

# **Stroud District Council**

Strategic Flood Risk Assessment for  
Local Development Framework  
Level 2 – Addendum Report

Addendum Report  
March 2014

**CH2M Hill Halcrow**



**Stroud District Council**  
Strategic Flood Risk Assessment for  
Local Development Framework  
Level 2 – Final Report  
Volume 1

**Contents Amendment Record**

This report has been issued and amended as follows:

<b>Issue</b>	<b>Revision</b>	<b>Description</b>	<b>Date</b>	<b>Signed</b>
1	0	Draft Report	26/03/14	R. Bailey
1	0	Final Report	27/03/2014	R. Bailey
1	1	Final Report	27/03/2014	R. Bailey

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Approved by: Rebecca Bailey



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**1 Introduction**

**1.1 Project Overview**

- 1.1.1 Halcrow Group Limited has been requested by Stroud District Council (DC) to produce an addendum to the existing Stroud Level 2 Strategic Flood Risk Assessment (SFRA) in order to assess the flood risk to three sites (Sites SA4, SA4a and SA5a) which have been identified for future development.
- 1.1.2 In March 2012, Halcrow completed a Level 2 SFRA for Stroud DC. This document included an assessment of flood risk from all sources for 124 sites and presented flood risk policies for future management of these sites. As a consequence of representations made by the Environment Agency, both parties agreed to update the Level 2 SFRA for three sites where updated flood risk information has become available or where further modelling was considered necessary in order to confirm the flood risk posed to the sites.
- 1.1.3 This addendum report builds on the previous Level 2 SFRA and provides an update to the assessment of flood risk for the three sites identified by Stroud District Council. It should be read in conjunction with the Stroud Level 2 SFRA (Halcrow, March 2012). This addendum report supersedes the Level 2 assessment for sites 9 and 321. The assessments and advice included in all other sections of the Stroud Level 2 Report remain relevant.
- 1.1.4 Since the publication of the Level 2 SFRA, the Government has replaced Planning Policy Statement 25 Development and Flood Risk (PPS 25) with the new National Planning Policy Framework (NPPF). The Government has also released National Planning Practice Guidance that replaces the previous NPPF Technical Guidance and the PPS25 Practice Guide. This addendum has been written in accordance with this new framework and Planning Practice Guidance.

**1.2 Study Aims and Objectives**

- 1.2.1 The aim of this Level 2 SFRA addendum is to provide an update to the assessment of flood risk posed to three sites identified by Stroud DC as requiring further assessment since the completion of the Level 2 SFRA in March 2012.
- 1.2.2 The three sites identified for assessment are detailed in Table 1.1.

**Table 1.1: Sites identified for assessment in the March 2014 Level 2 SFRA update**

Site ID	Previous SHLAA Ref, in Level 2 SFRA	Site Name
SA4	9	Land south of Severn Distribution Park
SA4a	n/a	Hunts Grove extension
SA5a	321	Quedgeley East

- 1.2.3 The main objectives of the study are to:
  - Extend the existing Quedgeley model approximately 1200m upstream of the current upstream boundary of the Beaufair Brook to incorporate the area to the north of Site SA4a and

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produce updated flood zone maps for the modelled watercourse taking into account the presence of flood defences and culverts.

- Use the updated Quedgeley model to determine whether there have been any impacts to the risk of flooding within Site SA4 (assessed as Site 9 within the March 2012 Level 2 SFRA).
- Utilise updated flood mapping information for the River Severn from the Environment Agency which incorporates both tidal and fluvial flood risk, for the area adjacent to Site SA5a in order to determine the flood risk to the site and implications for future development.
- Use the modelled results in conjunction with the updated surface water flood risk maps available from the Environment Agency to provide an assessment of the suitability of the identified sites for future development.
- Assess flood risk posed to the identified risk areas and recommend appropriate policies for potential development proposals that may come forward in the future.

1.2.4 Using the modelling results produced within this study and the new flood risk mapping for the River Severn at Sharpness, an assessment of flood risk posed to each of the sites has been undertaken, with associated recommendations provided. This will provide Stroud DC with a comprehensive understanding of flood risk posed to each potential development site, enabling the application of the Sequential and Exception Tests and informing the overall consideration of development. The site assessment methodology is explained in detail in Section 3 of the main Level 2 SFRA document. The results of the assessment are tabulated in tables March 2014 Addendum\_Table A.1 (Sites SA4 and SA4a) and March 2014 Addendum\_Table A.2 (Site SA5a), Appendix A of this addendum. Specific recommendations for each site are also presented in Appendix A and Section 5. Sections 3 and 4 present a summary of the findings of this SFRA update for the three sites.

1.2.5 The methodology for this Level 2 SFRA addendum takes full account of the requirements and guidance outlined in the National Planning Policy Framework (NPPF) (Department for Communities and Local Government, March 2012) and its accompanying Planning Practice Guidance.

1.2.6 The Environment Agency has been consulted throughout the study to ensure that the approach is robust and meets best practice. A letter of support from the Environment Agency is included in Appendix C.



## 2 Hydraulic & Hydrological Modelling Approach

2.1.1 This chapter provides a brief overview of the technical methods applied to produce the updated flood hazard mapping for the Quedgeley area covering Sites SA4 and SA4a. A technical note setting out the hydrological and hydraulic approach for the Quedgeley area can be found in the March 2014 Addendum\_Appendix B. Modelled flood hazard maps have been provided as digital GIS layers.

### 2.2 Hydrological Approach

2.2.1 The hydrological analyses undertaken for the existing modelling studies used within the March 2012 Level 2 SFRA have been maintained for this Level 2 SFRA update (Refer to Section 2.3 of Appendix B, Modelling Technical Note).

### 2.3 Hydraulic Approach

2.3.1 The modelling undertaken as part of the March 2012 Level 2 SFRA for the Quedgeley area has been utilised for this study. The modelling technical note in Appendix B details the updates made to the hydraulic model in order to extend the upstream boundary to incorporate Site SA4a. To enable 2D modelling, the 2D modelling software package TUFLOW was used in conjunction with LiDAR data and where appropriate, additional survey.

2.3.2 No additional hydraulic modelling was undertaken for Site SA5a.

### 2.4 UK Flood Hazard

2.4.1 In addition to the TUFLOW outputs of depth and velocity, the UK Flood Hazard is also calculated by the model. The output includes a grid of Flood Hazard derived from the flood depth and velocity outputs and a debris factor. The hazard and its associated classification are calculated within TUFLOW. The UK Flood Hazard is calculated by using the following equation from Defra's Flood Risks to People – Phase Two Document (FD2321/ TR2) (2006).

2.4.2 Hazard is calculated as follows:

$$\text{Hazard} = d \times (v + 0.5) + DF$$

Where **d** = depth (m)

**V** = velocity (m/s)

**DF** = debris factor

2.4.3 Based on the value of the hazard for a given area, a Hazard Classification is then assigned. The Flood Hazard classifications are divided into four classes of risk:

**Table 2.1: Flood Hazard Rating and Associated Category**

Flood Hazard Rating	Category
0.0 – 0.75	Low
0.75 – 1.25	Moderate
1.25 – 2.5	Significant
2.5 +	Extreme

2.4.4 These classes of risk then translate into the following Flood Hazard classification (Figure 2.1):

- Class 1: Danger for some – Flood zone with deep or fast flowing water that presents a hazard for some people (i.e. children)
- Class 2: Danger for most – Flood zone with deep or fast flowing water that presents a hazard for most people
- Class 3: Danger for all – Flood zone with deep or fast flowing water that presents a hazard for all people

2.4.5 For example, if peak water depths are 1.0 m, for velocities less than 1.0 m/s, the flooding is considered to present ‘Danger for some’. For velocities between 1.0 m/s and 2.0 m/s the flooding is considered to present ‘Danger for most’. For velocities greater than 2.0 m/s the flooding is considered to present ‘Danger for all’.



**Figure 2.1: Flood Hazard Classification**

2.4.6 Updated flood hazard outlines have been provided to the Council as digital GIS layers for the areas where updated modelling has been undertaken.

**2.5 Breach and Overtopping Scenarios**

**Culvert Blockage**

2.5.1 There are numerous culverts in the study area, each of which pose the risk of complete or partial blockage, or indeed collapse. This poses residual risk to the surrounding area (which might be bigger than the risk area identified by Flood Zones 2 and 3).

2.5.2 A review was undertaken of culverts along the modelled watercourses. Where the modelling exercise indicated issues of surcharging (due to insufficient capacity for a given flood event) or where a culvert was located in the vicinity a study area, an analysis of residual risk was deemed necessary. For the purposes of this study, 50% and 90% blockages were modelled using the 1 in 100 year events for the

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relevant watercourses. Section 3.5 summarises the locations at which culvert blockages were undertaken in relation to the modelled watercourses and identified sites.

### Defence Breach and Overtopping

- 2.5.3 Flooding behind flood defences can occur as a result of constructional or operational failure of the defence, either in whole or in part (breach), or water levels rising to exceed the level of the defence (overtopping). These mechanisms can lead to rapid inundation of areas by flood water and the consequences can be potentially catastrophic. A review of the Environment Agency's NFCDD database identified a series of defences within the Sharpness area adjacent to Site SA5a. These formed a series of earth embankments. Following consultation with the Environment Agency as part of the March 2012 Level 2 SFRA, it was agreed to undertake breach analysis at two locations along the defences to determine the residual risk. One of these locations was adjacent to Site SA5a and the results have been used in the assessment of residual risk from defence breach and overtopping for Site SA5a. Section 4.6 summarises the findings of this assessment.

### Canal Breach and Overtopping

- 2.5.4 No section of raised canal were identified adjacent to the sites assessed as part of this Level 2 SFRA update and therefore no canal breach or overtopping scenarios have been modelled.

## 2.6 Model QA

- 2.6.1 TUFLOW and ISIS automatically generate a list of errors, warnings and notes for each model run. A review of these messages was undertaken to assess any potential problems with the model. The messages were checked in the model and were either consistent with the model inputs or had no impact on the model results and thus no changes were required. All hydraulic and hydrological models have undergone a thorough checking process and subsequent QA and approval by a senior hydraulic modeller and senior hydrologist respectively.

### 3 Quedgeley: Site SA4 Hunts Grove Extension and Site SA4a Land at Quedgeley East

#### 3.1 Overview

3.1.1 The area of Quedgeley is located on the Gloucester Fringe. Two potential development sites have been identified as requiring assessment as part of this Level 2 SFRA update:

- Site SA4 'Hunts Grove Extension' covers approximately 27.26ha and is situated to the east of the B4008. Haresfield Lane forms the northern boundary of the site and the M5 is located to the south.
- Site SA4a 'Land at Quedgeley East' covers approximately 13.87ha and is located south of Quedgeley East Business Park between the M5 to the north, the B4008 to the west and Stonehouse to the south.

3.1.2 Two watercourses are located within the vicinity of sites. The Shorn Brook flows in a westerly direction to the north of Site SA4. The Beaufair Brook is located between the two sites, flowing in a westerly direction through the study area. Figure 3.1 shows the location of the two sites in relation to the Shorn Brook and Beaufair Brook. Neither of the watercourses flow within the sites themselves, however, the modelling from the March 2012 SFRA showed a risk of fluvial flooding to part of Site SA4.

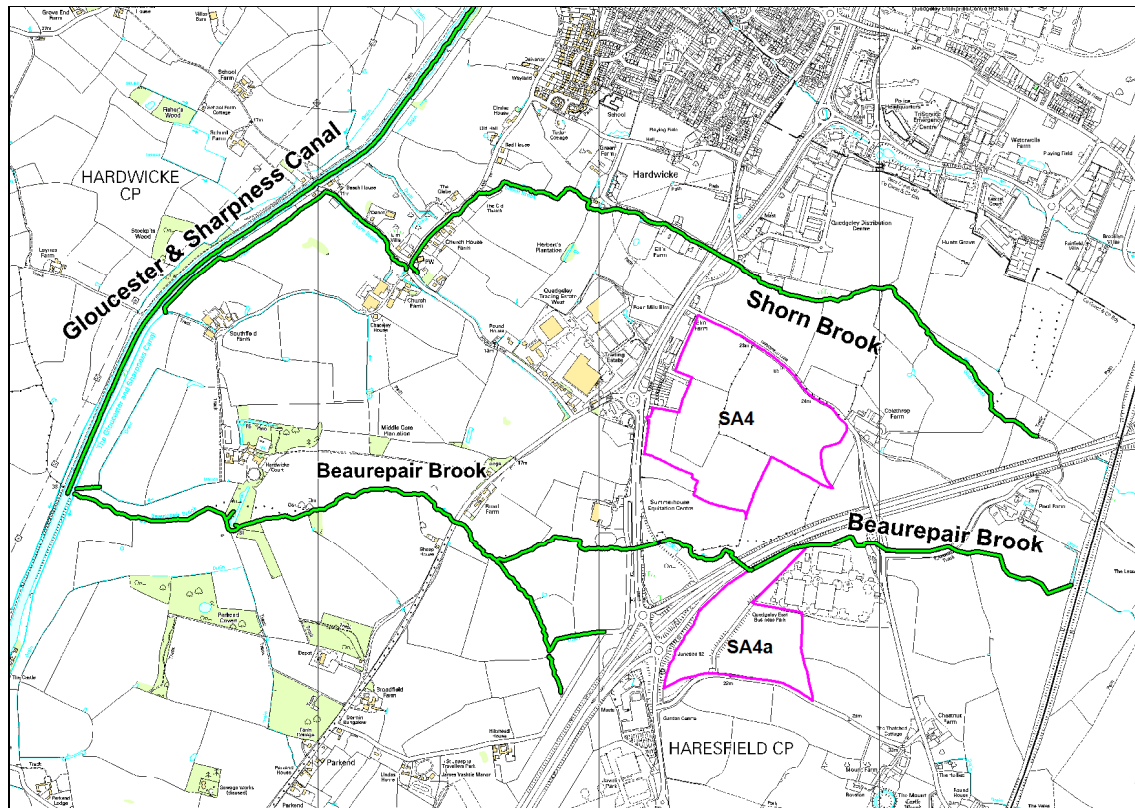


Figure 3. 1: Location of watercourses adjacent to Sites SA4 and SA4a (Site boundaries shown in pink. Watercourses shown in green)

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- 3.1.3 Site SA4 was assessed as part of the March 2012 Level 2 SFRA, being referred to as Site 9 in the March 2012 report. Both the Shorn Brook and Beaufair Brook were included in the hydraulic model. However, modelling undertaken for the Beaufair Brook did not cover the area adjacent to SA4a. It was therefore agreed by both Stroud District Council and the Environment Agency that additional modelling was required in order to extend the existing Level 2 SFRA model approximately 1200m upstream along the Beaufair Brook to incorporate Site SA4a to enable a more comprehensive assessment of fluvial flood risk to the site.

### **3.2 Aim of Level 2 SFRA Update**

- 3.2.1 The aim of this Level 2 SFRA update is to utilise the existing hydraulic model for Quedgeley produced as part of the March 2012 Level 2 SFRA, and extend the model approximately 1200m upstream along the Beaufair Brook to enable the risk of fluvial flooding to Site SA4a to be assessed in conjunction with the flood risk information available for other sources of flooding within the site. Based on the updated modelling, the risk of fluvial flooding to Site SA4 was also reassessed in order to determine whether there has been any change to the modelled flood outlines within the site.
- 3.2.2 A residual risk of flooding from blockage at three structures along the Beaufair Brook has been identified and hydraulic modelling has been undertaken to determine the residual risk to both sites SA4 and SA4a.
- 3.2.3 Appendix B outlines in more detail the hydrological and hydraulic modelling undertaken as part of the assessment. The results of the site assessments are tabulated in table March 2014 Addendum\_Table A.1, Appendix A of this addendum. Site plans are also presented in Appendix A. Digital GIS layers of the updated modelled flood outlines have also been provided to Stroud District Council.

### **3.3 Historic Flooding**

- 3.3.1 The Level 1 SFRA provided a detailed review of historic flooding within the Stroud area. March 2014 Addendum\_Table A.1 (Appendix A) and the individual site plans (Appendix A) demonstrate that there are no historic flood outlines affecting either of the sites. However, there are a number of recorded incidents of flooding shown to be within or adjacent to the sites.
- 3.3.2 For Site SA4, there are two recorded incidents of flooding recorded to the west of the site adjacent to the A4009. The recorded incidents of flooding are outside of the site itself and are from unknown sources. The recorded incidents also coincide with the modelled Flood Zones produced as part of this study.
- 3.3.3 For Site SA4a, there are two recorded incidents of flooding from other sources along Mount Lane at the southern boundary of the site. One of the incidents is recorded as surface water flooding which occurred as a result of heavy rainfall. This coincides with the Environment Agency's updated surface water risk map. The source of the second recorded incident is unknown. The recorded incidents also coincide with the modelled Flood Zones produced as part of this study.
- 3.3.4 Risk from groundwater flooding within the District is largely unknown. Although data collected for both the Level 1 and Level 2 SFRA has not uncovered specific areas potentially at risk, the assessment undertaken is not exhaustive and the risk of flooding from groundwater flooding should be considered as part of any further FRA. There are no recorded incidents of flooding from other sources within or adjacent to the site.

### 3.4 Assessment of Flood Risk

#### Fluvial Flood Risk – Model Results

- 3.4.1 The results of the model runs for the 1 in 20 year, 1 in 100 year and the 1 in 1000 year fluvial flood events are presented in the site plans of this addendum in Appendix A. The individual site assessment is presented in table March 2014 Addendum\_A.1, Appendix A.

#### Site SA4

- 3.4.2 With the updated hydraulic modelling along the Beaurepair Brook, there has been no significant change to the extent of fluvial flooding within Site SA4. The modelled flood zones show that the majority of the development site is located within Flood Zone 1, with the south western corner of the site marginally affected by Flood Zones 2, 3a and 3b. Figure 3.2 shows a comparison of the modelled Flood Zone 3a from the existing SFRA (March 2012) and the updated modelling undertaken as part of this study.

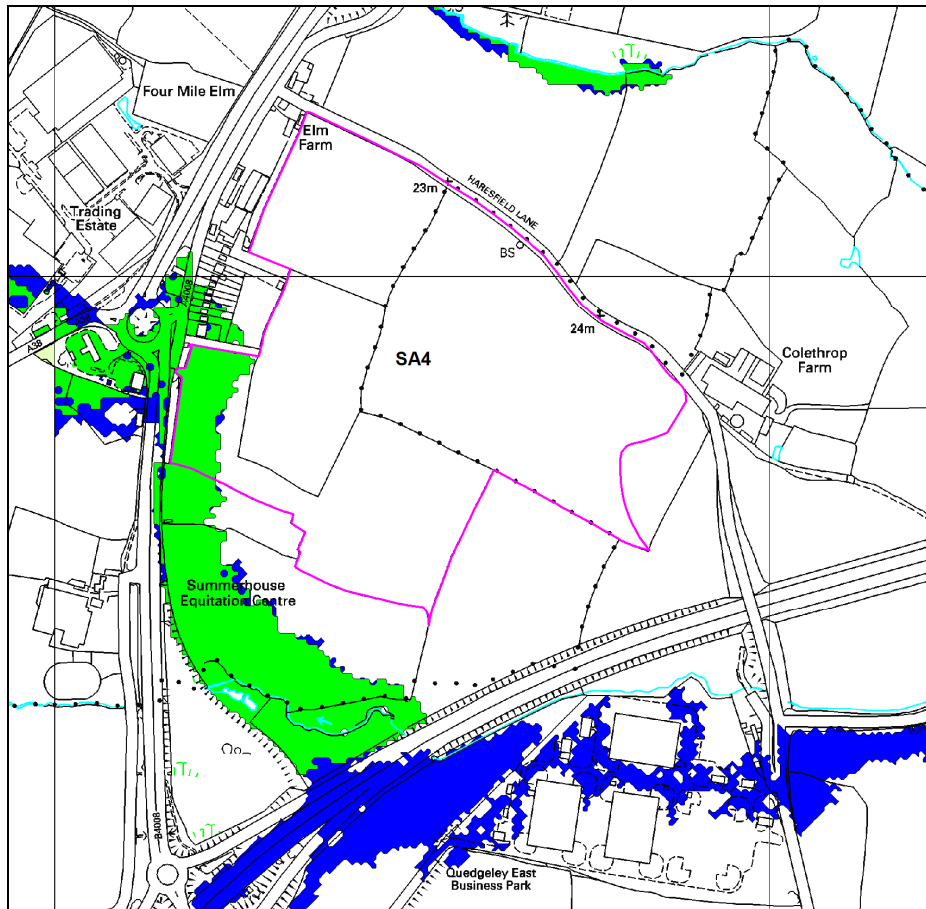


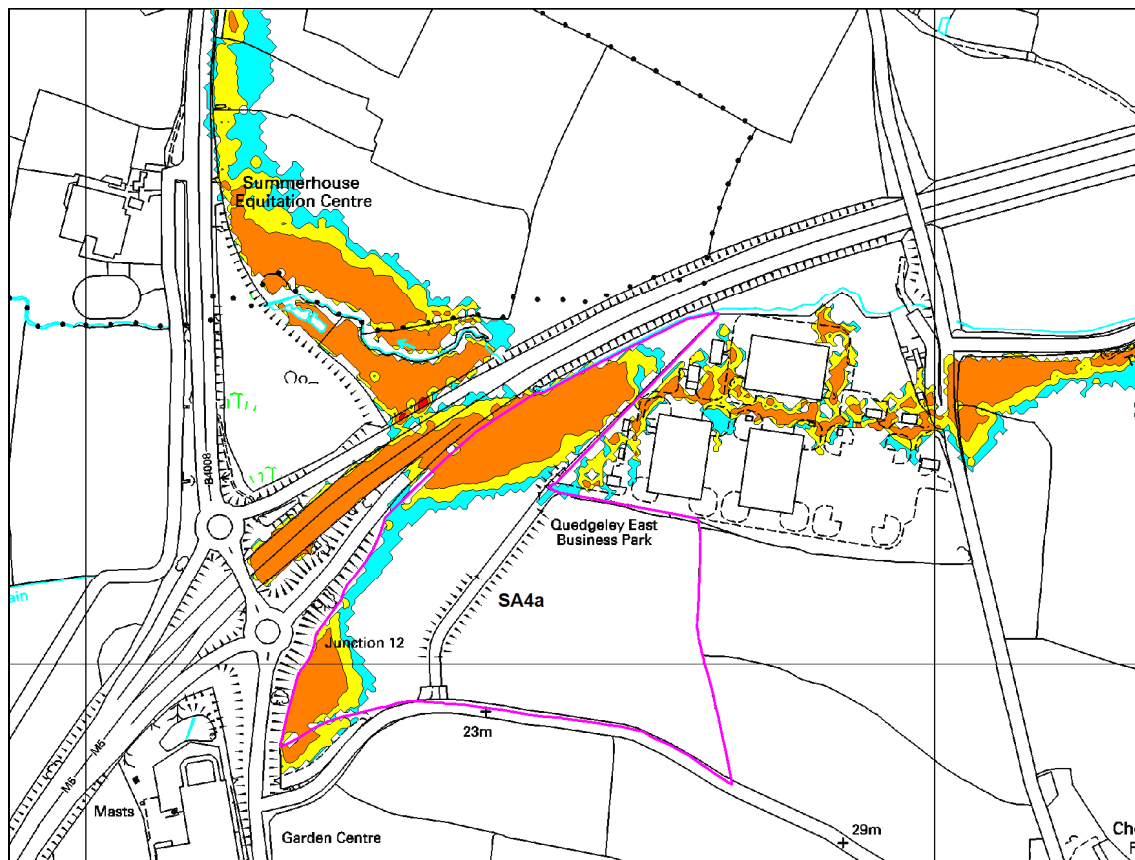
Figure 3.2: Comparison of updated Flood Zone 3a for the Quedgeley model (shown in blue) with the March 2012 Level 2 SFRA modelled Flood Zone 3a (shown in green). Site boundary is shown in pink.

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- 3.4.3 Flood water spills onto the floodplain on the left bank of the watercourse and flows in a westerly direction towards the M5. Water then backs-up behind the M5 structure, with some flood water spilling over the M5 and continuing in a northerly direction towards the development site.
- 3.4.4 As with the existing Level 2 SFRA, the hydraulic modelling undertaken has represented the floodplain in this area as a 2D domain. Access to the culvert beneath the B4008 was not possible, and as such, this culvert has not been represented within the model and the flow path shown by the modelled extents is considered conservative. However, a comparison of the modelled Flood Zone 3 with the locally agreed surface water map demonstrates a similar extent of surface water flooding in this area. This indicates that there is an overland flow route within this area where flood water is likely to flow and accumulate, which should be taken into consideration in development planning.

**Site SA4a**

- 3.4.5 The modelling undertaken as part of this Level 2 SFRA update has shown that the western and northern parts of the site are affected by Flood Zones 2, 3a and 3b from the Beaufreap Brook. There is little difference in the extent of flooding between the modelled events, and a review of the flood hazard classification shows that for Flood Zone 3b, the hazard is predominantly moderate to significant (Figure 3.3).



**Figure 3.3: Flood hazard classification for parts of Site SA4a affected by fluvial flooding (Light blue areas indicate low hazard, yellow areas indicate moderate hazard and orange areas represent significant hazard).**

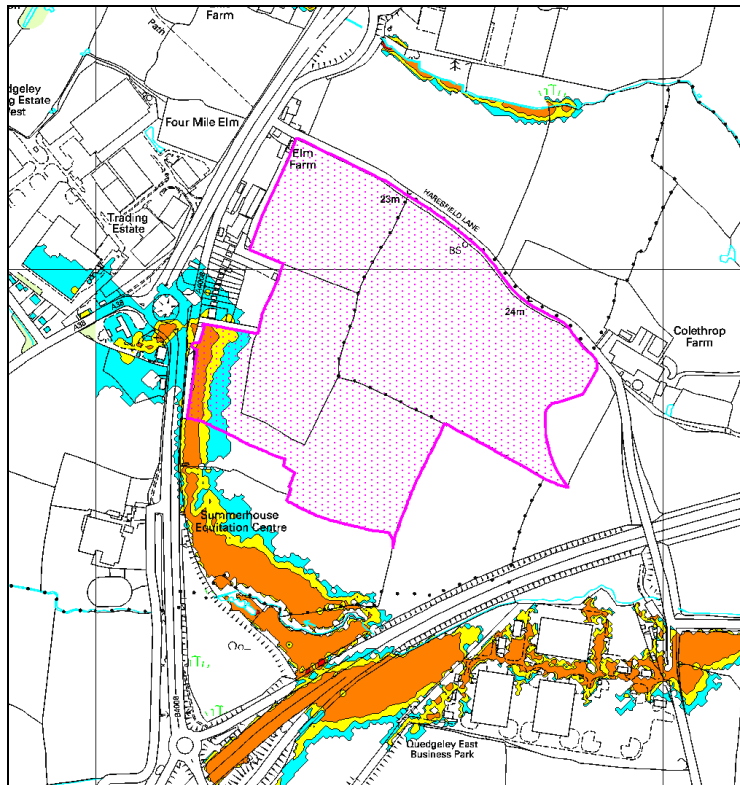
- 3.4.6 It should be noted that the modelled flood zones produced for the Quedgeley area as part of both the March 2012 Level 2 SFRA and this update study are considered to present a conservative estimation

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of flood risk to the site. As detailed in the modelling technical note included within Appendix B, the watercourses modelled have been represented using a Digital Terrain Model (DTM) as opposed to a detailed river channel survey and as such, the flow paths may be overestimated as the capacity of the river channel may be greater than that contained within the DTM. Given the moderate to significant flood hazard classification for the modelled Flood Zone 3b, it is strongly recommended that this area is kept as open space with identified flow paths kept clear, and built development directed towards the parts of the site at lowest risk within Flood Zone 1. Car parking in these areas should ideally be avoided, however if car parking is necessary within the identified risk areas, it should only be allowed if appropriate management plans are in place and people and property can be made safe in the event of a flood.

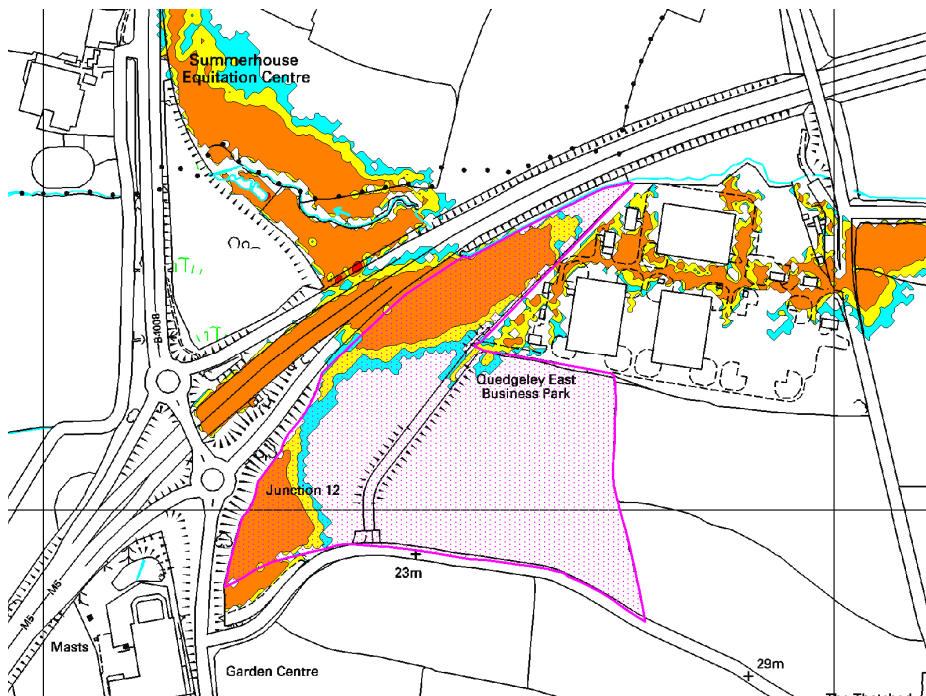
**Climate Change**

3.4.7 The results of the model runs for the 1 in 100 year climate change scenario are presented in the site plans of this addendum in Appendix A. Digital copies of the 1 in 100 year climate change flood outlines have also been provided to the council. The modelled extents for the 1 in 100 year climate change scenario have shown that for both Site SA4 (Figure 3.4) and SA4a (Figure 3.5), there is a marginal increase in the extent of flooding. For both sites, the flood hazard classification is predominantly moderate to significant within the affected parts of the site.



**Figure 3.4: Site SA4 - 1 in 100 Year Climate Change Scenario Hazard Map**





**Figure 3.5: Site SA4a - 1 in 100 Year Climate Change Scenario Hazard Map**

### Surface Water Flood Risk

3.4.8 Risk of surface water flooding has been assessed using the Environment Agency’s updated Flood Map for Surface Water. The site plans in Appendix A present maps of the surface water flood risk areas within the affected sites.

### Site SA4

3.4.9 The updated Flood Map for Surface Water shows a risk of surface water flooding to the south western corner of the site which is similar in extent to the modelled Flood Zone 3a. The risk of surface water flooding is considered low for much of the site, with the depth of flooding typically being less than 300mm. There are however some parts of the site where the depth of surface water flooding is shown to be between 300-900mm. Again, these areas generally coincide with the fluvial flood risk areas. It is recommended that development is directed away from the identified surface water risk areas, and the identified surface water flow routes are kept as open space.

### Site SA4a

3.4.10 The updated Flood Map for Surface Water shows a risk of surface water flooding within the western and northern extents of Site SA4a. Here, the extent of flooding is similar in extent to the modelled Flood Zone 3a and the depth of flooding is typically less than 300mm. There are however some parts of the site where the depth of surface water flooding is shown to be between 300-900mm. These are largely in the south western most corner and northern boundary of the site. Part of the eastern extent of the site is also shown to be at risk from surface water flooding. This is outside of the modelled flood zones and the depth of flooding is typically less than 300mm. It is recommended that development is directed away from the identified surface water risk areas, and the identified surface water flow routes are kept as open space.

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**3.5 Residual Risk**

**Culvert Blockage**

- 3.5.1 Modelling of both a 50% and 90% blockage has been undertaken at three key structures identified within the study area along the Beaurepair Brook. Table 3.1 details the locations where blockage scenarios were undertaken.

**Table 3.1: Culvert blockage locations along the Beaurepair Brook**

Watercourse	Location	Grid Reference
Beaurepair Brook	Haresfield Lane	SO 8100 1141
	M5 Culvert	SO 8051 1134
	B4008 Culvert	SO 8013 1140

**Site SA4**

- 3.5.2 The modelling results have demonstrated that with a 50% blockage applied to all three blockage locations during a 1 in 100 year event, there is a slight increase in the extent of flooding to the south western corner of the site within the area adjacent to Junction 12 of the M5. Within the identified residual risk area, the flood hazard is predominantly significant to extreme, with small areas of lower hazard further into the site.
- 3.5.3 With a 90% blockage applied to the three culverts identified in Table 3.1, the extent of flooding increases marginally within the south western corner of the site adjacent to Junction 12 of the M5. Again, the flood hazard is predominantly low within the effected parts of the site; however, within the south western part of the site, the flood hazard classification increases to significant to extreme.

**Site SA4a**

- 3.5.4 The modelling results have demonstrated that with a 50% blockage applied to all three blockage locations during a 1 in 100 year event, there is a marginal increase in flood extent within Site SA4a. In general, the flood hazard classification is low within the affected parts of the site; however the south western part of the site shows an increased flood hazard, being classified as significant to extreme.
- 3.5.5 With a 90% blockage applied to the three culverts identified in Table 3.1, the extent of flooding is marginally greater in extent to the modelled Flood Zone 3a. Again, the flood hazard is predominantly low within the effected parts of the site; however, within the south western part of the site, the flood hazard classification increases from significant to extreme.

**Canal Breach or Overtopping**

- 3.5.6 Neither of the sites are deemed to be at risk from canal breach or overtopping.

**3.6 Summary**

- 3.6.1 The modelling results have demonstrated that with the updates made to the Quedgeley Model at the Beaurepair Brook, there is no significant difference in the extent of flooding experienced within Site SA4. The modelled flood zones show that the majority of the development site is located within Flood Zone 1, with the south western corner of the site marginally affected by Flood Zones 2, 3a and 3b. As outlined in the March 2012 Level 2 SFRA, significant overland flow routes have been identified from the Beaurepair Brook which impact upon Site SA4. These are largely the result of an area of raised

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ground immediately upstream of the B4008, which forces the floodwater to the north. A comparison of the modelled Flood Zone 3 with the locally agreed surface water map demonstrates a similar extent of surface water flooding in this area. In addition, the flood hazard classification is significant. This indicates that there is an overland flow route within this area where flood water is likely to accumulate and development within the identified flood risk areas should be avoided.

- 3.6.2 For Site SA4a, the modelling has shown that the western and northern parts of the site are affected by Flood Zones 2, 3a and 3b from the Bearepair Brook. There is little difference in the extent of flooding between the modelled events, and the flood hazard classification is predominantly moderate to significant within the affected parts of the site. Given the extent of the modelled Flood Zone 3b within the site, and the moderate to significant flood hazard classification, it is strongly recommended that this area is kept as open space with identified flow paths kept clear. Any built development should be directed towards the areas of the site at least risk within Flood Zone 1. Car parking in these areas should ideally be avoided, however if car parking is necessary within the identified risk areas, it should only be allowed if appropriate management plans are in place and people and property can be made safe in the event of a flood.
- 3.6.3 Where surface water flooding has been identified, the risk areas generally coincide with the fluvial flood zones. This applies to both of the sites. The updated Environment Agency Surface Water maps show that the flooding is typically less than 300mm in depth, although there are some areas where the identified surface water flooding is greater than 300mm. As outlined in the 2012 Level 2 SFRA, Careful consideration should be paid to areas within Quedgeley where a high surface water flooding hazard has been demonstrated. Investigations as part of site specific flood risk assessments for new developments should seek to obtain additional information and refine the assessments made in this report. The need to make space for water is pertinent in many areas of Quedgeley and regeneration will provide an opportunity to manage this risk. Where surface water flow paths are identified it is recommended that these areas are kept clear of built development and are adopted as open space, particularly where access routes are required.

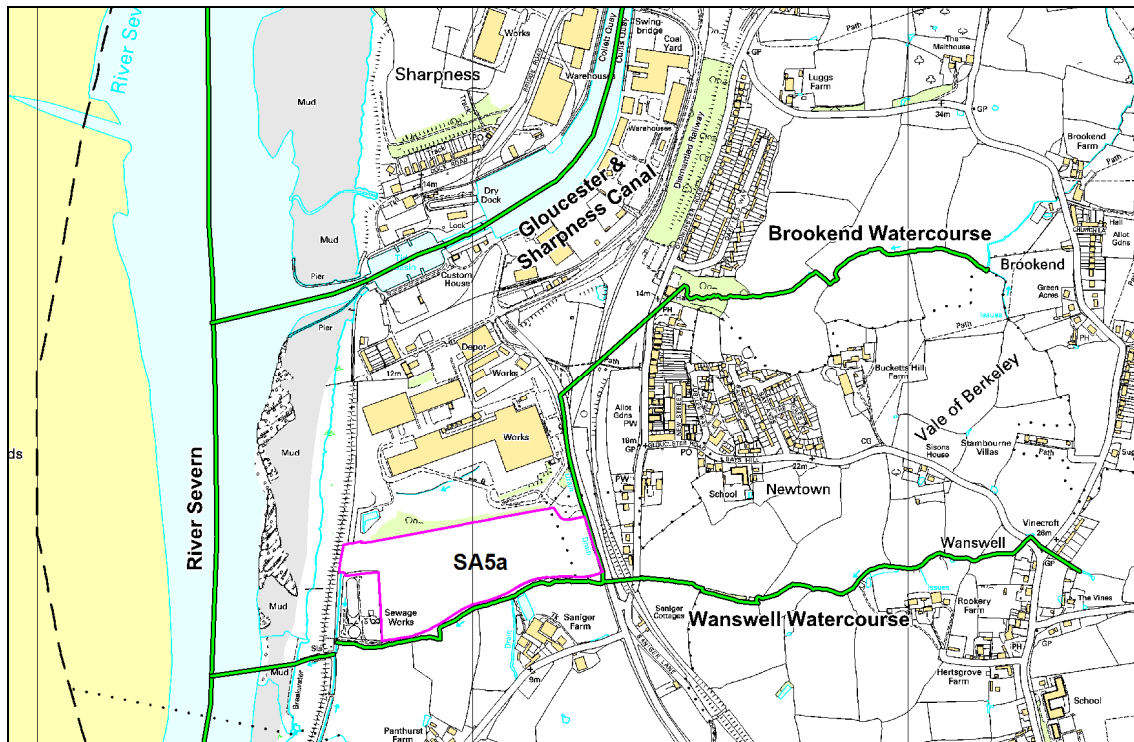
The main residual risk within the study extent is from the blockage or collapse of culverts. However, the modelling has shown that with both a 50% and 90% blockage applied to the identified culvert locations along the Bearepair Brook, there is little increase in the modelled flood extent, and the flood hazard shows a significant flood hazard. Any identified risk areas should be taken into consideration in the development of both Sites SA4 and SA4a.

## 4 Sharpness: Site SA5A – Land South of Severn Distribution Park

### 4.1 Overview

4.1.1 Sharpness is located within the south western extent of the Stroud District at the head of the Bristol Channel Navigation and the seaward end of the Gloucester and Sharpness Canal. Site SA5a is situated in land to the south of Severn Distribution Park (Figure 4.1). Part of the Sharpness area was assessed as part of the March 2012 Level 2 SFRA, being referred to as Site 321 in the existing report. In light of updated flood zone mapping provided by the Environment Agency in March 2014, it was agreed that the site should be reassessed.

4.1.2 Site SA5a covers an area of approximately 9.8ha. The B4066 forms the eastern boundary of the site. There are no watercourses within the site itself; however, there are three watercourses and a drain within the vicinity of the site.



**Figure 4.1: Location of watercourses adjacent to Site SA5a (Site boundaries shown in pink. Watercourses shown in green)**

4.1.3 The River Severn is located approximately 80m to the west of the site. A series of raised defences are located along the left bank of the watercourse within the area adjacent to the potential development site. These take the form of raised earth embankments. Throughout the part of the River Severn covering the study area, both fluvial and tidal influences are experienced. There is an unnamed watercourse along the southern boundary of the site. This was referred to as Wanswell in the March 2012 Level 2 SFRA. Wanswell flows in a westerly direction along the southern boundary of the site, before joining the River Severn at SO 6668 0134. At the downstream extent, there is a flapped outfall which becomes locked when there is a high tide on the River Severn. This prevents water from the watercourse flowing into the River Severn, causing it to back-up within the channel.

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Approximately 100m to the north of the site there is a further unnamed watercourse, referred to as Brookend in the March 2012 Level 2 SFRA. Brookend rises at Brookend, and flows in a westerly direction towards Sharpness. At SO 6748 0212 the watercourse flows into a culvert which is assumed to discharge into the Gloucester and Sharpness Canal at SO 6710 0230. An unnamed drain forms the eastern boundary of the site.

### **4.2 Aim of Level 2 SFRA Update**

- 4.2.1 The main aim of this Level 2 SFRA update is to reassess the risk of flooding from all sources to Site SA5a, incorporating the updated flood zone maps released by the Environment Agency in March 2014. The results of the assessment are tabulated in the table March 2014 Addendum\_A.2, Appendix A of this addendum. Site plans are also presented in Appendix A.

### **4.3 Historic Flooding**

- 4.3.1 The Level 1 SFRA provided a detailed review of historic flooding within the Stroud area. Historically flooding the River Severn Estuary has occurred since Roman times. Table March 2014 Addendum\_A.2 (Appendix A) and the individual site plans (Appendix A) demonstrate that there are no historic flood outlines which affect the site, with the site shown to be protected by the earth embankment situated along the western edge of the site. It should be noted that whilst there are no historic flood outlines shown to affect the site from the Wanswell and Brookend watercourses, this may be due to a lack of records as these watercourses flow through predominantly rural areas. However, the fluvial modelling undertaken as part of the March 2012 Level 2 SFRA did not show a risk of fluvial flooding to the site from these watercourses.
- 4.3.2 Risk from groundwater flooding within the District is largely unknown. Although data collected for both the Level 1 and Level 2 SFRA has not uncovered specific areas potentially at risk, the assessment undertaken is not exhaustive and the risk of flooding from groundwater flooding should be considered as part of any further FRA. There are no recorded incidents of flooding from other sources within or adjacent to the site.

### **4.4 Assessment of Flood Risk – Fluvial and Tidal**

#### **Fluvial Flood Risk – Model Results**

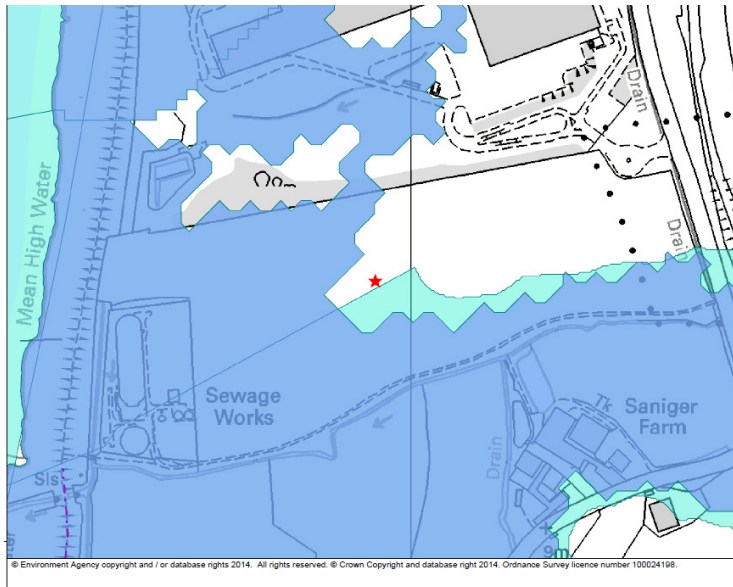
- 4.4.1 Fluvial flood risk to the site has been assessed using the modelled flood outlines and hazard maps produced for the Sharpness area as part of the March 2012 Level 2 SFRA. The results of the model runs for the 1 in 20 year, 1 in 100 year and 1 in 1000 year fluvial flood events are presented in the site plans in Appendix A. The individual site assessment is presented in March 2014 Addendum\_A.2, Appendix A.
- 4.4.2 The modelled fluvial flood outlines show that there is no risk of fluvial flooding to the site from the fluvial River Severn or the Wanswell and Brookend watercourses and the site is located fully in Flood Zone 1. It should be noted that the updated tidal mapping from the Environment Agency does however include some fluvial and tidal risk. This is discussed below. The earth embankment along the western edge of the site is shown to protect the area from inundation from the fluvial River Severn. Flooding is experienced from the Wanswell, affecting the area to the south of the site, however this does not impact on the site itself. The flood hazard is predominantly low for all of the modelled events.

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**Tidal Flood Risk – River Severn**

- 4.4.3 Tidal flood risk to the site has been assessed using the update Flood Zone maps released by the Environment Agency in March 2014. The latest flood mapping from the Environment Agency includes a combination of both the fluvial and tidal flood risk from the River Severn. The flood maps provided included the 1 in 200 year and the 1 in 1000 year undefended scenarios. The 1 in 200 year flood map has been taken to represent Flood Zone 3 and the 1 in 1000 year flood map has been taken to represent Flood Zone 2. No flood hazard maps were available for the River Severn, and therefore the assessment has been undertaken based on the flood extents only. The individual site assessment is presented in March 2014 Addendum\_A.2, Appendix A.
- 4.4.4 The River Severn at Sharpness is significantly influenced by tidal processes. The March 2014 Flood Zone maps demonstrate the extent of flooding from the combined fluvial and tidal flood risk for the undefended scenario (e.g. without the flood embankment in place). This shows that there is a risk of tidal flooding to the site, with approximately 75% of the site shown to be affected by Flood Zones 2 and 3 (Figure 4.2). Only the north eastern part of the site is shown to be located within Flood Zone 1. It should be noted that the flood map used for the River Severn at Sharpness represents Flood Zone 3 and has been produced using the 1 in 200 year modelled event from the combined fluvial and tidal model. Table 1: Flood Zones in the Planning Practice Guidance (PPG) that accompanies the NPPF (March 2014) defines Flood Zone 3a as a high probability event and comprises land assessed as having a 1 in 100 or greater annual probability of flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. There is no available flood map for Flood Zone 3b, and the fluvial modelling undertaken in the March 2012 SFRA did not identify flood flows affecting the site (either at the 1 in 100 year return period or below this at the 1 in 20, 1 in 25 or 1 in 50 year return periods). As such, it is concluded there is no Flood Zone 3b within the site itself. Table 1: Flood Zones of the PPG defines Flood Zone 3b as ‘the functional floodplain’. This zone comprises land where water has to flow or be stored in times of flood. The identification of functional floodplain should take into account local circumstances, however a good starting point is to consider land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood. Such areas are likely to be inundated more frequently than an area shown to be at risk within the 1 in 200 year flood extent map. Therefore, the flood extents shown to affect Site SA5a are likely to be experienced less frequently. Taking this into consideration, along with the fact that the flood map represents the undefended scenario and the site is protected by a flood embankment on the western edge, it could be concluded that strategically, Site SA5a could be considered more acceptable for development than other sites within the local authority area which have shown to be significantly affected by Flood Zone 3b.



**Figure 4.2: River Severn Fluvial and Tidal Flood Zone Maps for the 1 in 200 year event (dark blue) and the 1 in 1000 year event (light blue) (Source: Environment Agency (March 2014))**

- 4.4.5 The Level 1 SFRA outlined that the tributaries discharging into the River Severn estuary can be affected to some extent by the tide. Sea water from the Severn estuary is prevented from entering the tributaries by tidal flaps and a series of embankments along the River Severn. These structures allow water to discharge into the estuary freely at low tide but prevent sea water from entering the tributary at high tide. This can lead to an increase in flooding on the tributaries when high river flows in the watercourses coincide with high tides in the estuary, preventing flood water from discharging into the River Severn, thus backing up along the watercourse and overtopping river channels and embankments. This is referred to as ‘tide locking.’
- 4.4.6 The Wanswell watercourse flows directly into the River Severn. Through discussions with the Environment Agency, it is understood that this watercourse discharges to the River Severn via a flapped outfall structure, which is closed when a high tide occurs on the River Severn, to prevent tidal inundation. The modelling undertaken as part of this study has therefore assumed that the flapped outfall is closed during a flood event due to high water levels on the River Severn. This is to ensure that the worst case scenario for this watercourse has been modelled. With the tidal influence on the River Severn taken into consideration, the modelling has shown the floodwater from the Wanswell watercourse backs-up behind the outfall structure and follows an overland flow route to the south, ponding behind flood embankment. As outlined in the assessment of fluvial flood risk, flooding is not experienced within the site itself, but does inundate the land to the south of the site. Here, the flood hazard classification is low.

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### Climate Change

- 4.4.7 There are no modelled climate change flood maps available for the Tidal River Severn. Section 5.6 of the Level 1 SFRA details methods used to derive the climate change maps. This suggests that in the absence of modelled outlines for the climate change scenario, the current Flood Zone 2 should be used to determine the area at risk. Figure 4.2 indicates that Flood Zone 2 is slightly larger in extent than the Flood Zone 3 map for Site SA5a, mainly affecting a greater area within the central part of the site.

### 4.5 Surface Water Flood Risk

- 4.5.1 Risk of surface water flooding has been assessed using the Environment Agency's updated Flood Map for Surface Water (uFMfSW). The updated Flood Map for Surface Water does not show a risk of surface water flooding within the site itself, however, there are areas identified at risk from surface water flooding to the south and west of the site. The identified risk area to the south of the site largely coincides with the modelled Flood Zone 3a for the Wanswell watercourse. In general, the depth of flooding is low (less than 300mm), with isolated pockets of deeper flooding (300-900mm).

### 4.6 Residual Risk

#### Culvert Blockage

- 4.6.1 Culvert blockage analysis was undertaken as part of the March 2012 Level 2 SFRA (refer to Section 8.5 of the March 2012 SFRA document). Modelling of both a 50% and 90% blockage was undertaken at two key structures identified within the study area. Both of these structures are upstream of the areas within the vicinity of Site SA5a, and no further locations for potential blockage have been identified within or adjacent to the site. Therefore there is not deemed to be a residual risk to the current site from culvert blockage.

#### Canal Breach or Overtopping

- 4.6.2 The Gloucester and Sharpness Canal is located at the north western extent of Sharpness where it meets the River Severn at Sharpness Docks. The Brookend watercourse is thought to discharge directly into the canal via a culvert. Consultation with British Waterways as part of the Level 1 SFRA, and observations made during site visits undertaken as part of the 2012 Level 2 SFRA indicated that at the location considered as part of this study, the canal is not raised, therefore presenting no risk of breach. The site is also located a considerable distance from the canal.

#### Defence Breach

- 4.6.3 A series of raised defences are located along the left bank of the River Severn at Sharpness. These extend from Sharpness Docks (SO 6672 0194) to Berkeley Pill (SO 6669 9990). The March 2012 Level 2 SFRA details that two locations were assessed for defence breach as part of the Sharpness area modelling. These were:

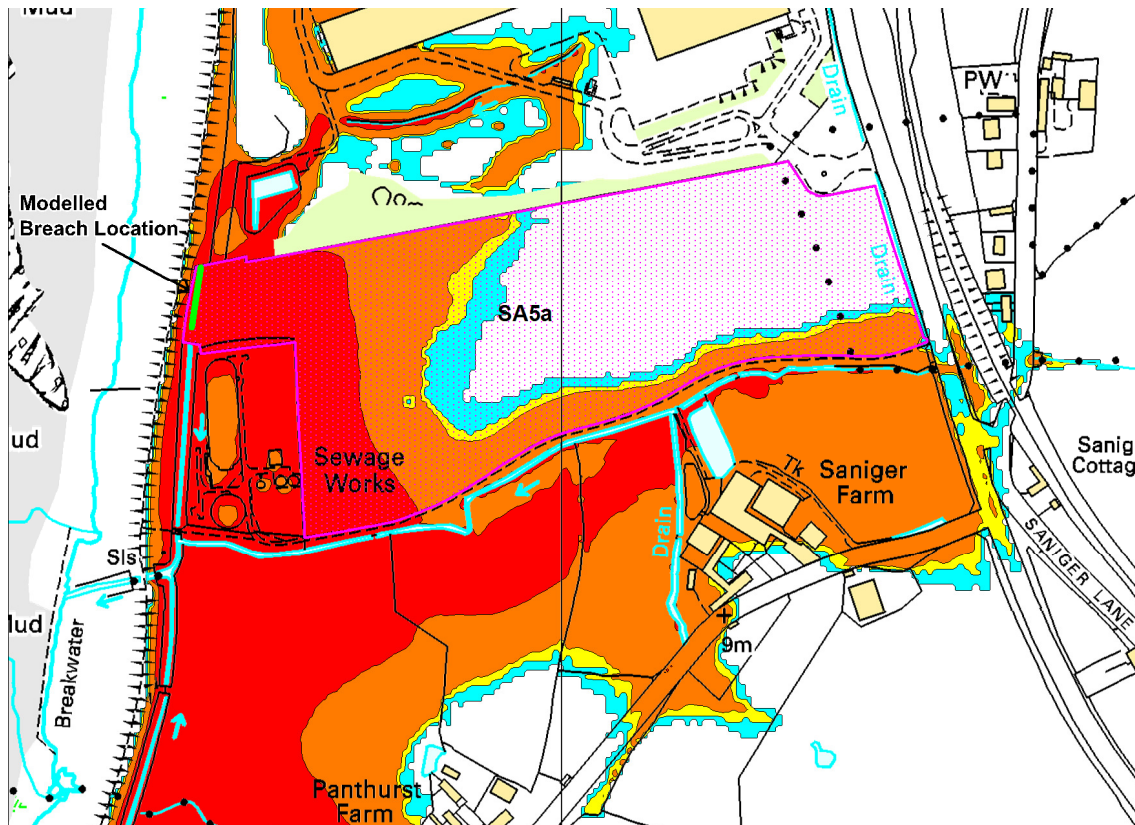
- North of the Sewage Works at SO 6670 0154; and
- West of Penthurst Cottage at SO 6669 9990.

- 4.6.4 The defence breach scenario at the Sewage Works is of relevance to Site SA5a. The results produced as part of the March 2012 Level 2 SFRA have been used to assess the residual risk to the site from defence breach. Section 8.5 of the existing Level 2 SFRA document outlines the modelling methodology used to assess the results and Drawing WN/CCAC/003 – View 7 from Volume 2 of the March 2012 Level 2 SFRA presents the results of the model runs for the breach scenario events.



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Figure 4.3 shows the modelled flood extent and flood hazard to the site based on the breach analysis undertaken.



**Figure 4.3: Defence Breach Scenario Flood Hazard Classification for Site SA5a (Light blue represents 'low' hazard, yellow moderate hazard, orange significant hazard and red 'extreme' hazard).**

4.6.5 The modelling has demonstrated that with a breach applied to the flood defence immediately north of the Sewage Works, the rate and onset of flooding is rapid, with the modelling showing dangerous high velocities within the area immediately adjacent to the breach location. The residual risk area is similar in extent, and marginally larger in places, to the Environment Agency's existing Flood Zone 3 for the River Severn. Within the identified risk area, the flood hazard is predominantly extreme, with the greatest hazard being within the area immediately adjacent to the embankment. This demonstrates that flood water would be deep and flow at a high velocity across the floodplain should a breach occur.

**4.7 Summary**

4.7.1 The modelling results from the March 2012 Level 2 SFRA indicate that Site SA5a is not at risk of fluvial flooding from the Wanswell watercourse, with only the area to the south of the site shown to be affected by fluvial flooding. However, the March 2014 updated Flood Zone maps for the River Severn have shown a significant risk of combined fluvial and tidal flooding from the River Severn, with approximately 75% of the site shown to be at risk. It should however be noted that these are 'undefended' flood outlines (e.g. the defences have been removed from the model) and with the defences in place, the site is shown to be protected from the River Severn. This is reflected in the

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available historic flood outlines which do not show records of flooding to the site from the River Severn. Only the north eastern corner of the site is shown to lie within Flood Zone 1. It should be noted that the flood map used for the River Severn at Sharpness represents Flood Zone 3 and has been produced using the 1 in 200 year modelled event from the combined fluvial and tidal model. Table 1: Flood Zones in the Planning Practice Guidance (PPG) that accompanies the NPPF (March 2014) defines Flood Zone 3a as a high probability event and comprises land assessed as having a 1 in 100 or greater annual probability of flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. There is no available flood map for Flood Zone 3b, and the fluvial modelling undertaken in the March 2012 SFRA did not identify flood flows affecting the site (either at the 1 in 100 year return period or below this at the 1 in 20, 1 in 25 or 1 in 50 year return periods). As such, it is concluded there is no Flood Zone 3b within the site itself. Table 1: Flood Zones of the PPG defines Flood Zone 3b as 'the functional floodplain'. This zone comprises land where water has to flow or be stored in times of flood. The identification of functional floodplain should take into account local circumstances, however a good starting point is to consider land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood. Such areas are likely to be inundated more frequently than an area shown to be at risk within the 1 in 200 year flood extent map. Therefore, the flood extents shown to affect Site SA5a are likely to be experienced less frequently. Taking this into consideration, along with the fact that the flood map represents the undefended scenario and the site is protected by a flood embankment on the western edge, it could be concluded that strategically, Site SA5a could be considered more acceptable for development than other sites within the local authority area which have shown to be significantly affected by Flood Zone 3b.

- 4.7.2 The predominant form of residual risk to the site is from breach of the flood defence embankments located along the left bank of the River Severn adjacent to the site. The identified defence breach residual risk areas affect the low lying land to the east of the River Severn, extending into the site itself. The residual risk area was shown to be similar in extent to the March 2014 updated Flood Zone maps provided by the Environment Agency. The flood hazard is predominantly significant to extreme, highlighting the importance of safeguarding the residual risk areas from development.

## **5 Recommendations**

### **5.1 Overview**

- 5.1.1 As part of the March 2012 Level 2 SFRA, site specific policy recommendations were outlined for each of the potential housing allocations which fell within the modelled study areas. In addition, Section 9 of the March 2012 Level 2 SFRA provided Strategic Policy Recommendations for all sites (Section 9.2), Development Control Policies (Section 9.4) and guidance for development in different flood zones (Section 9.5). This information is still relevant to the Stroud area and should be used in conjunction with the updated recommendations put forward for the individual sites assessed as part of this addendum.
- 5.1.2 The site assessments in tables March 2014 Addendum\_A.1 and March 2014 Addendum\_A.2, Appendix A provide recommendations as to the suitability of each site considered as part of this Level 2 SFRA update for development, based on the flood risk assessment undertaken. The tables also provide guidance as to whether the Exception Test is applicable and whether it is likely to be passed. Sections 6.2 to 6.3 below present a summary of this assessment.

### **5.2 Recommendations: Site SA4**

- 5.2.1 The site assessment had shown that Site SA4 lies predominantly in Flood Zone 1 and there is sufficient room to accommodate the proposed housing within the developable area. The updated modelling undertaken as part of this addendum has shown that there is no significant increase to fluvial flood risk within the site, with only the south western part of the site shown to be affected by Flood Zones 2, 3a and 3b. Areas identified as being at risk from surface water flooding generally coincide with the modelled flood zones and the depth of flooding is predominantly classified as low. It is strongly recommended that the identified Flood Zones 2, 3a and 3b are kept as open space. Provided that development within the identified flood risk areas is avoided, the Exception Test will therefore not be required. Requirements for development within Flood Zone 1 should be followed as outlined in Section 9.5 of the March 2012 Level 2 SFRA.
- 5.2.2 It is recommended that a site specific Flood Risk Assessment (FRA) be undertaken to investigate further the residual risk to Site SA4 from a culvert blockage or collapse of the culvert beneath the B4008 at the south western corner of the site. This should include a more detailed representation of the watercourse channel and structures along the watercourse, incorporating a full survey of both the Beaurepair and Shorn Brooks. It should be noted that the locally agreed surface water maps show surface water flooding to affect a similar extent as the modelled FZ3a. This demonstrates that there is an important flow route within this area where water is likely to accumulate, demonstrating the need to keep such areas as open space.

### **5.3 Recommendations: Site SA4a**

- 5.3.1 Approximately two-thirds of the site lies within Flood Zone 1. A risk of fluvial flooding has been identified from the Beaurepair Brook, with Flood Zones 2, 3a and 3b affecting the western and northern parts of the site within the areas adjacent to the watercourse. There is little difference in the extent of flooding between the modelled events, and the flood hazard classification is predominantly moderate to significant within the affected parts of the site. Given the extent of the modelled Flood Zone 3b within the site, and the moderate to significant flood hazard classification, it is strongly

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recommended that this area is kept as open space with identified flow paths kept clear. Any built development should be directed towards the parts of the site at lowest risk within Flood Zone 1. Car parking in these areas should ideally be avoided, however if car parking is necessary within the identified risk areas, it should only be allowed if appropriate management plans are in place and people and property can be made safe in the event of a flood. A site specific FRA will need to be undertaken for any planning application at this site. It is recommended that this includes a more detailed representation of the watercourse channel and structures along the watercourse, incorporating a full survey of the Beaurepair Brook. Requirements for development within Flood Zone 1 should be followed as outlined in Section 9.5 of the March 2012 Level 2 SFRA.

- 5.3.2 Areas susceptible to surface water have been identified. In the majority of cases, these coincide with the fluvial flood risk areas. It is therefore recommended that these areas are kept as open space. The area of surface water risk outside of the fluvial flood risk areas within the eastern part of the site has a shallow depth of flooding (<300mm) and it should therefore be possible to mitigate the risk of surface water flooding within these areas. Opportunities to improve runoff rates from the site and reduce flood risk should be sought.
- 5.3.3 The assessment has shown a residual risk to the south western corner of the site from culvert blockage with a 50% and 90% blockage applied to the culverts at Haresfield Lane (SO 8100 1141), the M5 (SO 8051 1134) and the B4008 (SO 8013 1140). The modelled flood extents are slightly larger in extent than the modelled Flood Zone 3a. It is recommended that identified residual risk areas are kept as open space and development is located towards lower risk areas. A culvert maintenance schedule should be developed to periodically clear culverts of debris, which will reduce the risk of blockage during a flood event.
- 5.3.4 It must be ensured that safe access and egress to any development is achievable for the 1 in 100 year climate change event. This scenario indicates that parts of the road into the site from Quedgeley East Business Park are affected. In general the flood hazard classification is significant. Access to the site will therefore need to be from the B4008 to the south. A site specific FRA should confirm safe access and egress to the site can be achieved during the 1 in 100 year climate change event.

## 5.4 Recommendations: Site SA5a – Land South of Severn Distribution Centre

- 5.4.1 Given the degree of flood risk posed to the site from the March 2014 updated Flood Zones, alternative sites located fully in Flood Zone 1 should be developed in preference to this site. However, given the proposed type of development is 'Employment', some types of development may be permitted within the site, for example, development classified as 'Less Vulnerable.' It is recommended that should the site be taken forward for development, the Sequential Approach is applied to the site, with development located towards the part of the site at lowest risk in the north eastern extent of the site (Flood Zone 1). Wherever possible, identified risk area should be kept as open space, or the type of development should be compatible with the risk areas. For example, where areas of higher flood hazard have been identified, these should be set aside for 'Water Compatible' uses such as open space. It must also be ensured that safe access and egress to the site can be achieved for the 1 in 200 year climate change scenario. For the unnamed drain on the eastern boundary of the site, a development easement should be applied. The exact distance from the top of the banks of the drain should be negotiated with the Lead Local Flood Authority and the Lower Severn Drainage Board.
- 5.4.2 The breach analysis undertaken as part of the March 2012 Level 2 SFRA has shown that the residual risk area is similar in extent to the updated Flood Zone 3 provided by the Environment Agency. Given

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the high flood hazard classification for the breach scenario, particularly in the western part of the site, it is recommended that the residual risk areas are kept as open space.