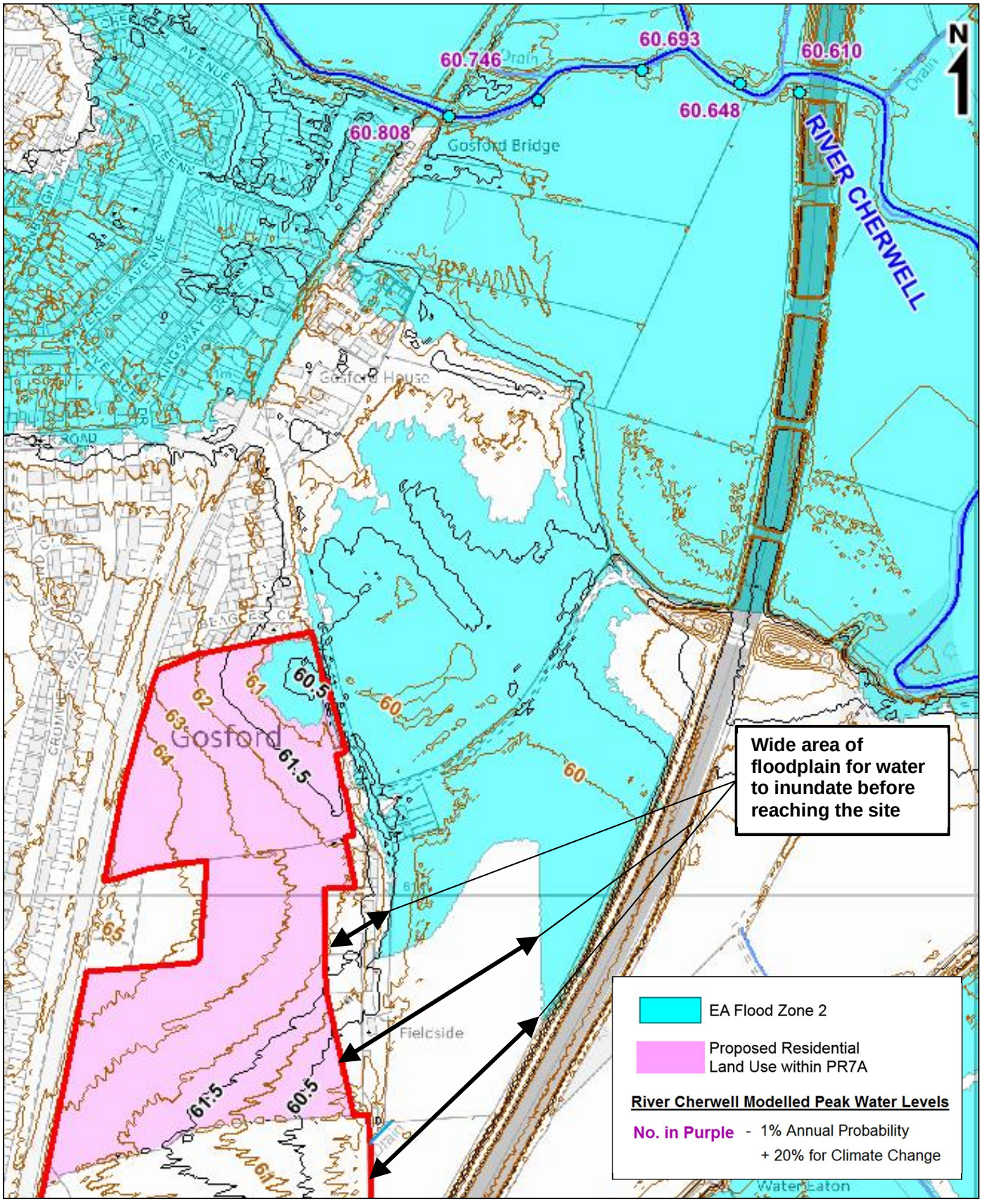

Figure C.2: Comparison of Environment Agency Modelled Peak Water Levels to LiDAR Contours within Site PR7

C.3 Site PR8 - Contours vs Modelled Water Levels along Rowel Brook

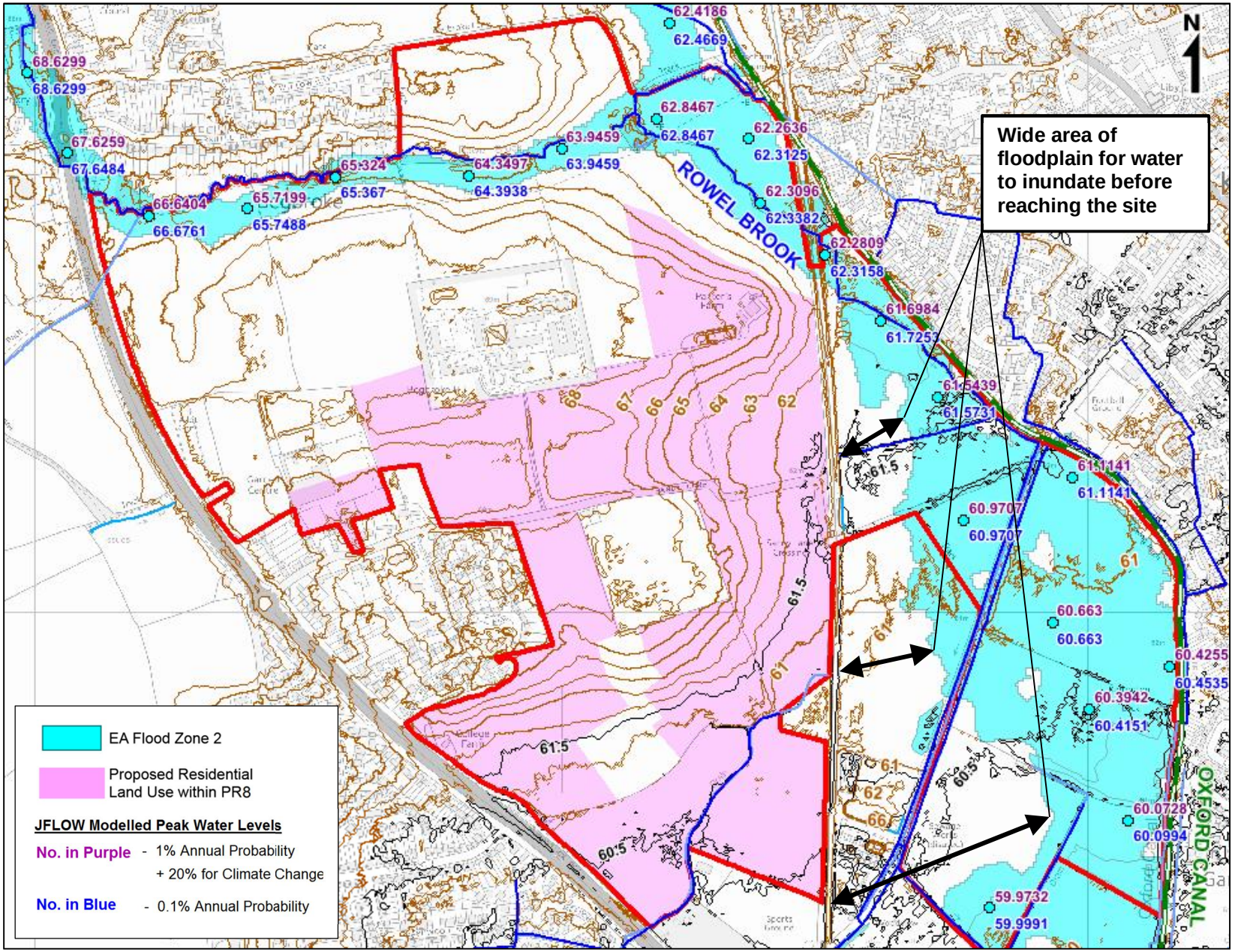

Figure C.3: Comparison of Environment Agency Modelled Peak Water Levels with LiDAR Ground Levels within Site PR8

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