4.3 Site H3E3

4.3.1 Site overview

Figure 4.3.1 – Location plan of site

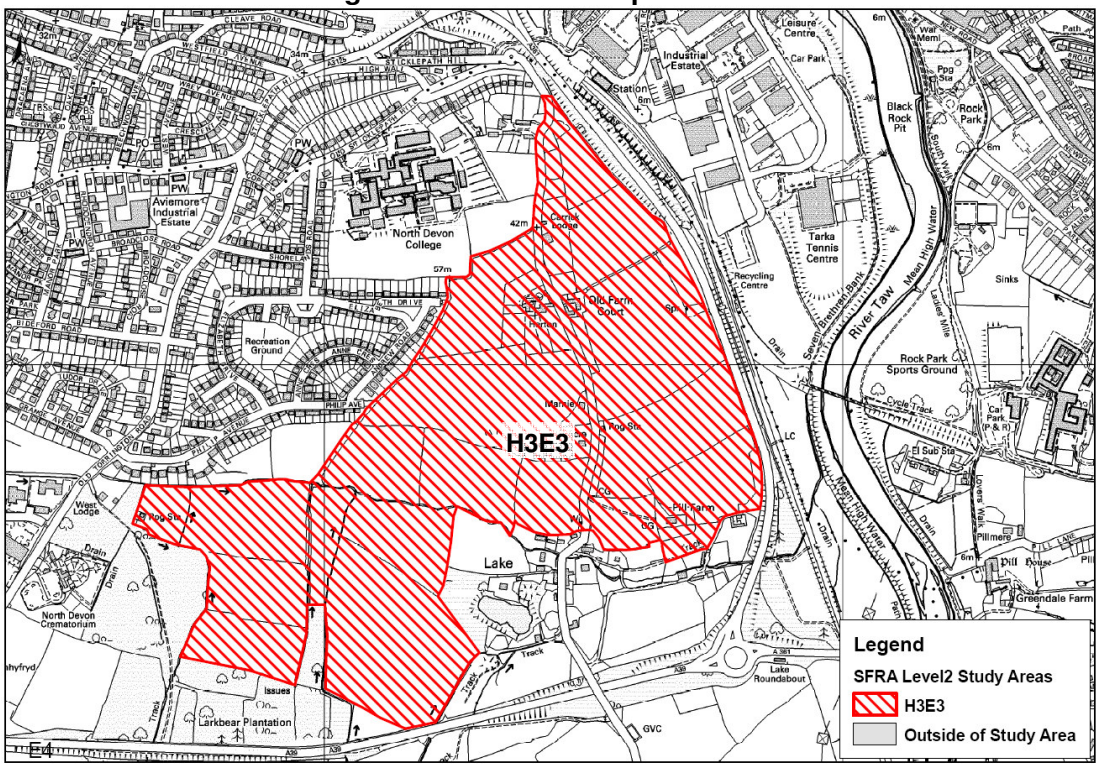

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Table 4.3.1- Site details

Site ID	Location	Area (ha)			Proposed use	Capacity		
		Site	Development			40dph	50dph	60dph
			Residen-tial	Employ-ment				
H3E3	Land at Larkbear Plantation	59	27	12	Mixed	1080	1350	1620

Site H3E3 is situated south and west of the River Taw adjacent to the North Devon College site. The A361 forms the east boundary of the site with the A39 to the south. It is one of the larger sites being considered for the Barnstaple Urban Extension with a total area of 59 hectares, 39 being available for a mixture of employment and residential development. Table 4.3.1 specifies the development details for the site as provided by North Devon Council.

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4.3.2 Overview of existing flood risk and inundation

Figure 4.3.2 – Existing Flood Risk

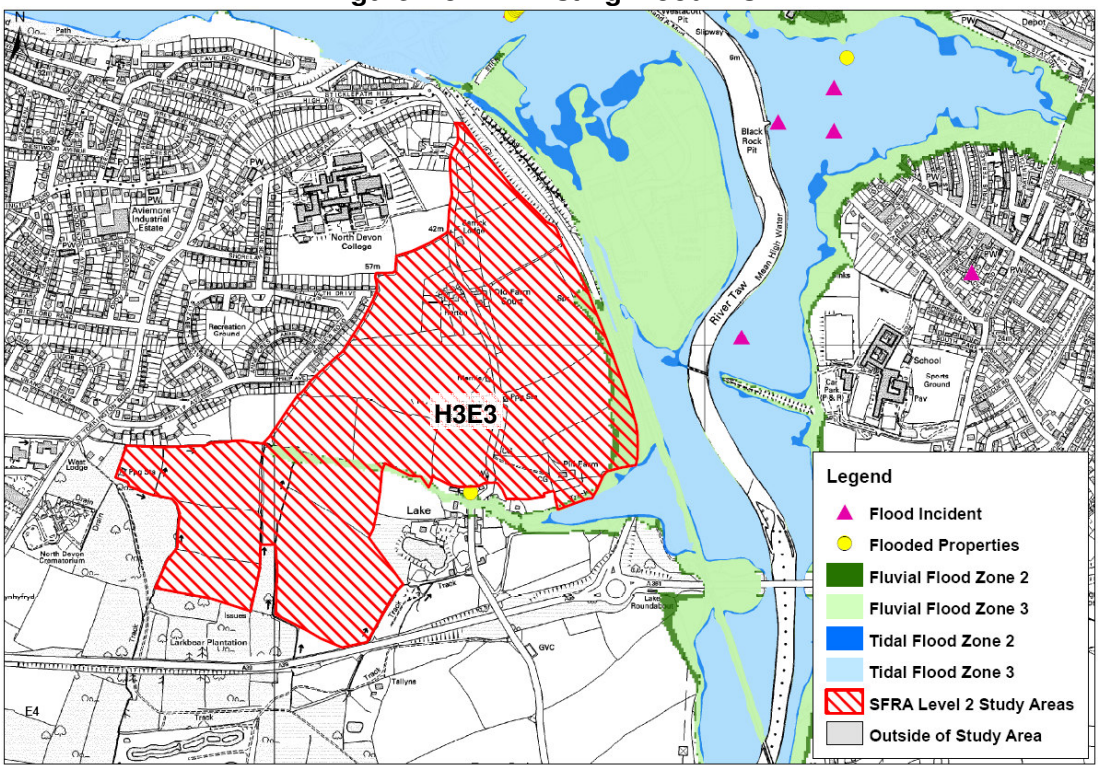

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Table 4.3.2– Indicators of existing flood risk

Entirely within FZ3	N	
Partly within FZ3	Y	Site in fluvial Flood Zone along eastern edge of site (River Taw) and through middle of site relating to tributary of River Taw. Tidal Flood Zone is adjacent but does not currently extend into site.
Partly within FZ2	Y	
Entirely within FZ1	N	
Other watercourses not considered by Environment Agency Flood Zones	Y	Five small streams/ditches on the site draining from the south into the tributary to the River Taw.
Historical flood event	N	Adjacent to the site, records show flooding in Autumn 1993 alongside the tributary to the River Taw from both tidal and fluvial sources.
Topography	• Elevation between 7mOD (east of site alongside River Taw) and 54mOD (west of site)	

The LiDAR suggests that the site drains to the River Taw to the east and to a small tributary (Lake stream) which flows from west to east, draining into the Taw.

The EA fluvial Flood Zones 2 and 3 relating to the tributary extend in the order of 380m

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through the site at a width of approximately 40m as illustrated by Figure 4.3.2. The land surrounding the tributary is low-lying and generally elevated above the Flood Zone by 5m or less. As a precautionary approach it is therefore suggested that low-lying land in and adjacent to the Flood Zones is retained as 'open space' if development is pursued at the site.

The EA fluvial Flood Zones 2 and 3 pertaining to the River Taw extend between 10m and 70m into the site along its eastern boundary (figure 4.3.2). The LiDAR shows that the site slopes steeply away from the Taw, therefore any development in this area will have to consider the effects of increased run-off due to development at lower elevations both within and adjacent to the site.

The EA tidal Flood Zones 2 and 3 relating both to the River Taw and the tributary do not currently extend into the site. However they are immediately adjacent to the site and any increase in extent, such as might occur due to the effect of climate change, could directly increase the flood risk to the site in the vicinity of Lake to the centre of the site.

South of the tributary (Lake Stream) to the River Taw the land is much flatter therefore the effects of increased run-off due to development must be considered with regard to the risk of ponding in addition to the risk of flooding from water entering the site from the Larkbear plantation to the south. Some small streams are also present in this part of the site which drain to the tributary of the Taw. They are too small for inclusion within the Environment Agency Flood Zones, however it is possible that they could present some level of flood risk to the site which would require further investigation prior to development. It would also have to be ensured that development did not increase the flow in the streams/ditches because this could have an impact on flood risk downstream, both on and off the site.

4.3.3 Existing defences, Verification of Defences and Areas Benefiting from Defences (ABDs)

NFCDD shows that there are no defences present on the site. Approximately 110m from the eastern boundary of the site there are raised man-made defences along the banks of the River Taw. These are maintained by the Environment Agency with a 1 in 100 year design standard of protection and a lowest crest elevation of 5.81mOD.

Note that there is a question regarding the standard of this defence due to the flood extents produced by the modelling, which shows that flooding occurs at the QMED event. Additional investigation may be required regarding the standard of protection of this structure.

4.3.4 Assessment of flood probability and hazard

The River Taw is located just over 130m from the eastern edge of the site and a tributary (Lake stream) to the Taw flows through the centre of the site from west to east. The River Taw was modelled for approximately 13km from Woodparks at Bishops Tawton to Yelland. The tributary was modelled for 0.7km from Lake Valley Road bridge to its confluence with the Taw. It was included in the model as a gully because the ISIS model of this watercourse proved to be unstable. ESTRY was used to represent the culvert under the A361 to the east of the site.

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Flood probability

Model results indicate that the site does not currently experience tidal or fluvial flooding, although both fluvial and tidal extents are present along the boundary of the site from Lake to the A361 with an onset of QMED and 1 in 10 year respectively (these are the lowest modelled return periods for each).

Flood depth

Flooding recorded by the model does not extend to the site therefore maps of flood depth are not displayed.

Flood hazard

There is no fluvial and tidal flood hazard to the site for the 1 in 100 and 1 in 200 year events under current conditions, however should a breach in the defences along the River Taw to the east of the site occur, or flood extents increase due to the effects of climate change, the hazard would likely increase for the eastern part of the site. The flood extents and associated hazards do not extend onto the site but run along southern boundary of the eastern half of the site in relation to the River Taw and the tributary to the Taw. The small area of hazard adjacent to the site is significant. To the south-east of the site there is an area of extreme hazard where the tributary to the Taw passes under the A361.

4.3.5 Impact of climate change

Increased flows due to the effects of climate change were modelled to increase fluvial flood extents in the vicinity of the site by between 0 and 20m laterally, however flood risk to the site is unaffected and is minimal for the land surrounding the site.

Tidal flood extents inclusive of the effects of climate change (for the years 2070 and 2115) are projected to expand up to 50m laterally from the current 1 in 200 year extent. However, tidal flooding is only expected to impact the SE corner of the site (area approx 1000m^2) by the year 2115.

Tidal and fluvial flood depths adjacent to the site are projected to increase with maximum depths of 4 to 6m.

Fluvial flood hazard was observed to remain extreme for the land to the east of the site including the surrounding land to the tributary to the Taw, but as with flood depth, because the fluvial flood extents do not reach the site, hazard for the site is not expected to increase due to the effects of climate change. The same applies to tidal hazard, with the exception that a small area (approx 1000m^2) in the SE of the site adjacent to the A361 experiences a significant hazard by 2115.

4.3.6 Access and Egress

Model results indicate that under current conditions the site and surrounding area does not experience tidal or fluvial flooding therefore access and egress does not present a problem at this site. Due to the effects of climate change tidal flood extents are projected to extend onto the site, however access and egress from the site remains safe.

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4.3.7 Overview of impact of development on flood risk elsewhere

Table 4.3.3 - Summary table of impacts of development

Return Period	% impermeable of net developable residential area	Flow (m^3/s)		
		Pre-development	Post-development	% increase
1 in 100 year	50	0.37	0.65	76
	70	0.37	0.76	106
	90	0.37	0.89	143

Table 4.3.3 suggests that development will have a considerable impact on the current flow regime of the site. Post-development flow rates are estimated to be between 0.65 and 0.89m3/s depending on the development option taken forward. This is approximately 15-20% of the 1 in 100 year peak flow for the tributary to the Taw which represents a considerable impact on the current flow regime. Therefore should development be pursued it is essential that surface water is stored and managed onsite and does not increase flood risk downstream. Another reason for minimising off-site flow is that the site is bounded on two sides by arterial transport routes for Barnstaple and any additional flow may increase the risk of flooding to already impermeable land. There may already be systems in place for managing surface water, however these will have been designed specifically for the capacity expected from the previously developed land and are unlikely to have sufficient spare capacity for additional flow.

The main risk of development on this site is likely to be the effect of increasing run-off to the tributary flowing through centre of site, which potentially may be sensitive to any additional flow since it discharges to the River Taw through a culvert which will have a finite capacity.

4.3.8 Surface water drainage

There are no recorded incidents of surface water flooding either on or adjacent to the site therefore it is suggested that there is currently no requirement for a SWMP in the vicinity of the site. This is supported by the ASSWF maps shown in Appendix E. However as there is flooding at Lake marsh to the east of the site a Surface Water strategy is likely to be required and due to the significant increase in run-off (at least 76% increase) expected to occur through development of the site, it is recommended that to minimise the impact on the surrounding area all surface water is managed onsite where possible, through the implementation of techniques such as sustainable drainage systems (SuDS).

No critical drainage areas have been identified, however it would be prudent to ensure that excess surface water is attenuated before reaching the tributary to minimise the risk of increasing flood risk downstream.

4.3.9 Consequences of infilling floodplain

There is only limited floodplain through the centre of the site. Development should be avoided in this area.

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4.3.10 Potential mitigation and management of residual risk

The site is mostly in Flood Zone 1 and model results show that development at the site would experience minimal risk from fluvial or tidal flooding. The main risk therefore is to the surrounding area as a result of increased run-off due to the impermeable surfaces created by development of the site. This is especially important given the steep topography of the site which would encourage any surface water to rapidly flow into the tributary to the River Taw in addition to affecting properties downstream of the site. It is also worth noting that the land to the south of the site is a plantation and at a higher elevation. Any development should therefore consider and aim to manage potential run-off onto the site from this source.

As detailed in section 4.3.8 SuDS would be required for any development in this area. Examples of the different types of SuDS that may be appropriate can be found in Appendix B. SuDS would also help to reduce the risk of increasing flow to the small number of streams/ditches onsite, the flood risk relating to which should be further investigated prior to any development. Should development be pursued at the site, these streams/ditches should not be culverted but used as a green corridor and maintenance regimes should be developed to minimise the risk of flooding from this source. Where possible it is suggested that land surrounding the streams/ditches is designated as 'open space' in order to further reduce the risk of flooding.

4.4 Site E4

4.4.1 Site overview

Figure 4.4.1 – Location plan of site

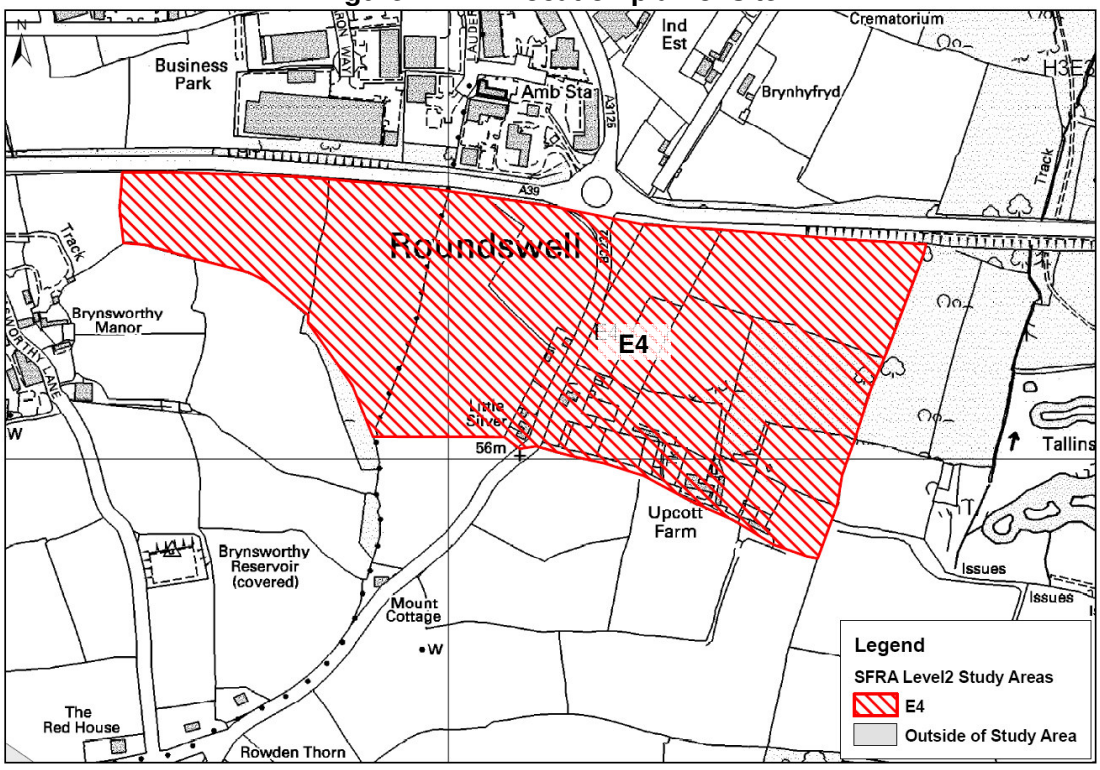

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Table 4.4.1- Site details

Site ID	Location	Area (ha)			Proposed use	Capacity		
		Site	Development			40dph	50dph	60dph
			Residen-tial	Employ-ment				
E4	Land south of A39, Roundswell	21	~	14	Employment	~	~	~

Site E4 is located to the south of Barnstaple at Roundswell with the A39 along its northern boundary. It is one of the sites being considered for the Barnstaple Urban Extension. Table 4.4.1 specifies the development details for the site as provided by North Devon Council.

4.4.2 Overview of existing flood risk and inundation

The site is contained entirely within the Environment Agency Flood Zone 1 and over 650m from the nearest areas of Flood Zones 2 and 3, therefore a figure has not been considered necessary for this section.

Table 4.4.2 – Indicators of existing flood risk

Entirely within FZ3	N	
Partly within FZ3	N	
Partly within FZ2	N	
Entirely within FZ1	Y	Lowest point of site is ~19m above and at least 670m from nearest area of FZ2 / FZ3.
Historical flood event	N	
Topography	• Site slopes from S to N with elevations between 37mOD (S) and 58mOD (N)	

There are no significant watercourses in or adjacent to the site. However the effects of development on surface water run-off and the impact this will have on flood risk to the site and surrounding area will still need to be taken into account.

The topography shows that the site is relatively flat, which suggests that should development go ahead, adequate drainage using sustainable drainage systems (SuDS) should be considered (see Appendix B for more information on SuDS). The land south of the site is steep and has an agricultural land use therefore it is recommended that some form of mitigation in order to manage the potential for run-off from this land to the site is considered should development go ahead.

4.4.3 Existing defences, Verification of Defences and Areas Benefiting from Defences (ABDs)

NFCDD shows that no defences are present on or adjacent to the site. Model results also indicate that flood risk to the site would not be affected should defences fail elsewhere in the region.

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4.4.4 Assessment of flood probability and hazard

Tidal and fluvial flooding do not constitute a risk to this site because there are no watercourses on or adjacent to the site therefore flood depth and hazard are not discussed in this section. However, it should be noted that other sources of flooding could still present a risk to the site.

4.4.5 Impact of climate change

Fluvial and tidal flooding does not extend onto the site for current or future modelled events therefore increased flows and sea level rise due to the effects of climate change are not expected to increase flood risk to the site or surrounding land.

4.4.6 Access and Egress

Model results indicate that the site and surrounding area does not experience tidal or fluvial flooding therefore access and egress does not present a problem at this site.

4.4.7 Overview of impact of development on flood risk elsewhere

Table 4.4.3 - Summary table of impacts of development

Return Period	% impermeable of net developable commercial area	Flow (m^3/s)		
		Pre-development	Post-development	% increase
1 in 100 year	95	0.14	0.33	133

Only commercial development is proposed at this site and therefore only one scenario that required testing as the net developable residential area was not relevant. The percentage increase is high but actual flow rates are very low with a post-development flow of less than $0.5m^3/s$. This indicates that the impact of development on the surrounding area would be minimal, although if development is pursued it is suggested that surface water run-off is managed on site as the site drains downslope towards the main A39 which may not have the drainage capacity to deal with extra surface water.

4.4.8 Surface water drainage

There are no recorded incidents of surface water flooding either on or adjacent to the site therefore it is suggested that there is currently no requirement for a SWMP in the vicinity of the site. This is supported by the ASSWF maps shown in Appendix E. However due to the significant increase in run-off (at least 133% increase) expected to occur through development of the site, it is recommended that to minimise the impact on the surrounding area all surface water is managed onsite where possible, through the implementation of techniques such as sustainable drainage systems (SuDS).

No critical drainage areas have been identified.

4.4.9 Consequences of infilling floodplain

Not applicable at this site.

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4.4.10 Potential mitigation and management of residual risk

The site is entirely in Flood Zone 1 and model results show that development at the site would not be at risk from fluvial or tidal flooding. The main risk therefore is to the surrounding area as a result of increased run-off due to the impermeable surfaces created by development of the site.

As detailed in section 4.4.8 SuDS would be required for any development in this area. Examples of the different types of SuDS that may be appropriate can be found in Appendix B. As stated in section 4.4.2, a SuDS pond could be appropriately located in the NE of the site.

4.5 Site H5E5

4.5.1 Site overview

Figure 4.5.1 – Location plan of site

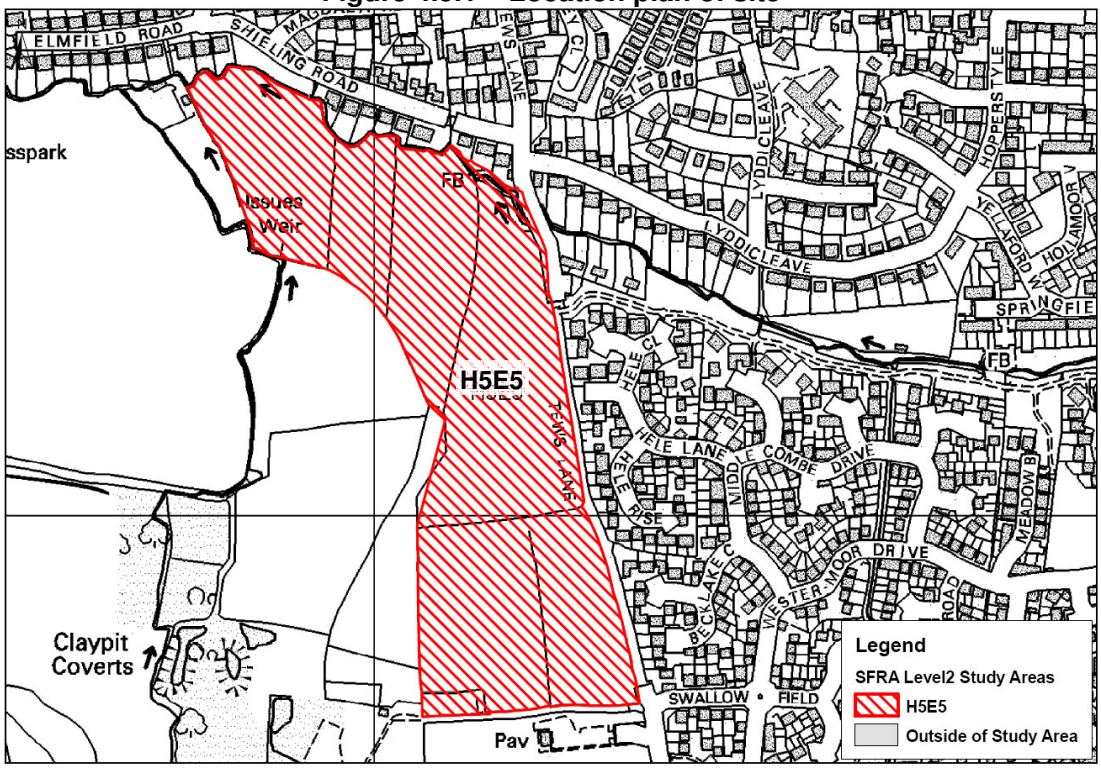

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Table 4.5.1- Site details

Site ID	Location	Area (ha)			Proposed use	Capacity		
		Site	Development			40dph	50dph	60dph
			Residen-tial	Employ-ment				
H5E5	Land west of Tews Lane, Barnstaple	9	4.5	1.5	Mixed	180	225	270

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Site H5E5 is located to the west of Tews Lane, south of Bickington. It is one of the smaller sites being considered for the Barnstaple Urban Extension. Table 4.5.1 specifies the development details for the site as provided by North Devon Council.

4.5.2 Overview of existing flood risk and inundation

Figure 4.5.2 – Existing Flood Risk

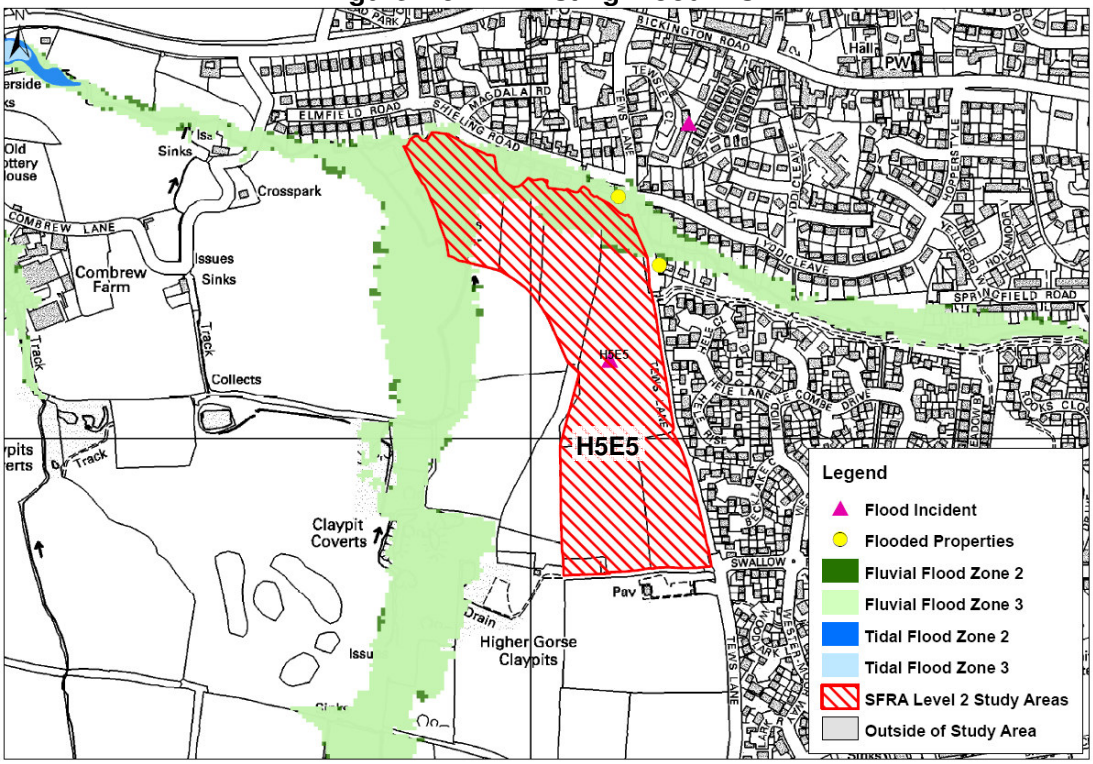

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Table 4.5.2 – Indicators of existing flood risk

Entirely within FZ3	N	
Partly within FZ3	Y (fluvial)	
Partly within FZ2	Y (fluvial)	
Entirely within FZ1	N	
Historical flood event	Y	• 2 properties flooded to NE of site from fluvial, sewerage and surface water. Date unknown. • Events in 1938, 1979, fluvial and surface water flooding in 1996 and 5 properties affected by fluvial flooding in 2004.
Topography	• Low-lying site, slopes to the north with elevations between 11mOD (NW) and 27mOD (SE)	

The Muddle Brook flows from east to west along the northern boundary of the site with a small unnamed watercourse, which converges with the Muddle Brook, to the west of the site. Both watercourses present a significant flood risk to the site. This is highlighted by the extent of the Environment Agency fluvial Flood Zones 2 and 3 associated with these

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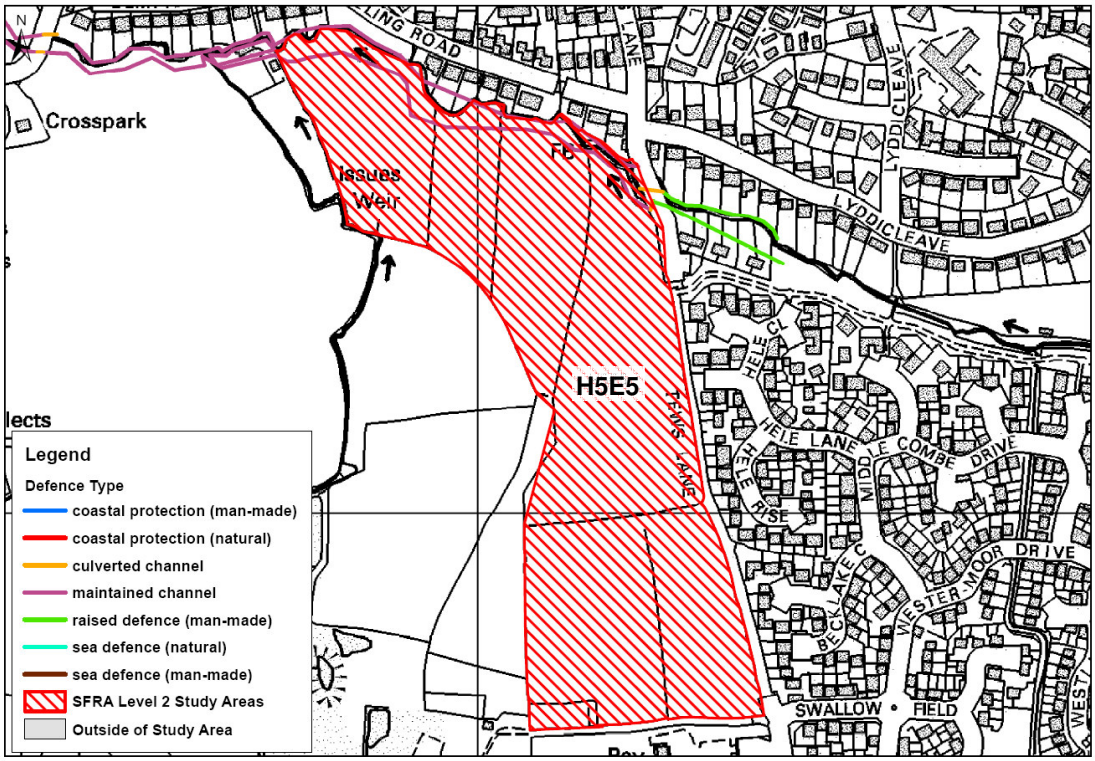
watercourses into the north and west of the site, covering approximately 20% of the total site area. Should development go ahead a sequential approach should be adopted to locate higher risk development away from the Flood Zones and a site specific FRA undertaken to further investigate the risks posed by the two watercourses (note that the tributary was not modelled as part of the Barnstaple 2D Modelling and Mapping study and therefore not considered within this SFRA).

There are several recorded historic incidents of flooding on and adjacent to the site and the topography shows that the entire site is low-lying with a shallow slope to the north. In view of this and the site's proximity to the Muddle Brook and tributary, the potential for development to increase flood risk to the site and surrounding area will need to be taken into account.

It is recommended that if development is pursued at this site, it is located towards the south of the site where the LiDAR suggests that ground elevations are between 1m and 7m above the current Flood Zones (as opposed to the north of the site where elevations are less than 0.5m above the Flood Zones). The land above and to the south of the site is currently rural therefore run-off from this land onto the site will need to be taken into account should development go ahead.

4.5.3 Existing defences, Verification of Defences and Areas Benefiting from Defences (ABDs)

Figure 4.5.3 – Defence Type



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NFCDD shows that there are no raised defences within the site. The Muddle Brook passes through the north of the site within a maintained channel (maintained by the EA). Immediately adjacent to the NE of the site the Muddle Brook passes through a culvert under Tews Lane with raised fluvial defences upstream of the culvert. These defences

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are maintained by the EA but have an unknown standard of protection.

The tributary of the Muddle Brook to the west of the site is not classified on NFCDD.

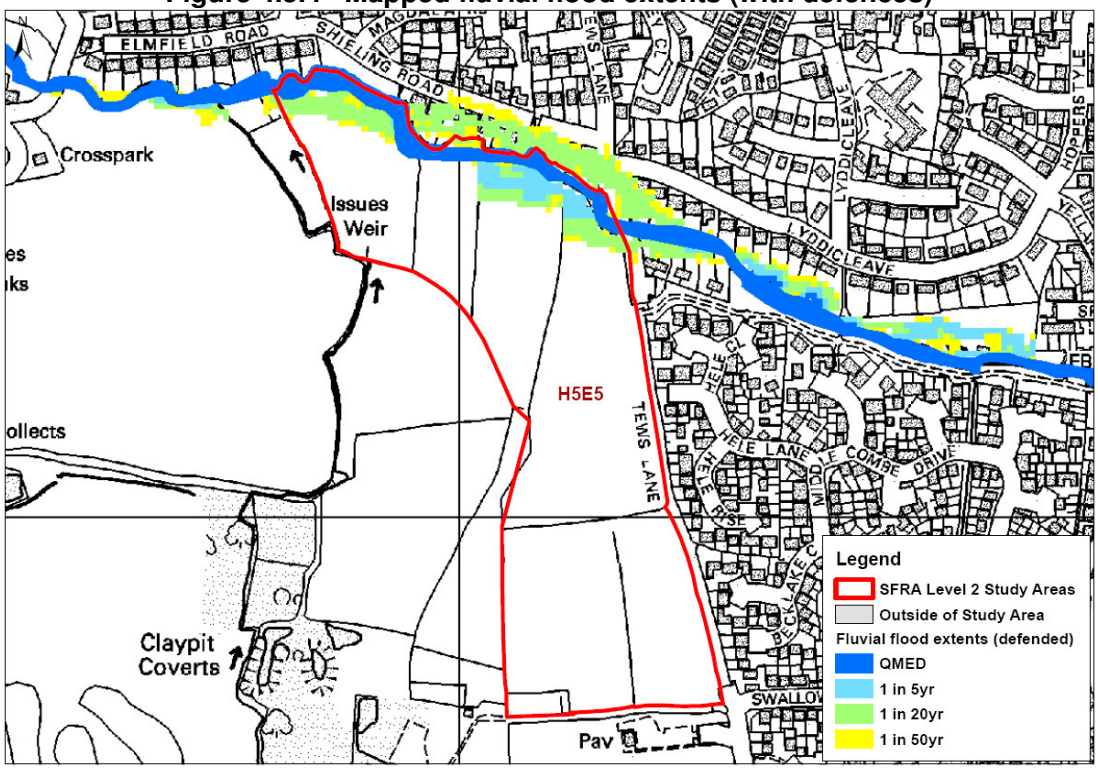
4.5.4 Assessment of flood probability and hazard

The Muddle Brook flows through the north of the site from east to west. It was modelled from the A3125 to Fremington Pill at Mill Hill Rd bridge. There are a number of small watercourses crossing the site and a small stream to the west (see figure 4.5.2) which discharges into the Muddle Brook approximately 50m downstream of the site. The EA Flood Zones 2 and 3 pertaining to this watercourse extend some way onto the site in the NW corner, however it was not included in the model, which should be taken into account when utilising the model results.

Flood probability

Figures 4.5.4 displays the fluvial flood extents derived from the model results for a variety of return periods for the defended scenario. Results indicate that the onset of fluvial flooding occurs at the QMED event, increasing in extent by the 1 in 5 year event with further increases at the 1 in 20 and 1 in 50 year events. The 1 in 10 year event is not displayed as there is no significant change from the 1 in 5 year event, similarly model results suggest that there is no further increase in extent after the 1 in 50 year event up to and including the 1 in 1000 year event.

Figure 4.5.4– Mapped fluvial flood extents (with defences)



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The EA tidal Flood Zones do not extend upstream as far as the site therefore tidal flooding does not occur at this site. This is supported by the Barnstaple 2D Modelling

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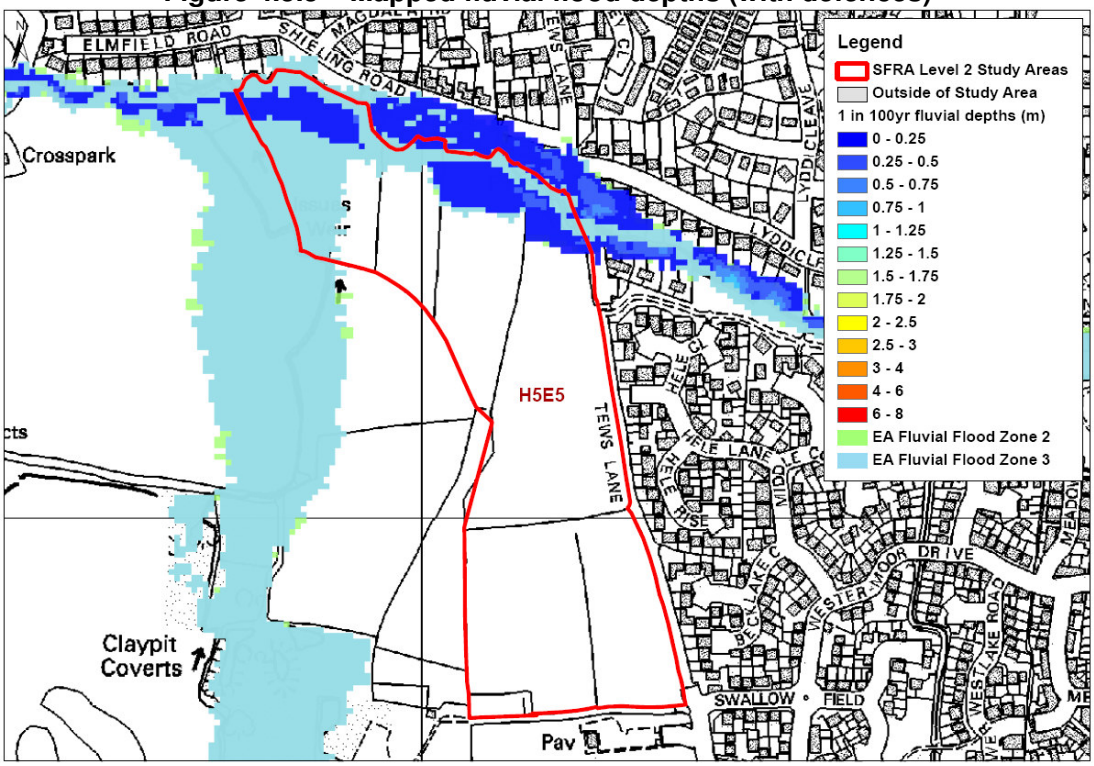
and Mapping results which show that the tidal flood extents for the 1 in 200 year defended tidal event are the same as the QMED fluvial event and as the tidal model runs were carried out in combination with a QMED fluvial event it can be suggested that the fluvial flow is responsible for any flooding indicated by the tidal results.

Flood depth

It can be seen from Figure 4.5.5 that the fluvial flood depths for the 1 in 100 year event are relatively small, on average 0.25m or less. The maximum depth on site is approximately 0.32m for the 1 in 100 year event with depths upstream of the site increasing to a maximum of 0.81m (although this is very localised).

Figure 4.5.5 – Mapped fluvial flood depths (with defences)



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Tidal flood depths for the defended scenario are negligible because as figure 4.5.5 shows, extents remain mostly in-channel and are a result of the combined fluvial and tidal flow dominated by the fluvial component, therefore no figures are included.

Flood hazard

Model results indicate that fluvial flood hazard is negligible for most of the site with an area of approximately 7500m^2 of low to moderate hazard where flooding occurs adjacent to the Muddle Brook. There is not expected to be any hazard from tidal flooding.

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4.5.5 Impact of climate change

Increased flows due to the effects of climate change were modelled to increase fluvial flood extents on and adjacent to the site by up to 10m laterally. Fluvial flood depths are projected to increase by 0.1-0.15m on and adjacent to the site, although this does not significantly increase the flood risk. The same is also true of fluvial flood hazard, where the impact of climate change was found to increase the area of low-moderate hazard on and around the site by approximately 5m laterally without increasing the hazard rating.

Tidal flood extents for 2070 and 2115 are not expected to increase the risk of tidal flooding to the site as tidal flood extents were not observed to extend beyond the 1 in 10 year event. Similarly the effect of climate change on tidal flood depths and hazard was found to be negligible in relation to this site.

4.5.6 Access and Egress

Access and egress remains safe for the site under all modelled fluvial and tidal events. However it is recommended that any access and egress routes are located to the south and east of the site to avoid the potential for flooding along the northern edge of the site and the largely unknown risk from the unnamed watercourse to the west.

4.5.7 Overview of impact of development on flood risk elsewhere

Table 4.5.3- Summary table of impacts of development

Return Period	% impermeable of net developable residential area	Flow (m3/s)		
		Pre-development	Post-development	% increase
1 in 100 year	50	0.06	0.10	68
	70	0.06	0.11	99
	90	0.06	0.13	134

Table 4.5.3 indicates that development will have a considerable impact on the current flow regime of the site. However because flow rates are so low (less than 0.15m^3/s which is approximately 1% of the 1 in 100 year peak flow for the Muddle Brook) the impact on the surrounding area is likely to be relatively small, nonetheless should development be pursued it is recommended that as far as possible surface water should be stored and managed onsite especially given that the site is bordered by residential areas to the north and east. This is in addition to the fact that the site primarily drains to the Muddle Brook which incorporates a defended section and culverts under transport routes both upstream and downstream of the site which may have limited capacity to manage additional flow inputs.

4.5.8 Surface water drainage

There is only one recorded incident of surface water flooding (1996) adjacent to the site on Tews Lane, therefore it is suggested that there is currently no requirement for a SWMP in the vicinity of the site. This is supported by the ASSWF maps shown in Appendix E. However due to the significant increase in run-off (at least 68% increase) expected to occur through development of the site, it is recommended that to reduce additional flow inputs to the Muddle Brook and to minimise the impact on the

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surrounding area all surface water is managed onsite where possible, through the implementation of techniques such as sustainable drainage systems (SuDS). However, due to the clay composition of the soil in the area certain types of SuDS, such as infiltration, may not be appropriate.

No critical drainage areas have been identified. However, in the NW corner of the site a small unnamed watercourse converges with the Muddle Brook. It could be suggested from the EA Flood Zones that the fluvial and tidal flood risk to the site from this watercourse is similar, if not a little greater, than that of the Muddle Brook, although this was unable to be verified during this study as the watercourse was not modelled. Therefore, should development go ahead at the site, it is suggested that:

- Further investigations regarding this watercourse are undertaken
- The northern edge in particular the NW of the site is designated as 'open space'
- SuDS sited outside of the flood risk area and open space provided with links to Combrew Lane which could improve the functional floodplain
- Surface water run-off is managed onsite in such a way as to minimise drainage to this part of the site.

4.5.9 Consequences of infilling floodplain

Floodplain infilling would be very likely to impact the storage potential of the floodplain, including the functional floodplain at this site. It is therefore recommended that development is located elsewhere on the site and that only water compatible development or open space is appropriate within the vicinity of the current EA Flood Zones.

4.5.10 Potential mitigation and management of residual risk

Both the model results and historical flood event information indicate that the main sources of flood risk for the site are fluvial and surface water. Since the site is currently a greenfield site, if development goes ahead it is recommended that the maximum amount of open space is maintained as this will assist in attenuating the flow and allowing surface water to infiltrate. In particular it is suggested that as far as possible, land in the north and north west of the site is designated as open space to account for the risk of flooding from the Muddle Brook and unnamed watercourse. Additionally this is the lowest point of the site, which slopes shallowly from south to north, and attenuation measures such as basins and ponds would be best located in this area in keeping with the natural flow paths.

As detailed in section 4.5.8 SuDS would be required for any development in this area. Examples of the different types of SuDS that may be appropriate can be found in Appendix B.

SuDS will help to minimise the impact of development on the surrounding areas, particularly the residential areas downstream of the site such as Muddlebridge and Fremington.

Mitigation measures may also need to be considered in order to manage any run-off flowing onto the site from the rural land to the west and south of the site.

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