Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	Marston Valley
	Area (ha)	587.6
	Current land use	Predominantly Greenfield
	Proposed land use	Residential
Sources of flood risk	**Existing drainage features**	• The site has an extensive drainage network of Ordinary Watercourses running across it. In total, at least 16 separate channels can be identified. • More prominent Ordinary Watercourses with notable catchments beyond the site boundary flow onto the site along the northern boundary and the eastern boundary. They share their confluence in the northern central area of the site becoming the Elstow Brook and continue to flow east, exiting the site along the north-eastern boundary. • At least four ponds are located on the site, the largest of which is located in the west of the site. • Several small drains and ditches are located across the site.
	IDB watercourse present?	The site is partially located within the IDB district of the Bedfordshire and River Ivel Board. The IDB coverage starts when the two most prominent Ordinary Watercourses converge to become the Elstow Brook.
	Fluvial	**Proportion of site at risk**

FZ3b	**FZ3a**	**FZ2**	**FZ1**
TBC	TBC	TBC	TBC

Flood Zones in the north west of the site in the vicinity of the Elstow Brook are informed by detailed 1D-2D hydraulic modelling and show a relatively narrow floodplain adjacent to the watercourse. There is a slight increase between FZ3b and FZ3a, but a greater increase between the FZ3a and FZ2 extent. 2D generalised modelling was carried out on more prominent ordinary watercourses in the northern area of the site. The application of 2D modelling techniques to assess the flood risk from other ordinary watercourses and field drains on site was determined not to be practical due to the flat topography and low resolution DTM coverage. As such, a detailed assessment of the flood risk posed from these watercourses should be carried out by the developer at the FRA stage.

Surface Water — **Proportion of site at risk (RoFfSW)**

30-year	**100-year**	**1,000-year**
TBC	TBC	TBC

Sporadic pockets of pooling surface water begin to affect the site in the 30-year event. Flow routes meanwhile follow the path of existing watercourse channels. The extent of surface water flooding continues to increase in the 100-year and 1,000-year event, largely restricted to ponding and flow routes along existing channels. However, in the 1,000-year event, a prominent overland flow route develops in the south east of the site, flowing south-west to south-east.

Canal	No canal infrastructure is present in the vicinity of the site
Reservoir	The site is not shown to be at risk of reservoir flooding.

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	Marston Valley			
	Area (ha)	587.6			
	Current land use	Predominantly Greenfield			
	Proposed land use	Residential			
	Flood history	The Environment Agency's historic flood map does not show the site as having flooded in the past.			
Climate Change	**Climate change allowances for '2080s'**	**River Basin District**	**Central**	**Higher Central**	**Upper End**
		Anglian	25%	35%	65%
	Rainfall – Upper end allowances	All England	10%	20%	40%
	Future implications for the site	Climate change is predicted to increase storm intensities and frequencies in the UK. Flood extents associated with the Elstow Brook and 2D modelled watercourses show an increase in the climate change extents. This is most prominent in the centre of the site. Flood extents associated with the unmodelled ordinary watercourses and field drains on site are also likely to increase as a result of climate change. Consideration of climate change impacts should be included when assessing the flood risk of the smaller drains the site-specific level. Considering the site is already at risk of surface water flooding climate change may increase in the extent, depth and frequency of surface water flooding to the site.			
Existing flood risk management infrastructure	**Defences**	**Defence Type**	**Standard of Protection**	**Condition**	
		-	-	-	
		This site is not protected by any formal flood defences.			
	Residual risk	Several roads traverse the site; there may be some residual flood risk posed by watercourses flowing under these roads, if these structures become blocked. Consideration of blockage flood risk at the site-specific FRA stage is advised.			
Emergency planning	**Flood warning**	The site is not located within an Environment Agency Flood Warning Area.			
	Access and egress	Dry access and egress is available via all surrounding roads in all return periods in the event of fluvial flooding. In the event of surface water flooding the following roads lose access in the following return period, *i.e. road name (return period access lost*) • Station Road - north (1,000-year) • A421 (1,000-year) • Station Road - south Woburn Road and Bedford Road are accessible in all surface water events. Flooding of surrounding roads however may limit evacuation beyond the immediate site.			

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	Marston Valley
	Area (ha)	587.6
	Current land use	Predominantly Greenfield
	Proposed land use	Residential
Requirements for drainage control and impact mitigation	**Groundwater Source Protection Zone**	The site is not located within a Groundwater Source Protection Zone.
	Historic Landfill Site	This site has areas within its boundary designated by the Environment Agency as being a landfill site. A thorough ground investigation will be required as part of a detailed site-specific FRA to determine the extent of the contamination and the impact this may have on SuDS. As such proposed SuDS should be discussed with the relevant stakeholders (LPA, LLFA and EA) at an early stage to understand possible constraints.

	Broadscale assessment of possible SuDS	• Geology at the site consists of:
		  ○ Bedrock – Mustone, Siltstone and Sandstone
		  ○ Superficial – Largely areas of no deposits with some of diamicton, sand and gravel
		• Source control techniques are likely to be suitable for this site.
		• Mapping suggest groundwater flooding may be an issue at the site, providing the site is not at medium to high risk from groundwater flooding infiltration techniques may be suitable. As areas of the site have been designated as containing historic landfill further site investigation should be carried out to assess the potential for drainage by infiltration.
		• Detention features may be feasible providing site slopes are <5% at the location of the detention feature. If groundwater / landfill contamination is a risk to the site, then a liner may be required to mitigate against potential contamination issues.
		• Filtration systems are probably suitable providing site slopes are <5% and the depth to the water table is >1m. If the site has contamination issues, or is at risk from groundwater, then a liner will be required.
		• All forms of conveyance features are likely to be suitable. Where slopes are >5%, features should follow contours or utilise check dams to slow flows.
		• The site is not designated by the Environment Agency as previously being a landfill site.

NPPF and planning implications	**Development Vulnerability Classification to Flooding**	Under NPPF developments associated with residential uses (i.e. dwellings and residential institutions) are considered ‘More Vulnerable’.

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	Marston Valley
	Area (ha)	587.6
	Current land use	Predominantly Greenfield
	Proposed land use	Residential
	Exception Test requirements	The Sequential Test will need to be passed before the Exception Test is applied. The Exception Test will need to be applied if: • More Vulnerable and Essential Infrastructure development is located in FZ3a and for Highly Vulnerable development located in FZ2. • Highly Vulnerable infrastructure should not be permitted within FZ3a and FZ3b. • More Vulnerable and Less Vulnerable Infrastructure should not be permitted within FZ3b. • Essential Infrastructure in Flood Zone 3b will require the Exception Test.

	Requirements and guidance for site-specific Flood Risk Assessment	• At the planning application stage, a site-specific Flood Risk Assessment will be required if any development is located within Flood Zones 2 or 3, is greater than one hectare, is located within 20m of a watercourse, or is identified as being at significant surface water flood risk by the Council. Other sources of flooding should also be considered. • Consultation with the Local Authority, Local Lead Flood Authority, and the Environment Agency should be undertaken at an early stage. • Developers should confirm the flood risk to the site from the ditches/ field drains located within or adjacent to the site where 2D modelling techniques were unsuitable, as part of a detailed assessment. • To reduce flood risk to development, the following hierarchy should be followed by developers, as per Local Plan policy: 1. Flood Avoidance - A sequential approach to site layout is applied, directing the most vulnerable uses to the areas at lowest risk from all sources of flooding (i.e. Flood Zone 1). 2. Raising Floor Levels - Where it is not possible to develop outside of flood risk areas, development should raise Finished Floor Levels to reduce the risk of flooding. 3. Flood Resistance - Where it is not possible to raise floor levels, development should incorporate Resistance measures into the building design to prevent the ingress of water. 4. Flood Resilience - Resilience measures may be implemented, often in conjunction with Resistance measures, with the aim that in the event of flooding damage is limited and occupancy/use can resume quickly and efficiently. • Sustainable drainage (SuDS) should be used on all new development as detailed through Policy CC5 (Climate change and sustainability document) and in accordance with The SuDS Manual (C753) and 'Central Bedfordshire Sustainable Drainage guidance: May 2015'. • Discharge methods for surface water runoff should comply with Planning Practice Guidance paragraph 80 and Building Regulations Approved Document H and should ease pressure of the development downstream, by reducing the impact of surface runoff entering a receiving waterbody or drainage network. • SuDS should ensure that post-development surface water run-off rates are attenuated to achieve a reduction in greenfield run-off rates and reduce existing downstream risk. This may include consideration of "off-site" solutions. • The design of SuDS should also take into consideration: biodiversity enhancement, mitigation of visual landscape impacts, maintenance and safety. • Onsite attenuation schemes would need to be tested against the hydrograph of the Elstow Brook to ensure flows are not exacerbated downstream within the catchment. • Assessment for runoff should include allowance for climate change effects. • Safe access and egress will need to be demonstrated. • Development in the near vicinity of a watercourse within an IBD area will require the consent of the relevant IDB. The developer should contact the relevant IDB to determine the risk of flooding from IDB watercourses to the site. • Wherever possible, developers should seek to reduce flood risk and provide wider sustainability benefits by undertaking or contributing towards the following:

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

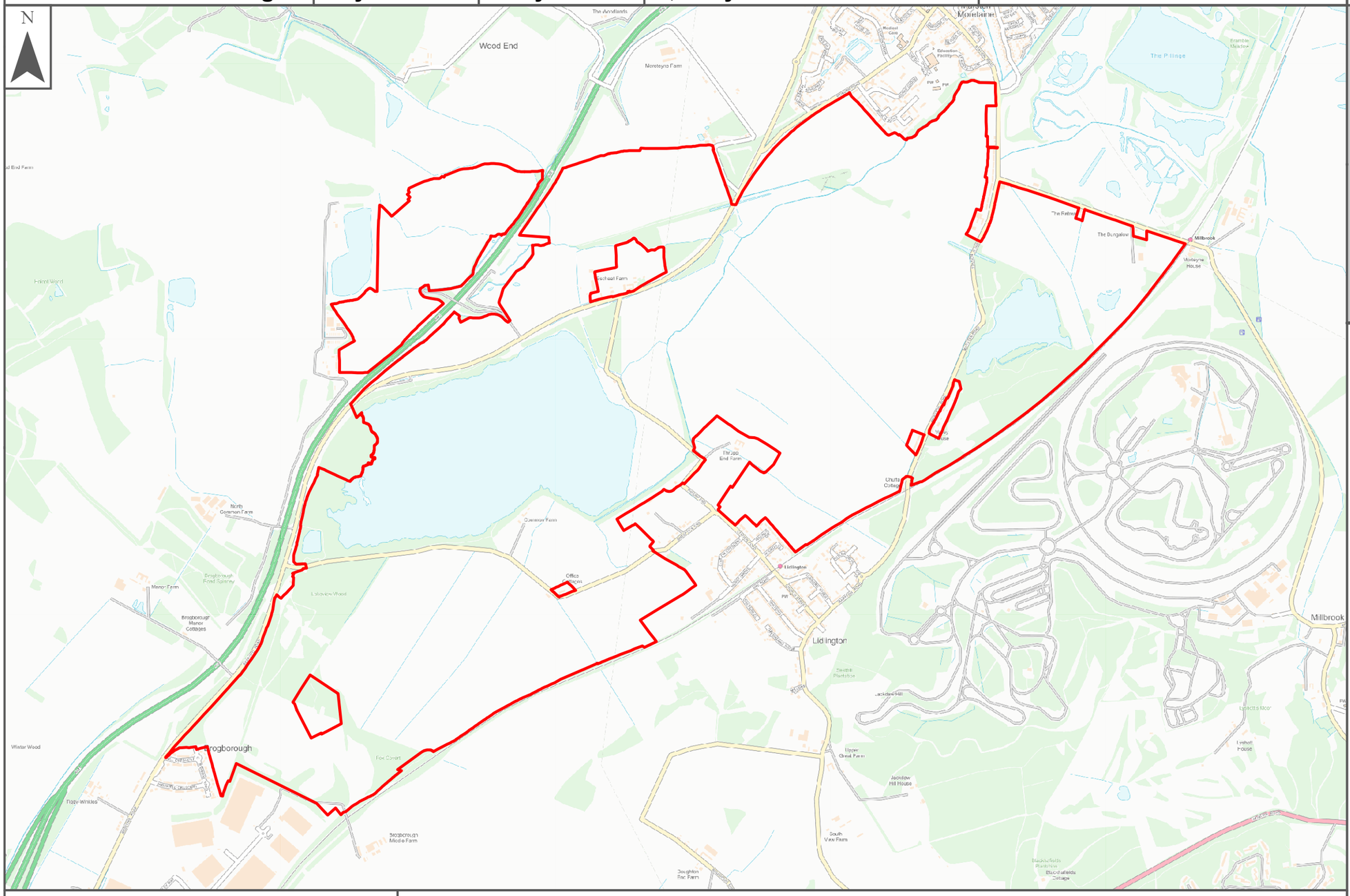
Site details	**Site Name**	Marston Valley
	Area (ha)	587.6
	Current land use	Predominantly Greenfield
	Proposed land use	Residential
		○ reconnection of rivers to the floodplain, ○ betterment of existing discharge rates and volumes, ○ removal of redundant in channel structures, ○ integrating or retrofitting surface water measures to replace and/or augment an existing drainage system in a developed catchment • Green infrastructure should be considered within the mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

Mapping Information	
Flood Zones	Flood Zones 2, 3a and 3b are based on a combination of 2D generalised modelling and detailed 1D-2D modelling on the Elstow Brook provided by the Environment Agency. 2D generalised modelling was carried out where watercourses were not represented on the Environment Agency's Flood Map for Planning Flood Zones and where 2D modelling was possible/ appropriate. Where detailed modelling is not available, developers should confirm the Flood Zones as part of a site-specific FRA, using detailed hydraulic modelling with channel topographic survey.
Climate change	The climate change allowances for the '2080s' scenario were modelled using 2D generalised modelling. Developers should confirm the climate change flood extents as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Surface Water	The Risk of Flooding from Surface Water has been used to define areas at risk from surface water flooding.
Groundwater	The risk of groundwater flooding to the site has been assessed using the Areas Susceptible to Groundwater Flooding dataset.
Depth, velocity and hazard mapping	Depth, velocity and hazard mapping for the 1 in 100-year event (Flood Zone 3a) have been taken from the 2D generalised modelling conducted as part of this Level 2 assessment. Developers should confirm the depth, velocity and hazard to the site as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Reservoir	The Environment Agency's online 'Long term flood risk information, Flood risk from reservoirs, Extent of flooding' viewer was used to define areas at risk from reservoirs.

Site ID: Marston Valley

LEVEL 2 SITE SUMMARY TABLES

OSNGR: 498391.12 , 239792.61	**Area:** 587.6	Predominately Greenfield	**Proposed Development Details:**	**STRATEGIC FLOOD RISK ASSESSMENT**
Flood Zone Coverage	**FZ3b :** TBC%	**FZ3a:** TBC%	**FZ2 :** TBC%	**FZ1 :** TBC%
Surface Water Coverage	**30-year :** TBC%	**100-year:** TBC%	**1,000-year:** TBC%	Residential



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LEGEND

Authority Information
- Central Bedfordshire Council boundary
- Potential Site Allocations
- Main River
- Detailed River Network

Defences
- Defence

Reservoir Inundation Map
- Reservoir Inundation

Source Protection Zone
- Zone 1
- Zone 2
- Zone 3

Other
- Flood Warning Area
- Flood Alert
- Historic Landfill

LEGEND

Flood Risk

Flood Zones
- Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

Climate Change
- Climate Change Central
- Climate Change Higher Central
- Climate Change Upper End

Surface Water
- RoSWf 30-year Extent
- RoSWf 100-year Extent
- RoSWf 1,000-year Extent

Area Susceptible to Groundwater Flooding
- < 25%
- >= 25% <50%
- >= 50% <75%
- >= 75%

Fluvial 100-year event

Depth (m)
- 0 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- >4.00

Velocity (m/s)
- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

Hazard Rating
- Very low hazard - caution
- Danger for some
- Danger for most
- Danger for all

Please refer to Main Report and Site Summary Table for further information on the datasets

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	North of Luton				
	Area (ha)	283.8				
	Current land use	Predominantly Greenfield				
	Proposed land use	Residential				
Sources of flood risk	**Existing drainage features**	• Houghton Brook (Main River) – located 120m to the south of the site flowing in an eastern direction • Several small ditches/ field drains located across the site				
	IDB watercourse present?	The site is not located within an IDB district.				
	Fluvial	**Proportion of site at risk**				
		FZ3b	**FZ3a**	**FZ2**	**FZ1**	
		TBC	TBC	TBC	TBC	
		Flood Zones show no fluvial flood risk to the site; however, there are small unmodeled field drains in the site, north of Whitehorse Vale. The application of 2D modelling techniques to assess the flood risk from these drains was determined not to be practical; as such, a detailed assessment of the flood risk from these field drains should be considered at the FRA stage. 2D generalised modelling shows the site as being outside the flood extents of the Houghton Brook due to topographic constraints and the presence of the M1 between them. However, if there is connectivity between the western and eastern sides of the M1 near the site, in the event of a blockage of the Houghton Brook, M1 culvert flooding may affect the site. On-site assessments should look to confirm if there is connectivity and if so consider modelling the Houghton Brook M1 culvert for blockage.				
	Surface Water	**Proportion of site at risk (RoFfSW)**				
		30-year	**100-year**	**1,000-year**		
		TBC	TBC	TBC		
		Surface water flooding starts to affect the site in the 30-year event with ponding surface water in areas along the northern and southern boundary. Extents increase slightly in the 100-year event with more prominent overland flow routes developing in the east, west and north of the site. Existing areas affected by surface water continue to see the area of risk expand in addition to sporadic pockets of surface water appearing across the site.				
	Canal	No Canal infrastructure is present in the vicinity of the site				
	Reservoir	The eastern area of the site is shown to be partially at risk of reservoir flooding.				
	Flood history	The Environment Agency's historic flood map does not show the site as having flooded in the past.				
		River Basin District	**Central**	**Higher Central**	**Upper End**	

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	North of Luton			
	Area (ha)	283.8			
	Current land use	Predominantly Greenfield			
	Proposed land use	Residential			
Climate Change	**Climate change allowances for '2080s'**	Thames	25%	35%	70%
	Rainfall – Upper end allowances	All England	10%	20%	40%
	Future implications for the site	Climate change is predicted to increase storm intensities and frequencies in the UK. Flood extents associated with the unmodelled field drains are likely to increase as a result of climate change. Consideration of climate change impacts should be included when assessing the flood risk of the field drains at the site-specific level. For the Houghton Brook, 2D generalised modelling was undertaken and showed no impacts in the vicinity of the site. The topography around the southern end of the site is very confined between the M1 and high ground, meaning that water levels would need to rise significantly to encroach near the site (above 2m). Considering the site is already at risk of surface water flooding, climate change may increase in the extent, depth and frequency of surface water flooding to the site.			
Existing flood risk management infrastructure	**Defences**	**Defence Type**	**Standard of Protection**	**Condition**	
		-	-	-	
		This site is not protected by any formal flood defences.			
	Residual risk	Although 2D generalised hydraulic modelling shows the site as being outside the flood extent of the Houghton Brook, if there is connectivity between the west and eastern sides of the M1 adjacent to the site, a blockage of the Houghton Brook M1 culvert could be considered. On-site assessments should look to confirm if there is connectivity and if so, blockage modelling of the Houghton Brook M1 culvert should be considered.			
Emergency planning	**Flood warning**	The site is not located within an Environment Agency Flood Warning Area.			
	Access and egress	Dry access and egress is available via all surrounding roads in all return periods in the event of fluvial flooding. In the event of surface water flooding the following roads lose access in the following return period, *i.e. road name (return period access lost*) • Great Bramingham lane (30-year) • Hampshire Way (1000-years) • Sundon Park Road (30-years) The B579 and Barton Road and accessible in all surface water events. Flooding of surrounding roads however may limit evacuation beyond the immediate site.			

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	North of Luton
	Area (ha)	283.8
	Current land use	Predominantly Greenfield
	Proposed land use	Residential
Requirements for drainage control and impact mitigation	**Groundwater Source Protection Zone**	The majority of the site is located within Groundwater Source Protection Zone 3. Infiltration techniques should only be used following the granting of any required environmental permits from the Environment Agency, although it is possible that infiltration may not be permitted. Proposed SuDS should be discussed with relevant stakeholders (LPA, LLFA and EA) at an early stage to understand possible opportunities and constraints.
	Historic Landfill Site	No Environment Agency designated historic landfill sites are underlying the site.

	Broadscale assessment of possible SuDS	• Geology at the site consists of:
		  ○ Bedrock – Chalk
		  ○ Superficial – Areas of no deposits and others underlain with Diamicton
		• Source control techniques are likely to be suitable for this site.
		• Providing the site is not at medium to high risk from groundwater flooding infiltration techniques may be suitable providing environmental permits have been given.
		• Detention features may be feasible providing site slopes are <5% at the location of the detention feature. If groundwater is a risk to the site, then a liner may be required to mitigate against potential contamination issues.
		• Filtration systems are probably suitable providing site slopes are <5% and the depth to the water table is >1m. If the site has contamination issues, or is at risk from groundwater, then a liner will be required.
		• All forms of conveyance features are likely to be suitable. Where slopes are >5%, features should follow contours or utilise check dams to slow flows.

NPPF and planning implications	**Development Vulnerability to Flooding**	Under NPPF developments associated with employment (i.e. offices, general industry, storage and distribution etc.) are considered 'Less Vulnerable'.
	Exception Test requirements	A sequential approach to site layout is encouraged, to steer development away from areas of flood risk on the site (i.e. where surface water is prevalent, especially in the 30-year event). The Exception Test will need to be applied if: • More Vulnerable and Essential Infrastructure development is located in FZ3a and for Highly Vulnerable development located in FZ2. • Highly Vulnerable infrastructure should not be permitted within FZ3a and FZ3b. • More Vulnerable and Less Vulnerable Infrastructure should not be permitted within FZ3b. • Essential Infrastructure in Flood Zone 3b will require the Exception Test.

	Requirements and guidance for site-specific Flood Risk Assessment	• At the planning application stage, a site-specific Flood Risk Assessment will be required if any development is located within Flood Zones 2 or 3, is greater than one hectare, is located within 20m of a watercourse, or is identified as being at significant surface water flood risk by the Council. Other sources of flooding should also be considered. • Consultation with the Local Authority, Local Lead Flood Authority, and the Environment Agency should be undertaken at an early stage. • Developers should confirm the flood risk to the site from the small ditches/ field drains located within or adjacent to the site, where 2D modelling techniques were unsuitable. • To reduce flood risk to development, the following hierarchy should be followed by developers, as per Local Plan policy: 1. Flood Avoidance - A sequential approach to site layout is applied, directing the most vulnerable uses to the areas at lowest risk from all sources of flooding (i.e. Flood Zone 1). 2. Raising Floor Levels - Where it is not possible to develop outside of flood risk areas, development should raise Finished Floor Levels to reduce the risk of flooding. 3. Flood Resistance - Where it is not possible to raise floor levels, development should incorporate Resistance measures into the building design to prevent the ingress of water. 4. Flood Resilience - Resilience measures may be implemented, often in conjunction with Resistance measures, with the aim that in the event of flooding damage is limited and occupancy/use can resume quickly and efficiently. • Sustainable drainage (SuDS) should be used on all new development as detailed through Policy CC5 (Climate change and sustainability document) and in accordance with The SuDS Manual (C753) and 'Central Bedfordshire Sustainable Drainage guidance: May 2015'. • Discharge methods for surface water runoff should comply with Planning Practice Guidance paragraph 80 and Building Regulations Approved Document H and should ease pressure of the development downstream, by reducing the impact of surface runoff entering a receiving waterbody or drainage network. • SuDS should ensure that post-development surface water run-off rates are attenuated to achieve a reduction in greenfield run-off rates and reduce existing downstream risk. This may include consideration of "off-site" solutions. • The design of SuDS should also take into consideration: biodiversity enhancement, mitigation of visual landscape impacts, maintenance and safety. • Onsite attenuation schemes would need to be tested against the hydrograph of the Houghton Brook to the south to ensure flows are not exacerbated downstream within the catchment. • Assessment for runoff should include allowance for climate change effects. • Safe access and egress will need to be demonstrated. • Wherever possible, developers should seek to reduce flood risk and provide wider sustainability benefits by undertaking or contributing towards the following: o reconnection of rivers to the floodplain, o betterment of existing discharge rates and volumes, o removal of redundant in channel structures, o integrating or retrofitting surface water measures to replace and/or augment an existing drainage system in a developed catchment

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	North of Luton
	Area (ha)	283.8
	Current land use	Predominantly Greenfield
	Proposed land use	Residential
		• Green infrastructure should be considered within the mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

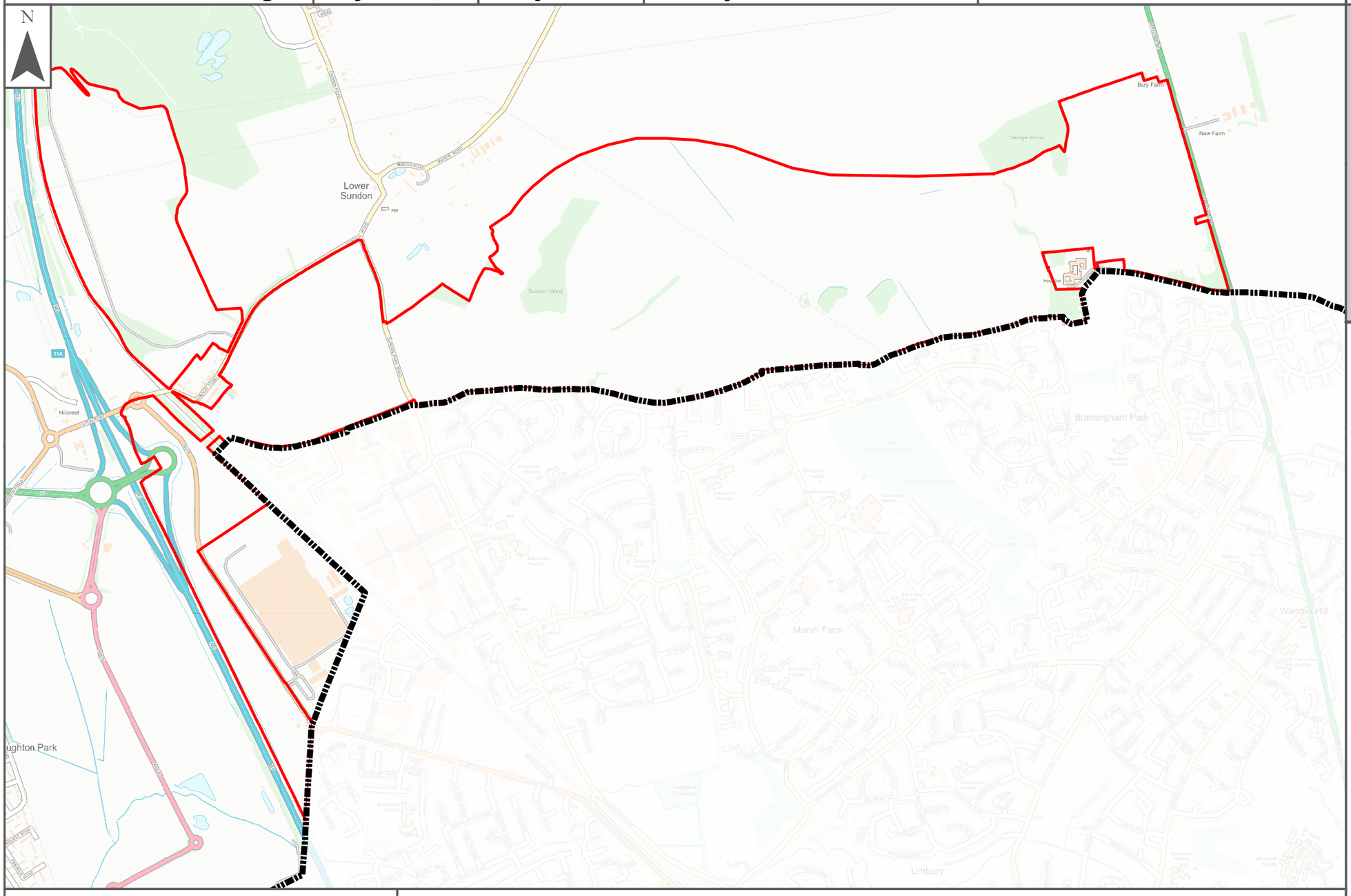
Mapping Information	
Flood Zones	Flood Zones 2 and 3a are based on the Environment Agency's Flood Map for Planning Flood Zones. Developers should confirm the Flood Zone extents within the site as part of a site-specific FRA, using detailed hydraulic modelling where deemed appropriate.
Climate change	2D generalised modelling was undertaken and showed no impacts to the site. If applicable, developers should confirm the climate change flood extents as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Surface Water	The Risk of Flooding from Surface Water dataset has been used to define areas at risk from surface water flooding.
Groundwater	The risk of groundwater flooding to the site has been assessed using the Areas Susceptible to Groundwater Flooding dataset.
Depth, velocity and hazard mapping	If applicable, developers should confirm the depth, velocity and hazard to the site as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Reservoir	The Environment Agency's online 'Long term flood risk information, Flood risk from reservoirs, Extent of flooding' viewer was used to define areas at risk from reservoirs.

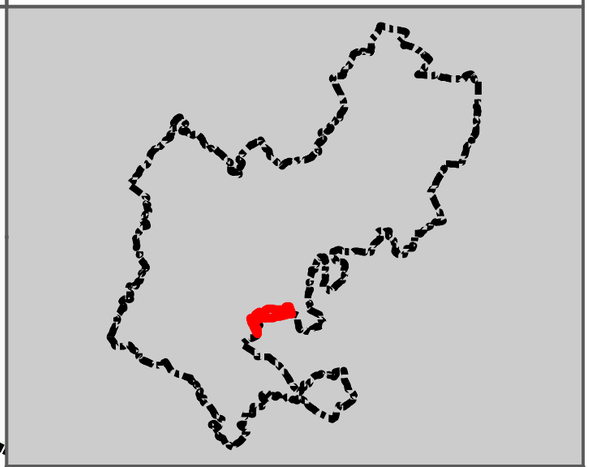
Site ID: North of Luton

LEVEL 2 SITE SUMMARY TABLES

STRATEGIC FLOOD RISK ASSESSMENT

OSNGR: 505904.74 , 226493.70	**Area:** 283.8	Predominately Greenfield		**Proposed Development Details:** Residential
Flood Zone Coverage	**FZ3b :** TBC%	**FZ3a:** TBC%	**FZ2 :** TBC%	**FZ1 :** TBC%
Surface Water Coverage	**30-year :** TBC%	**100-year:** TBC%	**1,000-year:** TBC%	





0 0.3 0.6 1.2 km

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LEGEND

Authority Information
- Central Bedfordshire Council boundary
- Potential Site Allocations
- Main River
- Detailed River Network

Defences
- Defence

Reservoir Inundation Map
- Reservoir Inundation

Source Protection Zone
- Zone 1
- Zone 2
- Zone 3

Other
- Flood Warning Area
- Flood Alert
- Historic Landfill

LEGEND

Flood Risk

Flood Zones
- Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

Climate Change
- Climate Change Central
- Climate Change Higher Central
- Climate Change Upper End

Surface Water
- RoSWf 30-year Extent
- RoSWf 100-year Extent
- RoSWf 1,000-year Extent

Area Susceptible to Groundwater Flooding
- < 25%
- >= 25% <50%
- >= 50% <75%
- >= 75%

Fluvial 100-year event

Depth (m)
- 0 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- >4.00

Velocity (m/s)
- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

Hazard Rating
- Very low hazard - caution
- Danger for some
- Danger for most
- Danger for all

Please refer to Main Report and Site Summary Table for further information on the datasets

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	RAF Henlow
	Area (ha)	222.7
	Current land use	Mixed Greenfield-Brownfield
	Proposed land use	Employment
Sources of flood risk	**Existing drainage features**	• The River Hiz is located 630m to the east of the site at the closest point flowing in a northern direction • An unnamed Ordinary Watercourse (OW A) flows immediately along the site's southern boundary in a west to east direction before its confluence with the River Hiz 700m to the east of the site. • An unnamed Ordinary Watercourse (OW B) flows west to east through the northern area of the site. • An unnamed Ordinary Watercourse flows south to north along the western site boundary until its confluence with OW A. • An unnamed Ordinary Watercourse flows along the eastern boundary of the site adjacent to the B659 until its eventual confluence with OW A. • An unnamed Ordinary Watercourse flows generally in a north-eastern direction on the opposite side of the A507 along the northern boundary before flowing away from the site in a western direction. • Several small ditches/drains located across the site.
	IDB watercourse present?	The site is largely located within the IDB district of the Bedfordshire and River Ivel Board. The IDB coverage includes the watercourse that flows through the site in addition to those that flow along the site boundary.
	Fluvial	**Proportion of site at risk**

FZ3b	**FZ3a**	**FZ2**	**FZ1**
TBC	TBC	TBC	TBC

Environment Agency Flood Zones show FZ3a encroaches on the south-eastern corner of the site. There is a slight increase in the extent of FZ2 when compared against FZ3. Flood Zones also show a narrow band of flooding running adjacent to the unnamed Ordinary Watercourse flowing across the north of the site. There is a slight increase in extents between FZ3a and FZ2.

		Surface Water	**Proportion of site at risk (RoFfSW)**		
			30-year	**100-year**	**1,000-year**
			TBC	TBC	TBC
			Sporadic pockets of pooling surface water begin to affect the site in the 30-year event with greater concentrations near existing watercourses. The extent of surface water flooding continues to increase in the 100-year event. In the 1,000-year event, surface water flow routes along and adjacent to existing channels affects much of the site.
	Canal	No canal infrastructure is present in the vicinity of the site.			
	Reservoir	The site is not shown to be at risk of reservoir flooding.			
	Flood history	The Environment Agency's historic flood map does not show the site as having flooded in the past.			

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	RAF Henlow			
	Area (ha)	222.7			
	Current land use	Mixed Greenfield-Brownfield			
	Proposed land use	Employment			
Climate Change	**Climate change allowances for '2080s'**	**River Basin District**	**Central**	**Higher Central**	**Upper End**
		Anglian	25%	35%	65%
	Rainfall – Upper end allowances	All England	10%	20%	40%
	Future implications for the site	Climate change is predicted to increase storm intensities and frequencies in the UK. Fluvial climate change extents are generally comparable with those of existing Flood Zones and represent a slight increase in extents in some areas along the southern boundary and in the north of the site in the Upper End allowance. Considering the site is already at risk of surface water flooding climate change may increase in the extent, depth and frequency of surface water flooding to the site.			
Existing flood risk management infrastructure	**Defences**	**Defence Type**	**Standard of Protection**	**Condition**	
		-	-	-	
		This site is not protected by any formal flood defences.			
	Residual risk	-			
Emergency planning	**Flood warning**	The site is not located within an Environment Agency Flood Warning Area.			
	Access and egress	Dry access and egress is available via the A600 in certain reaches, but not where surface water flooding follows the topography of watercourses. is available in all return periods in the event of fluvial flooding. The B659 has drainage ditches on both sides, largely inundating this road in all surface water events.			

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	RAF Henlow
	Area (ha)	222.7
	Current land use	Mixed Greenfield-Brownfield
	Proposed land use	Employment
Requirements for drainage control and impact mitigation	**Groundwater Source Protection Zone**	The majority of the site is located within Groundwater Source Protection Zone 3. Infiltration techniques should only be used following the granting of any required environmental permits from the Environment Agency, although it is possible that infiltration may not be permitted. Proposed SuDS should be discussed with relevant stakeholders (LPA, LLFA and EA) at an early stage to understand possible opportunities and constraints.
	Historic Landfill Site	No Environment Agency designated historic landfill sites are underlying the site.

	Broadscale assessment of possible SuDS	• Geology at the site consists of:
		  ○ Bedrock – Sandstone, Mudstone and Siltstone
		  ○ Superficial –Diamicton
		• Source control techniques are likely to be suitable for this site.
		• Providing the site is not at medium to high risk from groundwater flooding infiltration techniques may be suitable providing environmental permits have been given.
		• Detention features may be feasible providing site slopes are <5% at the location of the detention feature. If groundwater is a risk to the site, then a liner may be required to mitigate against potential contamination issues.
		• Filtration systems are probably suitable providing site slopes are <5% and the depth to the water table is >1m. If the site has contamination issues, or is at risk from groundwater, then a liner will be required.
		• All forms of conveyance features are likely to be suitable. Where slopes are >5%, features should follow contours or utilise check dams to slow flows.

NPPF and planning implications	**Development Vulnerability Classification to Flooding**	Under NPPF developments associated with employment (i.e. offices, general industry, storage and distribution etc.) are considered 'Less Vulnerable'.
	Exception Test requirements	The Sequential Test will need to be passed before the Exception Test is applied. The Exception Test will need to be applied if: • More Vulnerable and Essential Infrastructure development is located in FZ3a and for Highly Vulnerable development located in FZ2. • Highly Vulnerable infrastructure should not be permitted within FZ3a and FZ3b. • More Vulnerable and Less Vulnerable Infrastructure should not be permitted within FZ3b.

	Requirements and guidance for site-specific Flood Risk Assessment	• At the planning application stage, a site-specific Flood Risk Assessment will be required if any development is located within Flood Zones 2 or 3, is greater than one hectare, is located within 20m of a watercourse, or is identified as being at significant surface water flood risk by the Council. Other sources of flooding should also be considered. • Consultation with the Local Authority, Local Lead Flood Authority, and the Environment Agency should be undertaken at an early stage. • Detailed hydraulic modelling should be undertaken by the developer at FRA-level assessment, to confirm the flood risk extents at the site, given existing results are based on 2D generalised modelling. • To reduce flood risk to development, the following hierarchy should be followed by developers, as per Local Plan policy: 1. Flood Avoidance - A sequential approach to site layout is applied, directing the most vulnerable uses to the areas at lowest risk from all sources of flooding (i.e. Flood Zone 1). 2. Raising Floor Levels - Where it is not possible to develop outside of flood risk areas, development should raise Finished Floor Levels to reduce the risk of flooding. 3. Flood Resistance - Where it is not possible to raise floor levels, development should incorporate Resistance measures into the building design to prevent the ingress of water. 4. Flood Resilience - Resilience measures may be implemented, often in conjunction with Resistance measures, with the aim that in the event of flooding damage is limited and occupancy/use can resume quickly and efficiently. • Sustainable drainage (SuDS) should be used on all new development as detailed through Policy CC5 (Climate change and sustainability document) and in accordance with The SuDS Manual (C753) and 'Central Bedfordshire Sustainable Drainage guidance: May 2015'. • Discharge methods for surface water runoff should comply with Planning Practice Guidance paragraph 80 and Building Regulations Approved Document H and should ease pressure of the development downstream, by reducing the impact of surface runoff entering a receiving waterbody or drainage network. • SuDS should ensure that post-development surface water run-off rates are attenuated to achieve a reduction in greenfield run-off rates and reduce existing downstream risk. This may include consideration of "off-site" solutions. • The design of SuDS should also take into consideration: biodiversity enhancement, mitigation of visual landscape impacts, maintenance and safety. • Onsite attenuation schemes would need to be tested against the hydrograph of watercourses discharged into to ensure flows are not exacerbated downstream within the catchment. • Assessment for runoff should include allowance for climate change effects. • Safe access and egress will need to be demonstrated. • Development in the near vicinity of a watercourse within an IBD area will require the consent of the relevant IDB. The developer should contact the relevant IDB to determine the risk of flooding from IDB watercourses to the site.

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	RAF Henlow
	Area (ha)	222.7
	Current land use	Mixed Greenfield-Brownfield
	Proposed land use	Employment

		• Wherever possible, developers should seek to reduce flood risk and provide wider sustainability benefits by undertaking or contributing towards the following:
		  ○ reconnection of rivers to the floodplain,
		  ○ betterment of existing discharge rates and volumes,
		  ○ removal of redundant in channel structures,
		  ○ integrating or retrofitting surface water measures to replace and/or augment an existing drainage system in a developed catchment
		• Green infrastructure should be considered within the mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

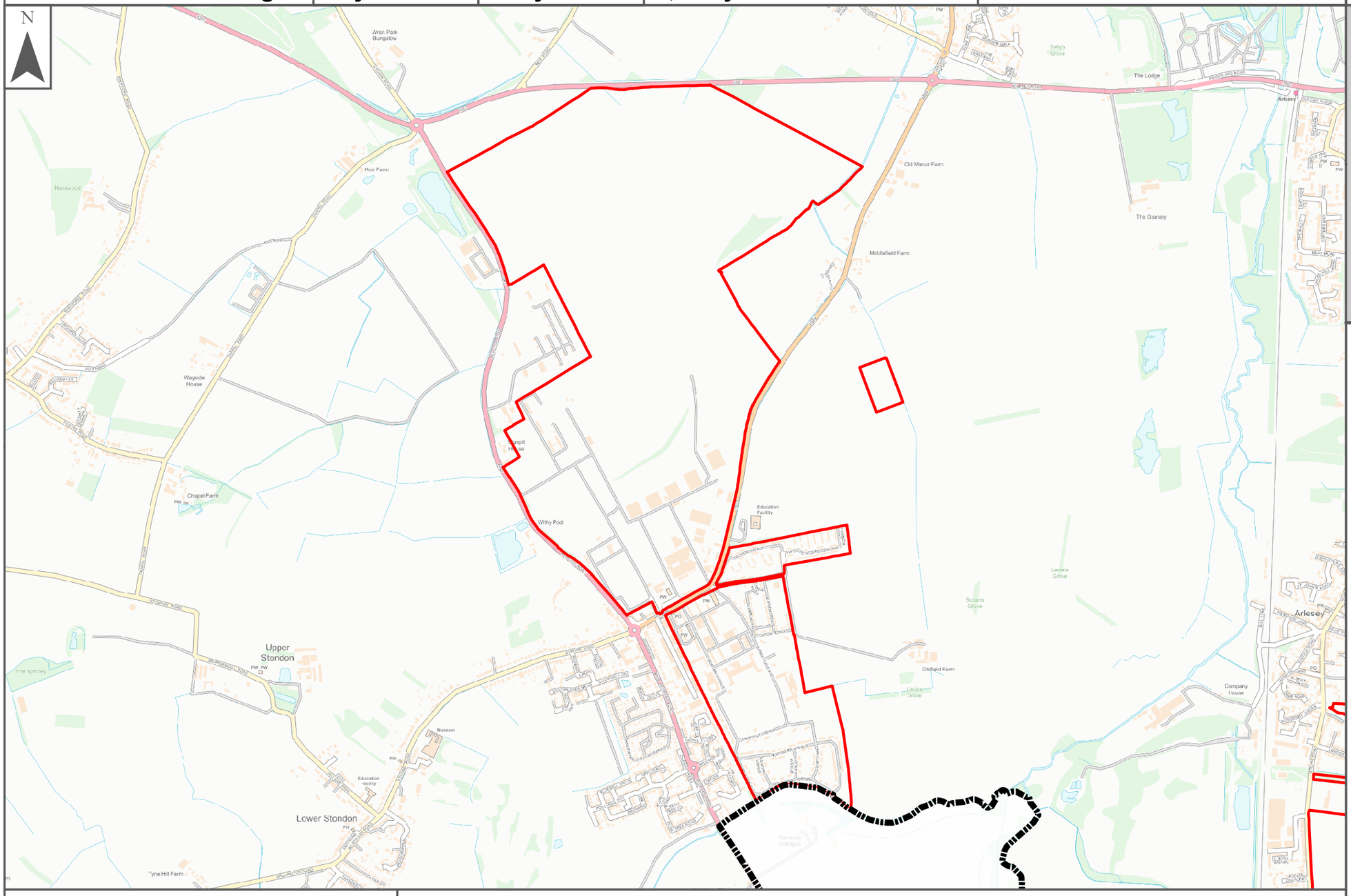
Mapping Information	
Flood Zones	Flood Zones 2, 3a and 3b re based on 2D generalised modelling, because the watercourses were not represented on the Environment Agency's Flood Map for Planning Flood Zones. Developers should confirm the Flood Zone extents as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Climate change	The climate change allowances for the '2080s' scenario were modelled using 2D generalised modelling. Developers should confirm the climate change flood extents as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Surface Water	The Risk of Flooding from Surface Water has been used to define areas at risk from surface water flooding.
Groundwater	The risk of groundwater flooding to the site has been assessed using the Areas Susceptible to Groundwater Flooding dataset.
Depth, velocity and hazard mapping	Depth, velocity and hazard mapping for the 1 in 100-year event (Flood Zone 3a) have been taken from the 2D generalised modelling conducted as part of this Level 2 assessment. Developers should confirm the depth, velocity and hazard to the site as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Reservoir	The Environment Agency's online 'Long term flood risk information, Flood risk from reservoirs, Extent of flooding' viewer was used to define areas at risk from reservoirs.

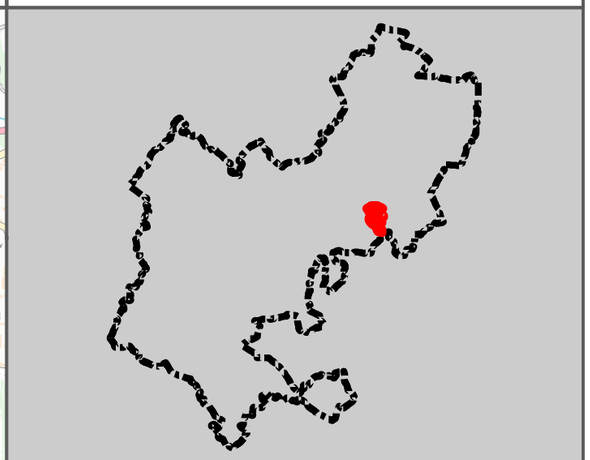
Site ID: RAF Henlow

LEVEL 2 SITE SUMMARY TABLES

STRATEGIC FLOOD RISK ASSESSMENT

OSNGR: 516601.17 , 236682.44	**Area:** 222.7	Mixed Greenfield and Brownfield	**Proposed Development Details:** Employment	
Flood Zone Coverage	**FZ3b :** TBC%	**FZ3a:** TBC%	**FZ2 :** TBC%	**FZ1 :** TBC%
Surface Water Coverage	**30-year :** TBC%	**100-year:** TBC%	**1,000-year:** TBC%	





0 0.325 0.65 1.3 km

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LEGEND

Authority Information
- Central Bedfordshire Council boundary
- Potential Site Allocations
- Main River
- Detailed River Network

Defences
- Defence

Reservoir Inundation Map
- Reservoir Inundation

Source Protection Zone
- Zone 1
- Zone 2
- Zone 3

Other
- Flood Warning Area
- Flood Alert
- Historic Landfill

LEGEND

Flood Risk

Flood Zones
- Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

Climate Change
- Climate Change Central
- Climate Change Higher Central
- Climate Change Upper End

Surface Water
- RoSWf 30-year Extent
- RoSWf 100-year Extent
- RoSWf 1,000-year Extent

Area Susceptible to Groundwater Flooding
- < 25%
- >= 25% <50%
- >= 50% <75%
- >= 75%

Fluvial 100-year event

Depth (m)
- 0 - 0.10
- 0.10 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- >4.00

Velocity (m/s)
- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0

Hazard Rating
- Very low hazard - caution
- Danger for some
- Danger for most
- Danger for all

Please refer to Main Report and Site Summary Table for further information on the datasets

Mapping

Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables

Site details	**Site Name**	Sundon RFI
	Area (ha)	50.0
	Current land use	Greenfield
	Proposed land use	Employment
Sources of flood risk	**Existing drainage features**	• The River Flit is located 145m to the west of the site flowing in a generally north-west direction away from the site. • Unnamed ordinary watercourse/ field drain starts 30m to the west of the site and flows in a western direction away from the site until its confluence with the River Flit.
	IDB watercourse present?	The Bedfordshire and River Ivel IDB boundary runs up to within 40m of the site's western boundary; however, it does not encroach upon the site.
	Fluvial	**Proportion of site at risk**

FZ3b	FZ3a	FZ2	FZ1
TBC	TBC	TBC	TBC

EA Flood Zones show no fluvial flood risk to the site. 2D hydraulic modelling techniques were applied on the unnamed ordinary watercourse to the west of the site. Results show the watercourse does not present a flood risk to the site as it is located to the west of the railway line and M1, which flows away from the site.

Surface Water

Proportion of site at risk (RoFfSW)

30-year	100-year	1,000-year
TBC	TBC	TBC

Isolated pockets of surface water flooding begin to affect the site in the 30-year event and increase slightly in the 100-year event. In the 1,000-year event, an overland flow route propagates along the site's western boundary, with previous pockets of pooling surface water expanding and small pockets emerging.

	Canal	No canal infrastructure is present in the vicinity of the site
	Reservoir	The site is not shown to be at risk of reservoir flooding.
	Flood history	The Environment Agency's historic flood map does not show the site as having flooded in the past.

Climate Change	**River Basin District**	**Central**	**Higher Central**	**Upper End**
Climate change allowances for '2080s'	Thames	25%	35%	70%
Rainfall – Upper end allowances	All England	10%	20%	40%

	Future implications for the site	Climate change is predicted to increase storm intensities and frequencies in the UK. Considering the site is already at risk of surface water flooding, climate change may increase in the extent, depth and frequency of surface water flooding to the site.

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	Sundon RFI		
	Area (ha)	50.0		
	Current land use	Greenfield		
	Proposed land use	Employment		
Existing flood risk management infrastructure	**Defences**	**Defence Type**	**Standard of Protection**	**Condition**
		-	-	-
		This site is not protected by any formal flood defences.		
	Residual risk	-		
Emergency planning	**Flood warning**	The site is not located within an Environment Agency Flood Warning Area.		
	Access and egress	Dry access and egress is available via all surrounding roads in all return periods in the event of fluvial flooding. In the event of surface water flooding, the following roads lose access in the following return period (i.e. road name (return period access lost) • Great Bramingham lane (30-years) • Sundon Park Road (30-years) • Hampshire Way (1,000-years) The B579 and Barton Road are accessible in all surface water events. Flooding of surrounding roads, however, may limit evacuation beyond the immediate site.		

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	Sundon RFI
	Area (ha)	50.0
	Current land use	Greenfield
	Proposed land use	Employment
Requirements for drainage control and impact mitigation	**Groundwater Source Protection Zone**	The majority of the site is located within Groundwater Source Protection Zone 3. Infiltration techniques should only be used following the granting of any required environmental permits from the Environment Agency, although it is possible that infiltration may not be permitted. Proposed SuDS should be discussed with relevant stakeholders (LPA, LLFA and EA) at an early stage to understand possible opportunities and constraints.
	Historic Landfill Site	No Environment Agency designated historic landfill sites are underlying the site.

	Broadscale assessment of possible SuDS	• Geology at the site consists of:
		  ○ Bedrock – Chalk
		  ○ Superficial – No deposits
		• Source control techniques are likely to be suitable for this site.
		• Providing the site is not at medium to high risk from groundwater flooding, infiltration techniques may be suitable providing environmental permits have been received.
		• Detention features may be feasible providing site slopes are <5% at the location of the detention feature. If groundwater is a risk to the site, then a liner may be required to mitigate against potential contamination issues.
		• Filtration systems are probably suitable providing site slopes are <5% and the depth to the water table is >1m. If the site has contamination issues, or is at risk from groundwater, then a liner will be required.
		• All forms of conveyance features are likely to be suitable. Where slopes are >5%, features should follow contours or utilise check dams to slow flows.

NPPF and planning implications	**Development Vulnerability Classification to Flooding**	Under NPPF, developments associated with employment (i.e. offices, general industry, storage and distribution etc.) are considered 'Less Vulnerable'.
	Exception Test requirements	A sequential approach to site layout is encouraged, to steer development away from areas of flood risk on the site (i.e. where surface water is prevalent, especially in the 30-year event). As the site is located entirely within FZ1, the Exception Test is not required for developments.

	Requirements and guidance for site-specific Flood Risk Assessment	• At the planning application stage, a site-specific Flood Risk Assessment will be required if any development is located within Flood Zones 2 or 3, is greater than one hectare, is located within 20m of a watercourse, or is identified as being at significant surface water flood risk by the Council. Other sources of flooding should also be considered. • Consultation with the Local Authority, Local Lead Flood Authority, and the Environment Agency should be undertaken at an early stage. • To reduce flood risk to development, the following hierarchy should be followed by developers, as per Local Plan policy: 1. Flood Avoidance - A sequential approach to site layout is applied, directing the most vulnerable uses to the areas at lowest risk from all sources of flooding (i.e. Flood Zone 1). 2. Raising Floor Levels - Where it is not possible to develop outside of flood risk areas, development should raise Finished Floor Levels to reduce the risk of flooding. 3. Flood Resistance - Where it is not possible to raise floor levels, development should incorporate Resistance measures into the building design to prevent the ingress of water. 4. Flood Resilience - Resilience measures may be implemented, often in conjunction with Resistance measures, with the aim that in the event of flooding damage is limited and occupancy/use can resume quickly and efficiently. • Sustainable drainage (SuDS) should be used on all new development as detailed through Policy CC5 (Climate change and sustainability document) and in accordance with the The SuDS Manual (C753) and 'Central Bedfordshire Sustainable Drainage guidance: May 2015'. • Discharge methods for surface water runoff should comply with Planning Practice Guidance paragraph 80 and Building Regulations Approved Document H and should ease pressure of the development downstream, by reducing the impact of surface runoff entering a receiving waterbody or drainage network. • SuDS should ensure that post-development surface water run-off rates are attenuated to achieve a reduction in greenfield run-off rates and reduce existing downstream risk. This may include consideration of "off-site" solutions. • The design of SuDS should also take into consideration: biodiversity enhancement, mitigation of visual landscape impacts, maintenance and safety. • Onsite attenuation schemes would need to be tested against the hydrograph of the River Flit and unnamed watercourse to ensure flows are not exacerbated downstream within the catchment. • Assessment for runoff should include allowance for climate change effects. • Safe access and egress will need to be demonstrated. • Due to the close proximity of the site to an IDB district, the IDB should be consulted. • Wherever possible, developers should seek to reduce flood risk and provide wider sustainability benefits by undertaking or contributing towards the following: o reconnection of rivers to the floodplain, o betterment of existing discharge rates and volumes, o removal of redundant in channel structures, o integrating or retrofitting surface water measures to replace and/or augment an existing drainage system in a developed catchment • Green infrastructure should be considered within the mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	Sundon RFI
	Area (ha)	50.0
	Current land use	Greenfield
	Proposed land use	Employment

Mapping Information	
Flood Zones	Flood Zones 2 and 3a are based on the Environment Agency's Flood Map for Planning Flood Zones. The site does not fall within these Flood Zones, nor are there ordinary watercourses shown to be in the site on OS mapping. For those located nearby, 2D generalised modelling was undertaken as a test, which confirmed no impacts to the site.
Climate change	If applicable, developers should confirm the climate change flood extents as part of a site-specific FRA. As there are no field drains or watercourses likely to impact the site, this may not be required.
Surface Water	The Risk of Flooding from Surface Water has been used to define areas at risk from surface water flooding.
Groundwater	The Risk of groundwater flooding to the site has been assessed using the Areas Susceptible to Groundwater Flooding dataset.
Depth, velocity and hazard mapping	There is no fluvial flood risk shown to the site as part of this assessment. If applicable, developers should confirm the depth, velocity and hazard to the site as part of a site-specific FRA of any local field drains.
Reservoir	The Environment Agency's online 'Long term flood risk information, Flood risk from reservoirs, Extent of flooding' viewer was used to define areas at risk from reservoirs.

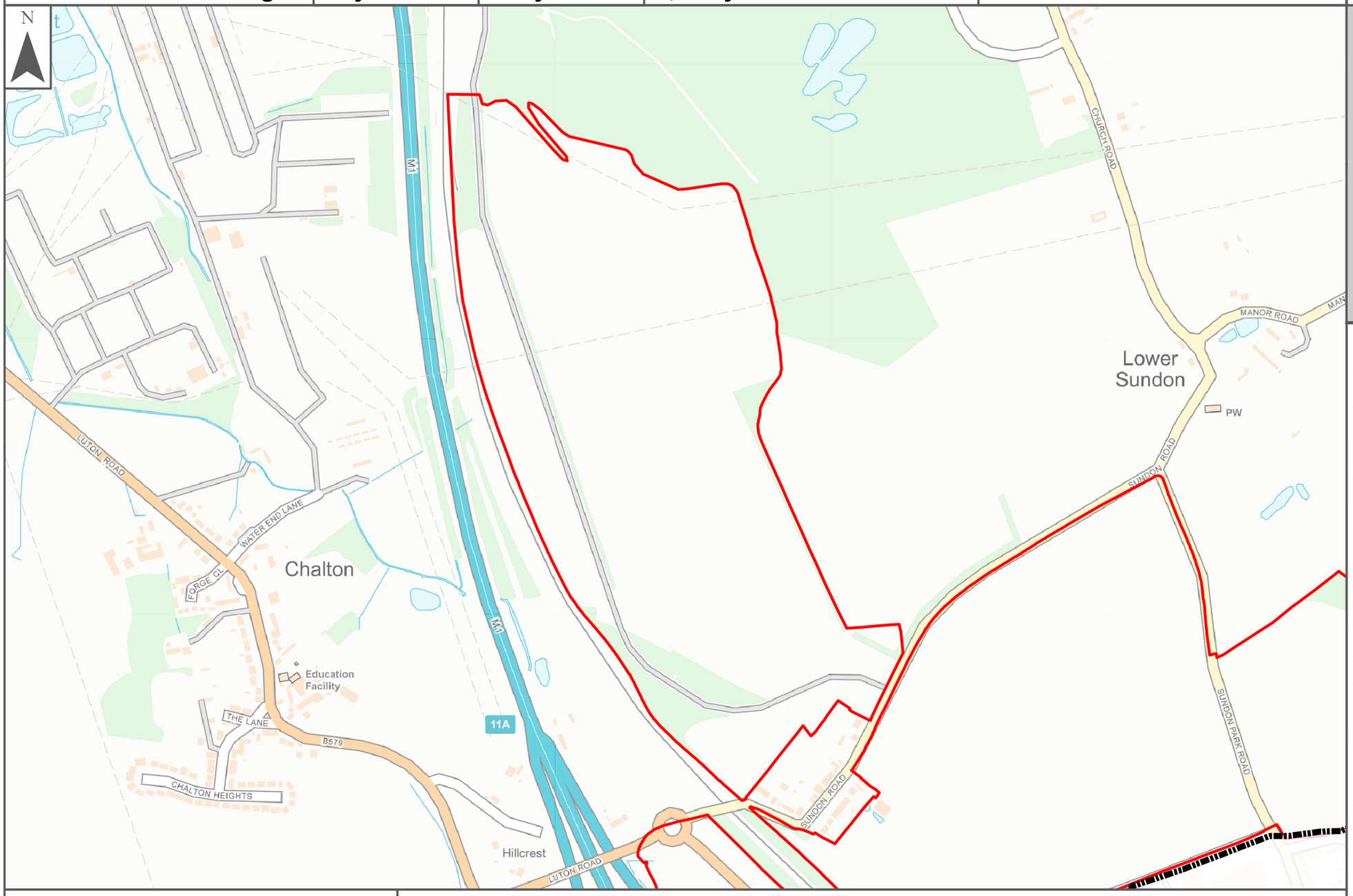
Site ID: Sundon RFI

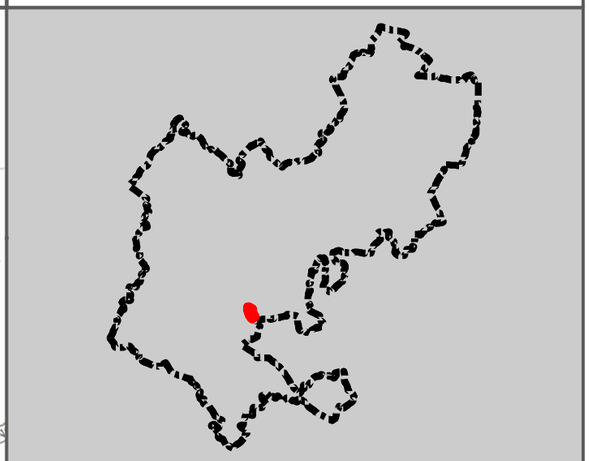
OSNGR: 503840.53 , 226811.32	**Area:** 50.0	Greenfield		
Flood Zone Coverage	**FZ3b :** TBC%	**FZ3a:** TBC%	**FZ2 :** TBC%	**FZ1 :** TBC%
Surface Water Coverage	**30-year :** TBC%	**100-year:** TBC%	**1,000-year:** TBC%	

Proposed Development Details:
Employment

LEVEL 2 SITE SUMMARY TABLES

STRATEGIC FLOOD RISK ASSESSMENT





LEGEND

Flood Risk

Flood Zones
- Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

Climate Change
- Climate Change Central
- Climate Change Higher Central
- Climate Change Upper End

Surface Water
- RoSWf 30-year Extent
- RoSWf 100-year Extent
- RoSWf 1,000-year Extent

Area Susceptible to Groundwater Flooding
- < 25%
- >= 25% <50%
- >= 50% <75%
- >= 75%

Fluvial 100-year event
- Depth (m): 0 - 0.10; 0.10 - 0.50; 0.50 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; 2.50 - 3.00; 3.00 - 3.50; 3.50 - 4.00; >4.00
- Velocity (m/s): 0 - 0.2; 0.2 - 0.5; 0.5 - 1.0; 1.0 - 2.0; > 2.0
- Hazard Rating: Very low hazard - caution; Danger for some; Danger for most; Danger for all

Please refer to Main Report and Site Summary Table for further information on the datasets

0 0.125 0.25 0.5 km

JBA consulting

LEGEND

Authority Information
- Central Bedfordshire Council boundary
- Potential Site Allocations
- Main River
- Detailed River Network

Defences
- Defence

Reservoir Inundation Map
- Reservoir Inundation

Source Protection Zone
- Zone 1
- Zone 2
- Zone 3

Other
- Flood Warning Area
- Flood Alert
- Historic Landfill

Mapping

Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables

<table>
<tr><td rowspan="4">Site details</td><td>Site Name</td><td colspan="4">West of A1, Biggleswade</td></tr>
<tr><td>Area (ha)</td><td colspan="4">130.6</td></tr>
<tr><td>Current land use</td><td colspan="4">Predominantly Greenfield</td></tr>
<tr><td>Proposed land use</td><td colspan="4">Employment</td></tr>
<tr><td rowspan="6">Sources of flood risk</td><td>Existing drainage features</td><td colspan="4">• The River Ivel (Main River) is located 850m to the west of the site.
• An unnamed Ordinary Watercourse flows through the northern portion of the site, entering along the eastern boundary and flowing in a western direction before exiting along the western boundary and proceeding to flow in a north-west direction away from the site.
• An unnamed Ordinary Watercourse has its source along the eastern boundary and flows around the eastern and southern boundaries of the site before flowing away from the site in a western direction.
• Several small ditches/ drains located across the site.</td></tr>
<tr><td>IDB watercourse present?</td><td colspan="4">The site is largely located within the IDB district of the Bedfordshire and River Ivel Board. The IDB coverage includes the watercourse that flows through the site in addition to those that flow along the site boundary.</td></tr>
<tr><td rowspan="4">Fluvial</td><td colspan="4">Proportion of site at risk</td></tr>
<tr><td>FZ3b</td><td>FZ3a</td><td>FZ2</td><td>FZ1</td></tr>
<tr><td>TBC</td><td>TBC</td><td>TBC</td><td>TBC</td></tr>
<tr><td colspan="4">EA Flood Zones show no fluvial flood risk to the site due to the catchments not being represented on the FEH CD-ROM. The unnamed Ordinary Watercourse that flows along the southern boundary was modelled using 2D hydraulic modelling techniques. The flood extents from this watercourse are shown to encroach slightly along the southern boundary area.
There are several unmodelled field drains within and adjacent to the site. The application of 2D modelling techniques to assess the flood risk from these drains was determined not to be practical due to the flat topography and low resolution DTM coverage. As such, a detailed assessment of the flood risk from these field drains should be carried out by the developer at the FRA stage.</td></tr>
<tr><td rowspan="4">Surface Water</td><td colspan="3">Proportion of site at risk (RoFfSW)</td></tr>
<tr><td>30-year</td><td>100-year</td><td>1,000-year</td></tr>
<tr><td>TBC</td><td>TBC</td><td>TBC</td></tr>
<tr><td colspan="3">Sporadic pockets of pooling surface water begin to affect the site in the 30-year event with greater concentrations near existing watercourses. The extent of surface water flooding continues to increase in the 100-year event. In the 1,000-year event surface water flow routes along and adjacent to existing channels affects much of the site.</td></tr>
<tr><td>Canal</td><td colspan="4">No canal infrastructure is present in the vicinity of the site.</td></tr>
<tr><td>Reservoir</td><td colspan="4">The site is not shown to be at risk of reservoir flooding.</td></tr>
<tr><td>Flood history</td><td colspan="4">The Environment Agency's historic flood map does not show the site as having flooded in the past.</td></tr>
</table>

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	West of A1, Biggleswade			
	Area (ha)	130.6			
	Current land use	Predominantly Greenfield			
	Proposed land use	Employment			
Climate Change	**Climate change allowances for '2080s'**	**River Basin District**	**Central**	**Higher Central**	**Upper End**
		Anglian	25%	35%	65%
	Rainfall – Upper end allowances	All England	10%	20%	40%
	Future implications for the site	Climate change is predicted to increase storm intensities and frequencies in the UK. Fluvial climate change extents from the Ordinary Watercourse that flows along the southern boundary are shown to be increase slightly compared to FZ3a with the Upper End allowance being comparable with FZ2. Flood extents associated with the unmodeled Ordinary Watercourse / field drains are likely to increase as a result of climate change. Consideration of climate change impacts should be included when assessing the flood risk of the field drains at the site-specific level. Considering the site is already at risk of surface water flooding climate change may increase in the extent, depth and frequency of surface water flooding to the site.			
Existing flood risk management infrastructure	**Defences**	**Defence Type**	**Standard of Protection**	**Condition**	
		-	-	-	
		This site is not protected by any formal flood defences.			
	Residual risk	-			
Emergency planning	**Flood warning**	The site is not located within an Environment Agency Flood Warning Area.			
	Access and egress	Dry access and egress is available via the A1 / London Road is available in all return periods in the event of fluvial flooding. In the event of surface water flooding the A1 / London Road is accessible until the 1,000-year event at which point access and egress is lost.			

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	West of A1, Biggleswade
	Area (ha)	130.6
	Current land use	Predominantly Greenfield
	Proposed land use	Employment
Requirements for drainage control and impact mitigation	**Groundwater Source Protection Zone**	The site is partially located within Groundwater Source Protection (GSP) Zone 1, 2 and 3. Infiltration techniques should only be used outside of GSP Zone 1 and following the granting of any required environmental permits from the Environment Agency for GSP Zones 2 and 3, although it is possible that infiltration may not be permitted. Proposed SuDS should be discussed with relevant stakeholders (LPA, LLFA and EA) at an early stage to understand possible opportunities and constraints.
	Historic Landfill Site	No Environment Agency designated historic landfill sites are underlying the site.

	Broadscale assessment of possible SuDS	• Geology at the site consists of:
		  ○ Bedrock – Sandstone, Mudstone and Limestone
		  ○ Superficial –Diamicton, sand and gravel
		• Source control techniques are likely to be suitable for this site.
		• Although mapping suggest groundwater flooding may be an issue at the site, Infiltration techniques may be suitable, providing they are located in areas that are not at medium to high risk from groundwater flooding and they are located outside of GSP Zone 1.
		• Detention features may be feasible providing site slopes are <5% at the location of the detention feature. If groundwater flooding is a medium to high risk to the site, then a liner may be required to mitigate against potential contamination issues.
		• Filtration systems are probably suitable providing site slopes are <5% and the depth to the water table is >1m. If the site has contamination issues, or is at medium to high risk from groundwater flooding, then a liner will be required.
		• All forms of conveyance features are likely to be suitable. Where slopes are >5%, features should follow contours or utilise check dams to slow flows.

NPPF and planning implications	**Development Vulnerability Classification to Flooding**	Under NPPF developments associated with employment (i.e. offices, general industry, storage and distribution etc.) are considered 'Less Vulnerable'.

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

Site details	**Site Name**	West of A1, Biggleswade
	Area (ha)	130.6
	Current land use	Predominantly Greenfield
	Proposed land use	Employment
	Exception Test requirements	A sequential approach to site layout is encouraged, to steer development away from areas of flood risk on the site (i.e. where surface water is prevalent, especially in the 30-year event). The Exception Test will need to be applied if: • More Vulnerable and Essential Infrastructure development is located in FZ3a and for Highly Vulnerable development located in FZ2. • Highly Vulnerable infrastructure should not be permitted within FZ3a and FZ3b. • More Vulnerable and Less Vulnerable Infrastructure should not be permitted within FZ3b. • Essential Infrastructure in Flood Zone 3b will require the Exception Test.

	Requirements and guidance for site-specific Flood Risk Assessment	• At the planning application stage, a site-specific Flood Risk Assessment will be required if any development is located within Flood Zones 2 or 3, is greater than one hectare, is located within 20m of a watercourse, or is identified as being at significant surface water flood risk by the Council. Other sources of flooding should also be considered. • Consultation with the Local Authority, Local Lead Flood Authority, and the Environment Agency should be undertaken at an early stage. • Developers should confirm the flood risk to the site from the ditches/ field drains located within or adjacent to the site where 2D modelling techniques were unsuitable. • To reduce flood risk to development, the following hierarchy should be followed by developers, as per Local Plan policy: 1. Flood Avoidance - A sequential approach to site layout is applied, directing the most vulnerable uses to the areas at lowest risk from all sources of flooding (i.e. Flood Zone 1). 2. Raising Floor Levels - Where it is not possible to develop outside of flood risk areas, development should raise Finished Floor Levels to reduce the risk of flooding. 3. Flood Resistance - Where it is not possible to raise floor levels, development should incorporate Resistance measures into the building design to prevent the ingress of water. 4. Flood Resilience - Resilience measures may be implemented, often in conjunction with Resistance measures, with the aim that in the event of flooding damage is limited and occupancy/use can resume quickly and efficiently. • Sustainable drainage (SuDS) should be used on all new development as detailed through Policy CC5 (Climate change and sustainability document) and in accordance with The SuDS Manual (C753) and 'Central Bedfordshire Sustainable Drainage guidance: May 2015'. • Discharge methods for surface water runoff should comply with Planning Practice Guidance paragraph 80 and Building Regulations Approved Document H and should ease pressure of the development downstream, by reducing the impact of surface runoff entering a receiving waterbody or drainage network. • SuDS should ensure that post-development surface water run-off rates are attenuated to achieve a reduction in greenfield run-off rates and reduce existing downstream risk. This may include consideration of "off-site" solutions. • The design of SuDS should also take into consideration: biodiversity enhancement, mitigation of visual landscape impacts, maintenance and safety. • Onsite attenuation schemes would need to be tested against the hydrograph of the River Ivel to ensure flows are not exacerbated downstream within the catchment. • Assessment for runoff should include allowance for climate change effects. • Safe access and egress will need to be demonstrated. • Development in the near vicinity of a watercourse within an IBD area will require the consent of the relevant IDB. • The developer should contact the relevant IDB to determine the risk of flooding from IDB watercourses to the site. • Wherever possible, developers should seek to reduce flood risk and provide wider sustainability benefits by undertaking or contributing towards the following: o reconnection of rivers to the floodplain, o betterment of existing discharge rates and volumes, o removal of redundant in channel structures,

Mapping	**Central Bedfordshire Strategic Flood Risk Assessment - Level 2 Detailed Strategic Site Summary Tables**	

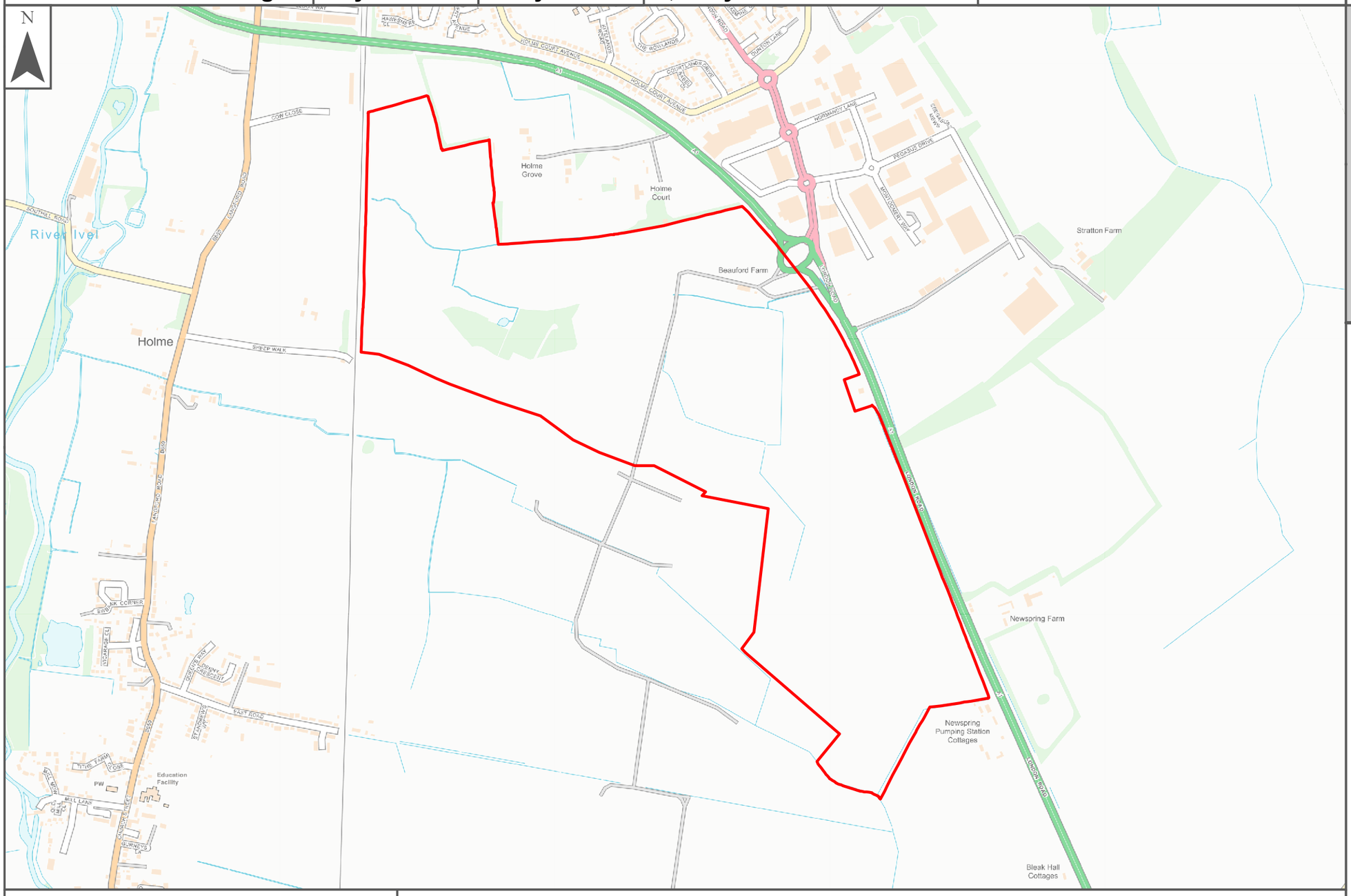
Site details	**Site Name**	West of A1, Biggleswade
	Area (ha)	130.6
	Current land use	Predominantly Greenfield
	Proposed land use	Employment
		○ integrating or retrofitting surface water measures to replace and/or augment an existing drainage system in a developed catchment • Green infrastructure should be considered within the mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

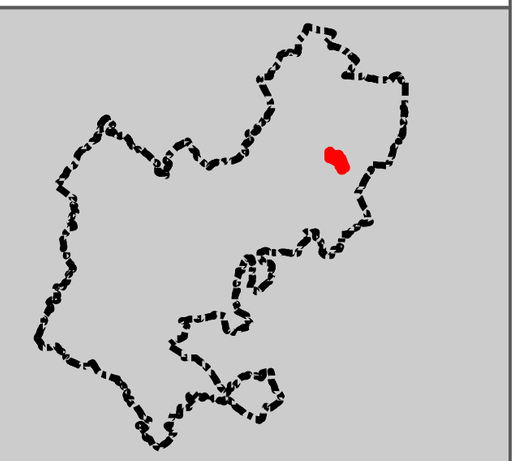
Mapping Information	
Flood Zones	Flood Zones 2, 3a and 3b re based on 2D generalised modelling because the watercourses were not represented on the Environment Agency's Flood Map for Planning Flood Zones. Developers should confirm the Flood Zone extents as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Climate change	The climate change allowances for the '2080s' scenario were modelled using 2D generalised modelling. Developers should confirm the climate change flood extents as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Surface Water	The Risk of Flooding from Surface Water has been used to define areas at risk from surface water flooding.
Groundwater	The risk of groundwater flooding to the site has been assessed using the Areas Susceptible to Groundwater Flooding dataset.
Depth, velocity and hazard mapping	Depth, velocity and hazard mapping for the 1 in 100-year event (Flood Zone 3a) have been taken from the 2D generalised modelling conducted as part of this Level 2 assessment. Developers should confirm the depth, velocity and hazard to the site as part of a site-specific FRA, using detailed hydraulic modelling and channel topographic survey.
Reservoir	The Environment Agency's online 'Long term flood risk information, Flood risk from reservoirs, Extent of flooding' viewer was used to define areas at risk from reservoirs.

Site ID: West of A1, Biggleswade

LEVEL 2 SITE SUMMARY TABLES

OSNGR: 520190.99 , 242470.89	**Area:** 130.6	Predominately Greenfield	**Proposed Development Details:**	**STRATEGIC FLOOD RISK ASSESSMENT**
Flood Zone Coverage	**FZ3b :** TBC%	**FZ3a:** TBC%	**FZ2 :** TBC%	**FZ1 :** TBC%	Employment	
Surface Water Coverage	**30-year :** TBC%	**100-year:** TBC%	**1,000-year:** TBC%			





LEGEND

Flood Risk

Flood Zones
- Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

Climate Change
- Climate Change Central
- Climate Change Higher Central
- Climate Change Upper End

Surface Water
- RoSWf 30-year Extent
- RoSWf 100-year Extent
- RoSWf 1,000-year Extent

Area Susceptible to Groundwater Flooding
- < 25%
- >= 25% <50%
- >= 50% <75%
- >= 75%

Fluvial 100-year event
- Depth (m): 0 - 0.10; 0.10 - 0.50; 0.50 - 1.00; 1.00 - 1.50; 1.50 - 2.00; 2.00 - 2.50; 2.50 - 3.00; 3.00 - 3.50; 3.50 - 4.00; >4.00
- Velocity (m/s): 0 - 0.2; 0.2 - 0.5; 0.5 - 1.0; 1.0 - 2.0; > 2.0
- Hazard Rating: Very low hazard - caution; Danger for some; Danger for most; Danger for all

Please refer to Main Report and Site Summary Table for further information on the datasets

LEGEND

Authority Information
- Central Bedfordshire Council boundary
- Potential Site Allocations
- Main River
- Detailed River Network

Defences
- Defence

Reservoir Inundation Map
- Reservoir Inundation

Source Protection Zone
- Zone 1
- Zone 2
- Zone 3

Other
- Flood Warning Area
- Flood Alert
- Historic Landfill

JBA consulting

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B Appendix - Technical Supporting Information

B.1 2D Modelling Technical Summary

NOTE TO FILE

JBA Project Code	2016s4180
Contract	Central Bedfordshire Council L2 SFRA
Client	Central Bedfordshire Council
Day, Date and Time	09 January 2018
Author	Roberta Whittaker
Subject	Central Bedfordshire Council – 2D generalised modelling

1 Introduction

This document is designed to give an overview of the 2D modelling approach for the strategic modelling used to assess fluvial flood risk to site allocations in the Central Bedfordshire Level 2 SFRA, where no detailed Environment Agency models were available.

2 Modelling Approach

2.1 Introduction to hydraulic modelling

Hydraulic modelling allows simplification of very complex processes, which can enable us to predict flooding caused by events of different return periods. Hydraulic models can be classified according to the number of dimensions in which they represent the spatial domain and flow processes.

One-dimensional models can be useful for studying flood levels and discharges in river systems, and have been applied to flood routing problems at the reach scale. They allow for rapid evaluation of water levels and are best suited for describing flow within channels and through hydraulic structures. They are computationally very efficient but can be potentially expensive in terms of time and data required. The areas between cross-sections are not explicitly represented and a secondary processing step is required in order to map flood inundation.

Two-dimensional models are capable of accurately simulating flow patterns during partial inundation and drainage of the floodplain in order to predict flood risk in these regions. They are therefore best suited for describing the lateral diffusion of shallow water flows over low-lying areas. With two-dimensional models the topography and roughness is described as a continua and they facilitate direct mapping of flood inundation. However, when compared to 1D models, 2D models can be relatively computationally expensive and poor at describing flow through hydraulic structures.

Coupled 1D-2D models can therefore be used to combine the best attributes of each model class to achieve acceptable, computationally affordable predictions of flood extent when compared to typically available verification data.

2.2 2D modelling using JFlow

JFlow® is JBA's proprietary 2D hydraulic model. The model solves the full Shallow Water Equations on a regular square cell grid, and utilises GPU technology to provide parallelised calculations which allows large regions to be modelled efficiently, whilst capturing a wide range of flood hydraulic processes.

The Shallow Water Equations are comprised of two components. The first part is the continuity equation which describes the amount of water that moves in a given amount of time (the given amount of time is known as the timestep). The second component is the momentum equation which describes the rate at which water will move between cells. By solving both of these components at a point in time, the velocity and depth of water at a location can be determined, and by solving these sequentially through time, the passage of a flood wave over an area can be determined.

The inputs to JFlow® are a topographical domain model, which is represented as a grid where each cell of the grid represents a coordinate position with elevation data. Water is then added to the grid as either a hydrograph (river discharge vs time) or as a hyetograph (rainfall depth vs time). A number of additional parameters to the Shallow Water Equations are also input, such as Manning's n, which is a friction coefficient that accounts for losses in momentum caused by water travelling over a surface.

JFlow® determines for each cell, for each timestep in a simulation, a water depth, and a velocity. This is done in three steps. Assuming that for a cell, the water depth and the velocity of the adjacent cell is known, the first step involves determining the volume of water in the cell and the adjacent cell, and calculating the amount of water that can move between those cells (Figure 1). The second step, the inter-cell flux, determines the rate at which the amount of water calculated in step 1 can move, using the velocity of water from the previous cell and the momentum component of the shallow water equations. These two steps then allow the water depth and velocity in the cell to be calculated. Step 3 then repeats

this calculation for all adjacent cells, to determine the direction, speed and volume of flow (Figure 2). This leads to a vector calculation from the cell, in the direction of the greatest hydraulic slope calculated from each of the intercell fluxes.

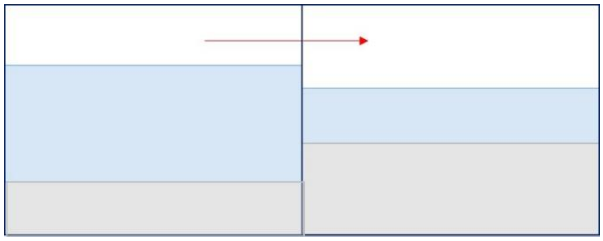


Figure 1: (Step 1 & 2) The Intercell Flux is calculated between two cells. The depth of water in each cell and the height of the terrain determines the volume of water to move. This figure will lead to a movement of water from the left side cell to the right side cell as represented by the red arrow.

The process is performed for all model cells in the domain for an interval of time (the time step), before the time interval is evolved and a new set of water depths in the grid are calculated based on the previous time interval. These steps are then repeated for the duration of the modelled flood event to determine the movement of the flood wave over the model domain.

In order to determine the greatest hazard from flooding, the maximum calculated flood depth for each cell across the time duration is calculated. The final hazard output represents a composition of the highest water depths for each cell, during the flood event. A series of model domains are used to model river reaches, before being amalgamated into a final flood hazard map.

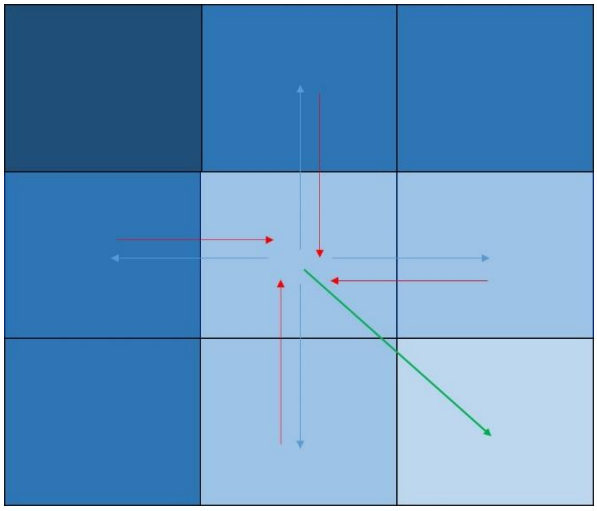


Figure 2: (Step 3) Calculating the intercell flux for all cells and solving to determine the new depth values. After step 1 and 2 are completed (red arrows), all intercell fluxes are calculated for adjacent cells and new values of depth are based on the net values of the intercell fluxes. The resulting sum in this example would see the overall flood wave propagating in the direction of the green arrow in the direction of greatest water slope

2.2.1 Hydrology

In order to run Jflow, hydrological estimates need to be generated for each inflow point. These estimates are based on catchment descriptors extracted from the FEH CD-ROM. Typically, there was an inflow point upstream of each of the site allocations requiring Jflow; however, on longer stretches of watercourse multiple points were used at 100m spacing intervals. The key information within the catchment

descriptors which was used to determine hydrological flows is listed in Table 1. In some cases, the catchment descriptors associated with an inflow point can be extracted from a nearby river or stream, which may cause jumps or falls in the hydrograph values compared with the rest of the reach. In these instances, donor catchments of nearby inflow points were used with adjustments made to the catchment descriptors to represent the new characteristics.

Table 1: Example catchment descriptors

Catchment Descriptor	Explanation
Area	Drainage area km^2
DPLBAR	Mean drainage path length (km)
DPSBAR	Mean slope between nodes (m/km)
FARL	Flood attenuation due to reservoirs and lakes (1.0 for no attenuation)
SAAR	Standard annual average rainfall 1961-1990 (mm)
BFIHOST	Baseflow index from hydrology of soil types
SPRHOST	Standard percentage runoff from soil types
PROPWET	Proportion of time catchment is wet (Soil moisture deficit < 6mm)
URBEXT1990	Urban extent in 1990

Once catchment descriptors had been extracted for each inflow point a JBA tool was used to generate hydrographs for various return periods. Flood Estimation Software (JFes) provides flood estimation for catchments in UK and Ireland. JFes has the capacity to create hydrographs suitable for use in JFlow to produce river hazard maps using catchment descriptors obtained from the FEH CD-ROM as described in the previous section. JFes uses information from the HiFlows-UK dataset to search for donor sites. HiFlows-UK provides flood peak data and station information, for approximately 1,000 gauging stations in the UK. Each point extracted from FEH CD-ROM has a unique ID. The output from the bulk extraction section of JFes produces a file for each requested return period comprising hydrographs for each point with and information about peak flows. The hydrograph is suitable for use in Jflow modelling and requires minimal data manipulation.

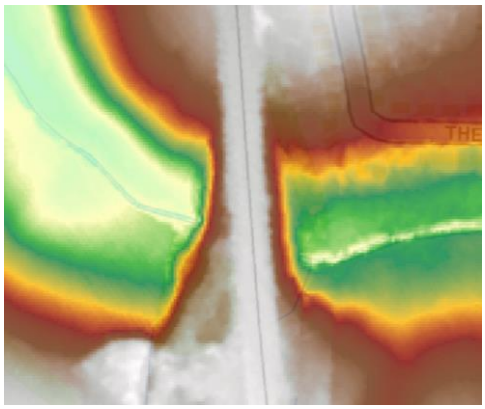
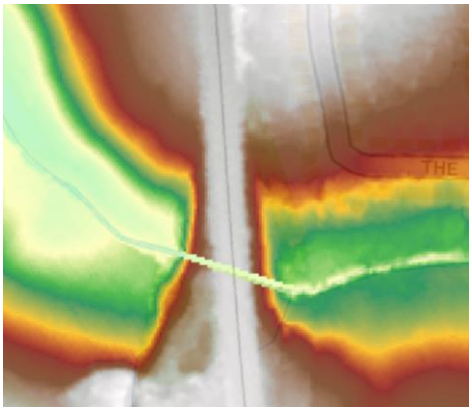
For the purpose of the SFRA the following return periods were modelled.

- 20-year (to inform Flood Zone 3b)
- 100-year (to inform Flood Zone 3a)
- 100-year + Climate Change (+35% and +70% to account for 2080s allowances)
- 1,000-year (to inform Flood Zone 2)

2.2.2 Digital Terrain Model

The Digital Terrain Model (DTM) was created from open LIDAR downloaded from the open.gov.uk website (supplied from Environment Agency). The DTM is a bare earth model but still contains some features such as bridges, subways and embankments which appear as high ground and act as obstacles to flow during the modelling process. This can result in flow accumulating behind which can cause unrealistically high depths and wide extents. In reality, water would flow underneath or around these structures. Where unusual flood extents and depths were observed, the presence or absence of a man-made structure was confirmed by inspecting aerial imagery and the terrain model. If a structure was identified, the high elevations due to man-made obstacles were ‘cut through’ enabling more natural flow (See Figure 3).

Figure 3: DTM cut through example

Original DTM	DTM + Cut through
	

2.2.3 Hydraulic Modelling Assumptions

A number of assumptions were made during the hydraulic modelling process:

- Channel capacity - This was assumed to equal QMED (2-year return period) for all rivers. Particularly in urban areas where channel improvements may have been carried out, this assumption can result in an underestimation of the channel capacity and hence an overestimation of the flood extent. However, studies have shown that unmodified river channel capacities frequently compare well with QMED and so this is deemed an appropriate assumption.
- Manning's *n* - A value of 0.1 was used throughout the study area. This represents a relatively conservative estimate but has been shown to provide acceptable model output in previous studies.
- Structures - Such as bridges and weirs were not explicitly modelled.
- Culverts - These were not explicitly modelled although smaller culverts through large structures such as railway embankments have been crudely cut into the DTM.
- Undefended - All river modelling is undertaken as undefended.
- Climate change hydrology – It has been assumed that hydrology for the 100-year + Climate Change 20%, 50% and 70% is a straight upscale of the 100-year hydrograph.

2.2.4 Outputs

Upon running Jflow, the following outputs were produced for each inflow point:

- Maximum depth
- Maximum velocity
- Maximum hazard

Following completion of the modelling, all outputs from each inflow point were mosaicked into one dataset per return period.

2.2.5 Quality Control

Once the hydraulic model was run for each return period, the resulting depth grid outputs were visually checked and adjustments to the modelling inputs were made where required. The adjustments and checks made include (but are not limited to):

- **Straight edges** – In some cases, straight edges can occur in the flood outlines where the flow is artificially restricted by the modelling domain size. The domain was extended to allow flow to run out naturally where possible.
- **Disconnected flooding** – Flood outlines can be disconnected as a result of a high point in the DTM that restricts the flow. This can be improved by moving an inflow point to the high point in an attempt to fill the break in the flood outline. In some cases, where the channel is not well represented, manual editing of the channel can occur. In all cases the channel was considered with reference to aerial imagery.
- **Cross section edges** - Due to the modelling methods used, straight edges of relatively deeper depths can occur where inflow points are located across the flood outline. This is especially prominent where flow can become constricted behind a road or railway line. To mitigate this, the inflow point was moved upstream further away from the restriction or the cross sections re-angled appropriately.
- **Alignment of points** – Due to the nature of the watercourses and the resolution of the LIDAR creation of inflow points, in some cases these were located outside of the river channel causing unrealistic flood outlines. These points were moved onto the lowest part of the river channel to correct this problem.
- **Restriction of flow due to structures** – The flood depths can be artificially increased by the presence of blockages in the DTM, these can be mitigated by DTM editing (as explained in section 2.1.2)
- **Increase in depth/extent per return** – both visual and automatic checks are undertaken to ensure that flood depths and flood extents increase with return period.
- **Unrealistic output** – in certain circumstances, JFlow can produce erroneous output where flood depths and extents are unrealistically produce. These errors were spotted both visually and through automatic checks.

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t:+44(0)1756 799919
e:info@jbaconsulting.com

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