4.15 The most representative fluvial flood level for the 1 in 100 year +35%CC event, as taken from the closest 2D model node (node 2) reported a flood level of 82.93mAOD. With reference to 1m EA LiDAR data, the lowest reported topographic level within the proposed footprint of the southern building is 83.11mAOD. As such, the proposed dwelling is to be set no less than 180mm above the 1 in 100 year +35%CC level (*Figure 8*).

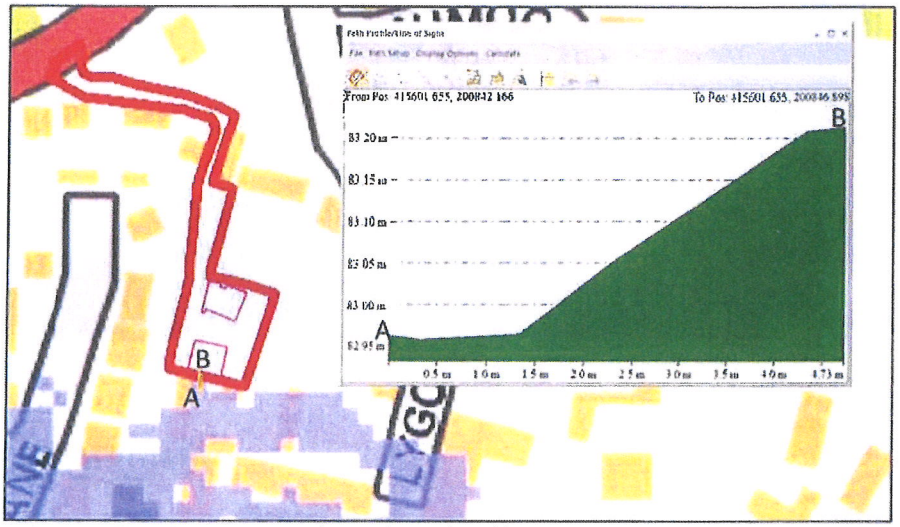

Figure 8 Steep topographic rise from edge of flood extent to southern dwelling.

4.16 Whilst the 1 in 100 year and 1 in 100 year + climate change simulations have been run using Flowroute as part of the FloodFutures product, the 1 in 1000 year was modelled as part of the UK FloodMap4 product. This is still simulated using Flowroute, but utilises a different topographic surface. As such, notable differences in flood patterns can be seen in *Figure 9*. Still, the redline boundary is located outside of the flood extent.

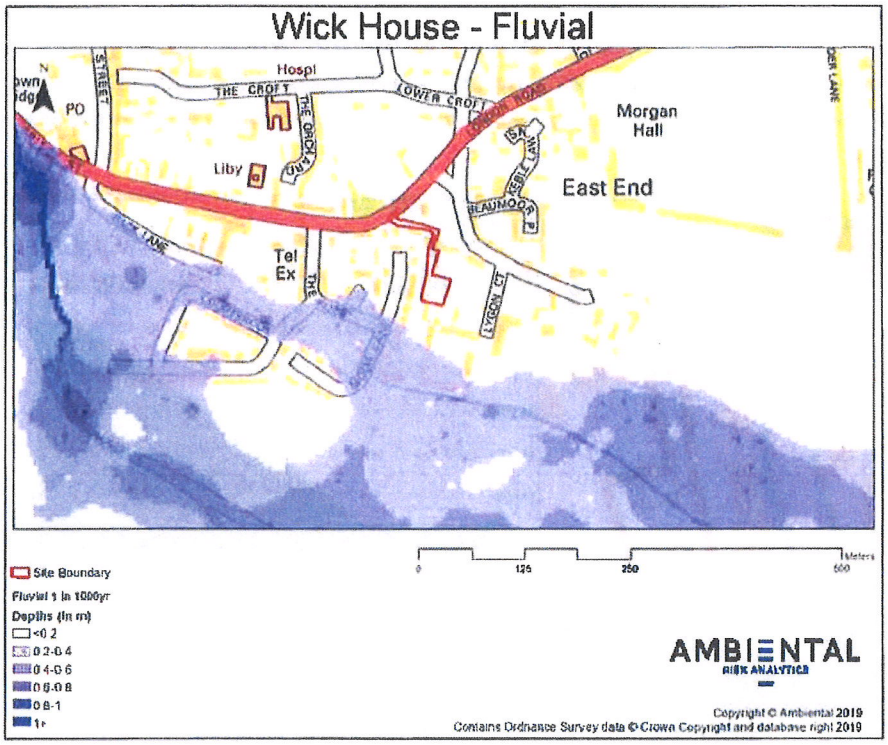

Figure 9 Flowroute 1 in 1000 year extent. The redline boundary is located entirely outside of the maximum flood extent.

4.17 **As such, the modelled flood levels extracted from the Flowroute products show the development to lie outside of the 30yr, 100yr, 100yr +35%CC, 100yr +70%CC and the 1000yr flood extent.**

4.18 The proposed residential dwellings can therefore be considered to be safe for their lifetime (classified under the NPPF to be 100 years whilst also accounting for climate change) without increasing flood risk elsewhere.

4.19 The southern dwelling has sleeping accommodation proposed at ground floor level. Given that:

- the proposed dwelling is located entirely within Flood Zone 1 with reference to the EA Flood Map for Planning;
- the proposed dwelling is located outside of the 30yr, 100yr, 100yr +35%CC, 100yr +70%CC and 1000yr Flowroute modelled maximum flood extents;
- with reference to 1m open-source LiDAR data, proposed finished floor levels will be no less than 180mm above the estimated flood level; and,
- flood proof mitigation measures will be recommended up to 600mm above the flood level of 82.93mAOD (discussed in Section 7 of this report);

Ambiental subsequently consider that it would be onerous for floor levels to require further raising.

4.20 As such, the risk of flooding from fluvial sources could be deemed to be **low**.

Surface Water (Pluvial)

4.21 The Environment Agency Flood Risk from Surface Water web site shows the proposed development to be within an area of 'Low' risk of flooding from surface water (*Figure 10*). Areas identified to be at 'Low' risk have a 0.1% to 1% annual risk of flooding from this source.

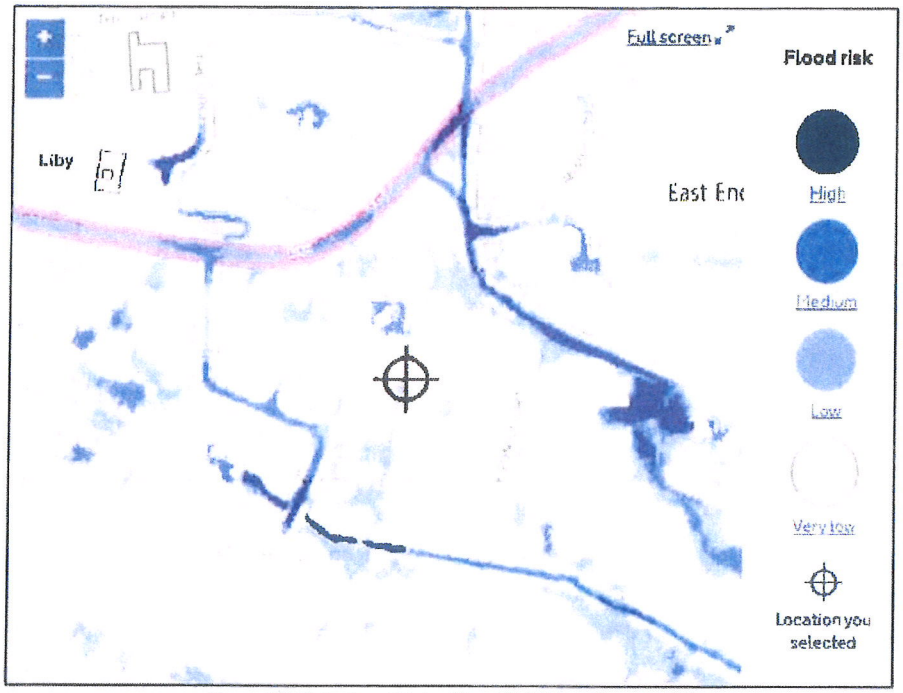

Figure 10 EA Surface Water Flood Risk Map. (Source: EA)

4.22 The EA Surface Water Flood Depth Map for the High Risk Scenario indicates that the proposed development is not affected in this event. The High Risk scenario displays areas that have a chance of flooding of greater than 3.3% each year. Similarly, for the Medium Risk Scenario, the proposed development and the surrounding area remain largely unaffected. The Medium Risk scenario displays areas with a chance of flooding between 1% and 3.3%.

4.23 The EA Surface Water Flood Depth Map for the Low Risk Scenario indicates that the proposed development may experience flood levels of less than 300mm in this event (*Figure 11*). A Low Risk Scenario has a 0.1% to 1% annual risk of occurring.

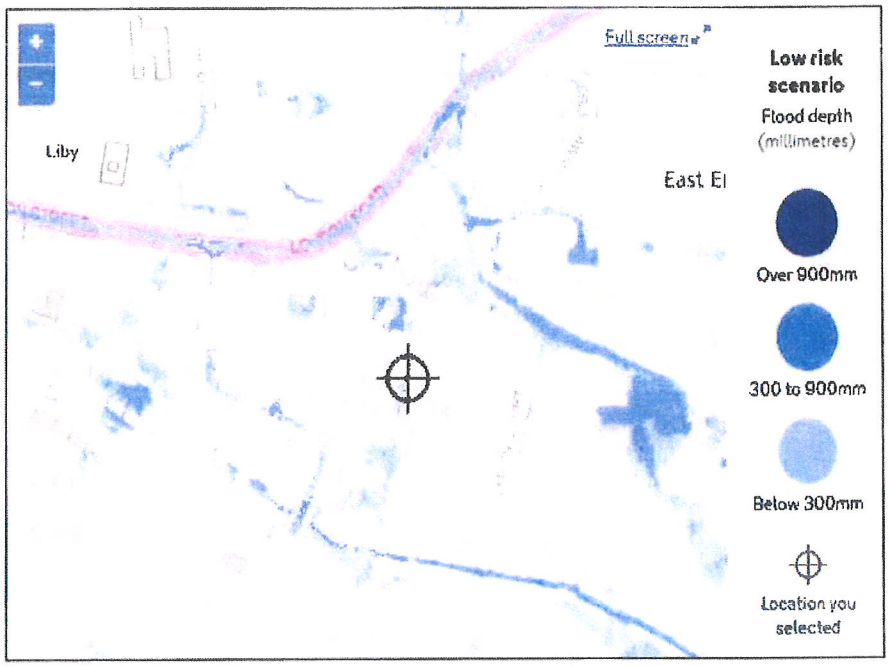

Figure 11 Surface Water Depths for a Low Risk Scenario (Source: EA)

4.24 The results of the EA Risk of Flooding from Surface Water (RoFSW) 1:1000-year rainfall event have also been assessed (*Figure 12*). Flood depths on site are predicted to reach up to 300mm along the access track to London Road (A417). Similar depths are predicted on the western edge of the two proposed buildings.

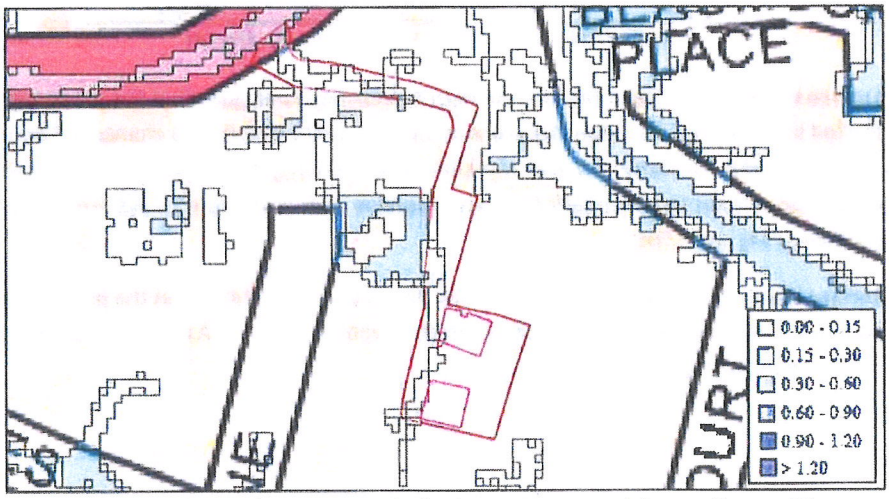

Figure 12 RoFSW surface Water Depths for the 1:1000 year rainfall event (Source: EA)

4.25 The EA have provided a historic flood extent that shows the site to have been previously affected by pluvial flooding in July 2007.

4.26 As such, the risk of flooding from this source could be deemed **relatively low to moderate**.

Groundwater

4.27 The British Geological Survey (BGS) Geology of Britain Viewer indicates that the underlying bedrock beneath the site is of the Cornbrash formation, comprising of limestone.

4.28 Superficial deposits have also been identified to lie beneath the surface. These have been identified to belong to the Northmoor Sand and Gravel Member by the BGS Geology of Britain Viewer.

4.29 With reference to the EA Magic Map online resource, the site is located within Zone II of a groundwater source protection zone (*Figure 13*). Source protection zones are defined around large potable groundwater abstraction sites, and indicate the risk of contamination from activities in the vicinity of the abstraction site. There is a predicted travel-time of 400 days for pollutants below the water table to reach the abstraction point.

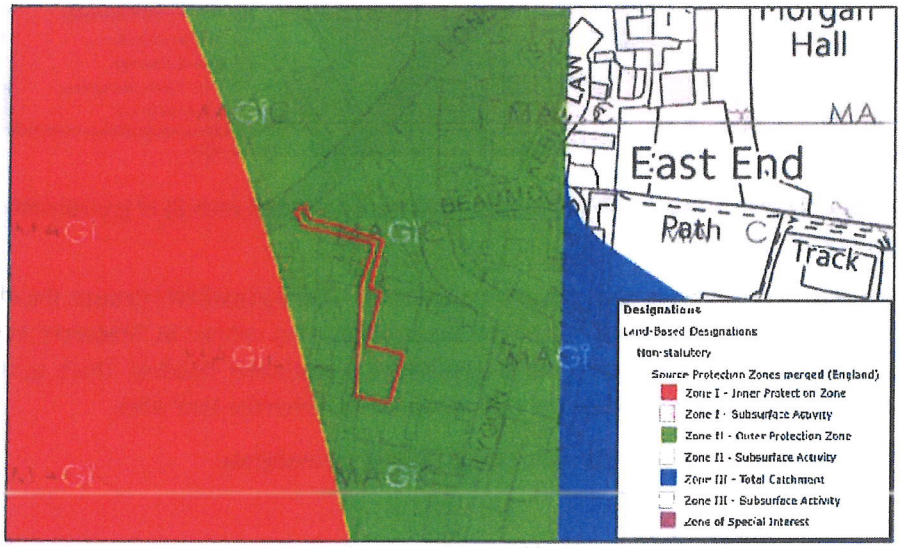

Figure 13 EA Groundwater Source Protection Zones. (Source: EA)

4.30 It has also been identified that the site lies above a Minor Aquifer of high vulnerability (*Figure 14*). This is considered to be a highly vulnerable secondary aquifer. Soils here have little ability to attenuate pollutants and therefore pollutants can rapidly reach groundwater.

4.31 The Cotswold District Council SFRA (2008) states how *"limestone aquifers can readily transmit groundwater as they are fractured in nature and thus may exacerbate flooding issues in watercourses when combined with other hydrological factors."*

4.32 Soils in the surrounding area have been defined as being freely draining lime-rich loamy soils. Freely draining soils absorb rainfall readily and allow it to drain through to underlying layers.

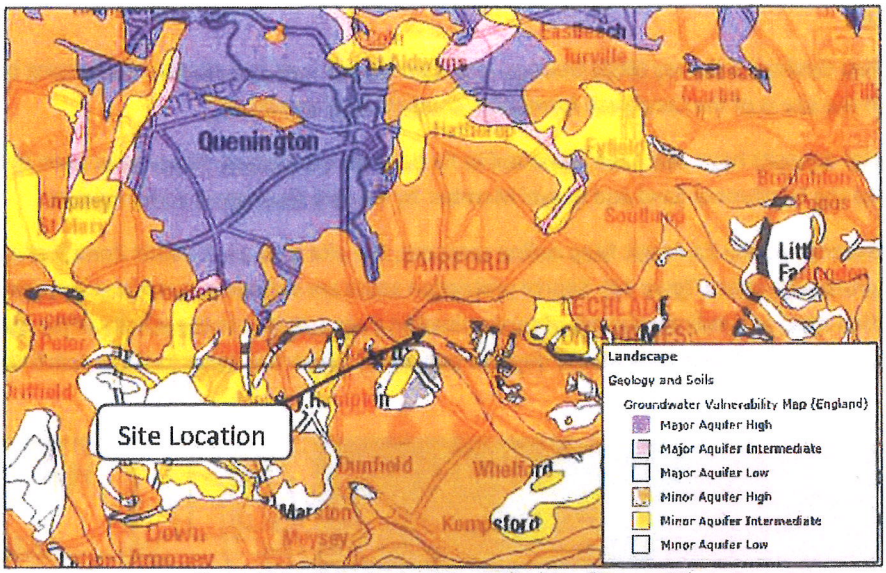

Figure 14 EA Groundwater Vulnerability Map. (Source: EA)

4.33 Neither the EA or the Cotswold District Council have provided any past records of groundwater flooding to have affected the site.

4.34 With reference to the EA Areas Susceptible to Groundwater Flooding (AStGWF) dataset, the site is located within a 1km^2 tile defined as having 'Moderate' Susceptibility. Tiles defined as 'Moderate' have between 50% to 75% of the tile considered to be susceptible to groundwater flooding. There is, however, no evidence to suggest that the site itself it of such susceptibility within the 1km^2 area.

4.35 As such, the risk of flooding from this source could be deemed **moderate**.

Sewer

4.36 Details of sewer flooding have been provided on a postal area basis by Severn Trent Water, Wessex Water and Thames Water as part of their DG5 Register. This is presented in a Table within The Cotswold District Council SFRA (2008).

4.37 The site lies in East End, GL7 4AP. The DG5 register for the postcode area 'GL7 4' is defined as being at a 'Low' level of risk within only one recorded property having being previously affected by sewer flooding at the time of the SFRA publication (2008). Elsewhere, in 'GL7 5' there are up to 39 records. A site is considered to be at low risk of sewer flooding if the postal area has no more than 5 properties with recorded incidents of sewer flooding. No records could be found to indicate sewer flooding in these areas since the 2008 SFRA.

4.38 As such, the risk of flooding from this source could be deemed **low**.

4.39 Any new sewer connection from the site should be agreed with the local sewer provider and fitted with non-return valves to mitigate against sewer flooding.

Surface Water Drainage Strategy

4.40 The existing site currently contains unkept tennis courts. It is understood that the proposed development is for the construction of two residential dwellings on site.

4.41 The Cotswold District Council SFRA (2008) states that SuDS should be implemented to ensure that runoff from the site (post development) is reduced. Where prevention, source control/infiltration cannot deal with all on-site site drainage, for both Greenfield and Brownfield sites, the development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions.

4.42 Superficial deposits have also been identified to lie beneath the surface. These have been identified to belong to the Northmoor Sand and Gravel Member by the BGS Geology of Britain Viewer.

4.43 The LPA have provided an initial consultation response on the application. Within the initial response, the LPA state that the site is underlain by freely draining lime-rich loamy soils, based on the Cranfield Soil and Agrifood Institute Soilscapes Mapping. The LPA further note:

"In accordance with SUDS hierarchy, soakaways and not a connection to mains drainage should be initially considered to dispose of surface water and the suggested soil type for this postcode would support the feasibility of that.

As part of the site, in the vicinity of proposed house 2, is within Flood Zones 2 and 3 an FRA is required to be submitted before any further comments can be made or a surface water condition specified."

4.44 This implies that the LPA may condition the use of SuDS within the scheme. As such, initial soakaway volume calculations have been undertaken to provide indicative storage volumes at this stage.

4.45 No infiltration tests have been carried out on site. However, based on the LPA comments above, infiltration may be possible on site given the underlying soils and geology. As no tests have been carried out on site, Table 25.1 of the CIRIA SuDS Manual can be used to approximately a typical infiltration rate based on the soil type/ texture. Using this guidance, based on BGS mapping indicating superficial sands and gravels at the site, a conservative infiltration rate of 1×10^{-5} m/s could be assumed. This should be confirmed on site prior to detailed design.

4.46 Assuming a rate of 1×10^{-5} m/s, indicative soakaway volume calculations can be undertaken for each proposed dwelling. Soakaways should be sized to accommodate the 1:100 year +CC (40%) runoff volume on site without increasing flood risk elsewhere.

4.47 The northernmost dwelling has a roof area of approximately $115m^2$ while the southernmost dwelling will have a roof area of approximately $108m^2$. Based on these areas, and the assume infiltration rate, there is a required storage volume of $7.5m^3$ for the northernmost dwelling, and a storage volume of $6.9m^3$ for the southernmost dwelling.

4.48 The indicative calculations in Appendix IV of this report assume a soakaway of $7.5m^2 \times 1.2m$ for the northern dwelling, and $6.3m^2 \times 1.2m$ for the southern dwelling.

4.49 These soakaway calculations should be confirmed at the detailed design stage once infiltration rates have been confirmed on site. Soakaway sizes and locations should also be confirmed at detailed design stage, taking into account the general 5m exclusion zone from building foundations. Consideration should also be shown to treatment of runoff given the site's location in Source Protection Zone 2.

4.50 The proposed external hardstanding areas should be Type A Permeable Paving which should effectively drain itself given the underlying geology and soils at the site. This should also be considered at the detailed design stage.

Records of Historical Flooding

4.51 The EA have provided historical records of fluvial and pluvial flooding in July 2007 (*Figure 15*). The site is shown to be located within the pluvial extent yet outside of the fluvial historical record. The EA have stated that the site flooded in 2007 due to local drainage surface water.

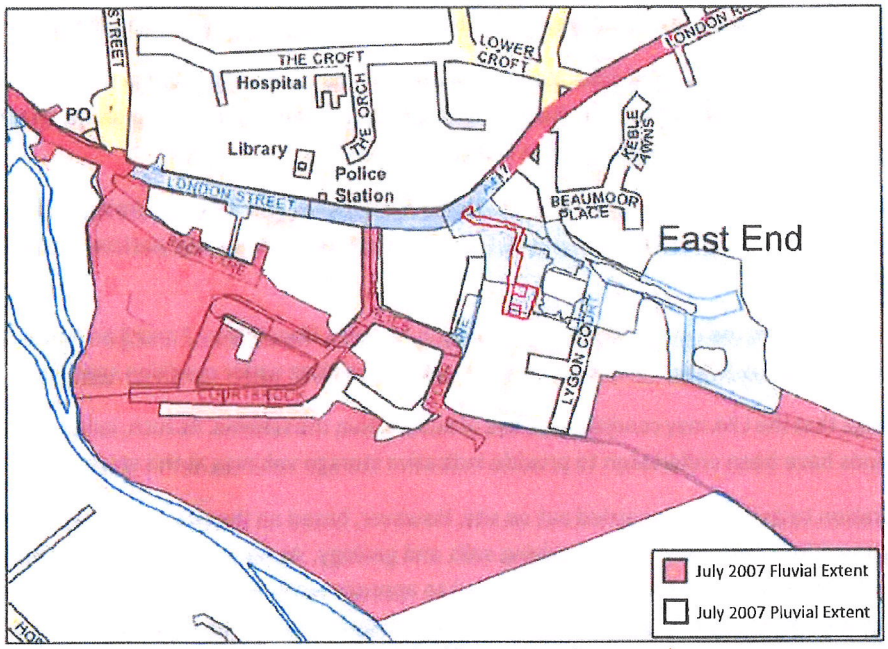

Figure 15 EA Historic Flood Extents Map. (Source: EA)

4.52 The EA or the Cotswold District Council SFRA have provided no records on past groundwater flooding events.

4.53 Details of sewer flooding have been provided on a postal area basis by Severn Trent Water, Wessex Water and Thames Water as part of their DG5 Register. The site lies in East End, GL7 4AP. The DG5 register for the postcode area 'GL7 4' is defined as being at a 'Low' level of risk within only one recorded property having being previously affected by sewer flooding.

5. Probability of Flooding

Flood Zones

5.1 According to the EA Flood Map for Planning, part of the site is located within Flood Zone 3 (high risk of flooding).

5.2 The EA Flood Map for Planning has been produced in part using a relatively coarse, national scale flood modelling strategy, and in part by detailed modelling. It is important to note that only the potential floodplain is modelled; **the mitigating effects of any flood defences currently in place are not considered**. For reference, the definition of the NPPF flood risk zones is included below.

Zone	Description
1	**Low Probability.** This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
2	**Medium Probability.** This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year.
3a	**High Probability.** This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
3b	**The Functional Floodplain.** This zone comprises land where water has to flow or be stored in times of flood. SFRA's should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the EA, including water conveyance routes).

Table 4 Definition of the NPPF Flood Zones. (Source: EA)

Climate Change on Site

5.3 Climate change is likely to increase the flow in rivers, raise sea levels and increase storm intensity. The range of allowances in Table 5 is based on percentiles. A percentile is a measure used in statistics to describe the proportion of possible scenarios that fall below an allowance level. The 50th percentile is the point at which half of the possible scenarios for peak flows fall below it and half fall above it.

5.4 The:

- central allowance is based on the 50th percentile
- higher central is based on the 70th percentile
- upper end is based on the 90th percentile

5.5 So, if the central allowance is 30%, scientific evidence suggests that it is just as likely that the increase in peak river flow will be more than 30% as less than 30%.

5.6 At the higher central allowance 70% of the possible scenarios fall below this value. So, if the higher allowance is 40%, then current scientific evidence suggests that there is a 70% chance that peak flows will increase by less than this value, but there remains a 30% chance that peak flows will increase by more (Source: EA).

5.7 The risk of flooding to the site would therefore be expected to increase following the effects of climate change. The likely increases in peak rainfall intensity would also lead to an increased risk of surface water flooding. The increase in river flows for the Thames basin has been provided below in Table 6.

Flood Zone	Essential Infrastructure	Highly Vulnerable	More vulnerable	Less Vulnerable	Water Compatible
2	Higher Central and Upper End	Higher Central and Upper End	Central and Higher Central	Central	None of the allowances
3a	Upper End	Development should not be permitted	Higher Central and Upper End	Central and Higher	Central
3b	Upper End	Development should not be permitted	Development should not be permitted	Development should not be permitted	Central

Table 5: Allowance and Flood Zone Table (Source EA)

Allowance category	Total potential change anticipated for the 2020's (2015 to 2039)	Total potential change anticipated for the 2050's (2040 to 2069)	Total potential change anticipated for the 2080's (2070 to 2115)
Upper end	25%	35%	70%
Higher central	15%	25%	35%
Central	10%	15%	25%

Table 6: Peak river flow allowances for Thames River Basin district (Source EA)

5.8 The proposed development is classified as 'More Vulnerable' (residential dwellings), located within Flood Zones 1, 2 and 3.

5.9 With reference to Table 5, the development should utilise the 'Higher Central and Upper End' allowances.

5.10 In Flood Zone 3, for More Vulnerable developments, the Higher Central climate change allowance is the minimum benchmark for flood risk mitigation. The vast majority of the site boundary (97.3%), including the whole of the two proposed dwellings, lies within Flood Zone 1 (with reference to the EA Flood Map for Planning). As such, Ambiental consider it to be onerous to consider the +70% flood level and as such the +35% has been deemed appropriate for flood risk mitigation measures.

5.11 Only a 20% allowance has been provided by the EA in their modelled flood extents in Appendix III.

5.12 As such, Ambiental have utilised in-house "Flowroute" software to determine maximum flood extents/ flood levels for the necessary return periods. The proposed development is shown to be located outside of the 30yr, 100yr, 100yr +35%, 100yr +70% and the 1000yr flood extents.

5.13 The 1:100-year +35%CC flood level at the nearest 2D node (node 2) has been reported to be 82.93mAOD.

5.14 With reference to 1m EA LiDAR data, the lowest reported topographic level within the proposed footprint of the northern building is 83.17mAOD. As such, the proposed dwelling is to be set no less than 240mm above the 1 in 100 year +35%CC flood level.

5.15 The lowest reported topographic level within the proposed footprint of the southern building is 83.11mAOD. As such, the proposed dwelling is to be set no less than 180mm above the 1 in 100 year +35%CC flood level.

5.16 The proposed residential dwellings could therefore be considered to be safe for their lifetime (classified under the NPPF to be 100 years whilst also accounting for climate change) without increasing flood risk elsewhere.

5.17 To adopt a conservative approach, Ambiental recommend that mitigation measures are installed up to 600mm above the 100 year +35%CC flood level (elaborated in Section 7 of this report).

6. Residual Risks

Identification of Residual Risks

6.1 Residual risks are those remaining after applying the sequential approach to the location of development and taking mitigating actions. Examples of residual flood risk include:

- the failure of flood management infrastructure such as a breach of a raised flood defence, blockage of a surface water conveyance system, overtopping of an upstream storage area, or failure of a pumped drainage system;
- failure of a reservoir, or;
- a severe flood event that exceeds a flood management design standard, such as a flood that overtops a raised flood defence, or an intense rainfall event which the drainage system cannot cope with.

Defence Breach

6.2 The EA have not provided evidence to suggest that the site benefits from the presence of fluvial defences. Furthermore, the EA Flood Map for Planning indicates that the proposed development site is located in an area that does not benefit from defences. As such there is no residual risk of defence failure.

Reservoir Failure

6.3 The EA Risk from Reservoir Map demonstrates that the site is outside flood extents in the event of reservoir flooding.

Drainage Exceedance

6.4 In the event of drainage exceedance/failure, overland flows will be dictated by external topography. A review of 1m LiDAR data for the area indicates that levels fall away steeply from the proposed southern building towards the unknown drain located approximately 105m south. As such, in the event of drainage exceedance/ failure, overland flows may be directed away from the buildings and to the south. Where possible, external levels should be designed to fall away from ground floor thresholds to provide further mitigation.

7. Flood Risk Management Measures

Flood Risks

7.1 The existing site currently contains unkept tennis courts. It is understood that the proposed development is for the construction of two residential dwellings on site.

7.2 Whilst the vast majority of the site, including the whole of the two proposed dwellings, is located within Flood Zone 1 (*Figure 2*), a small proportion of the wider redline application boundary is seen to be located in Flood Zone 2 and 3. The proposed development is considered to be 'More Vulnerable' under the NPPF.

7.3 After reviewing the proposed floor plans, the southern proposed dwelling has a bedroom proposed at ground floor level. The northern proposed building has all sleeping accommodation located at first floor level.

7.4 The EA have provided modelled flood extents for the site which can be found in Appendix III of this report. It can be seen that the site is located outside the modelled 1:100 year +CC (20%) and 1:1000 year flood extents. Under the February 2016 guidance a 35% and 70% increase in river flow should be used to account for the potential impacts of climate change.

7.5 As such, Ambiental have utilised in-house "Flowroute" software to determine water levels for the 100 year, 100 year +35% increase in flows (to account for climate change), 100 year +70% increase in flows and the 1000 year design events. **Modelled flood levels extracted from the Flowroute products show the development to lie outside of the 100yr, 100yr +35%, 100yr +70% and the 1000yr flood extent.**

7.6 Given that the vast majority of the site, including the whole of the two proposed dwellings lie within Flood Zone 1 (with reference to the EA Flood Map for Planning), Ambiental considered it to be onerous to mitigate against the 100 year +70%CC flood level. As such, the nearest 100 year +35%CC flood level was analysed to be 82.93mAOD. Given that the lowest reported topographic level in the proposed southern footprint is 83.11mAOD, the proposed dwelling is to be set no less than 180mm above the 100 year +35%CC flood level.

7.7 Given that:

- the proposed dwellings are to be located entirely within Flood Zone 1 with reference to the EA Flood Map for Planning;
- the proposed dwellings are to be located outside of the 30yr, 100yr, 100yr +35%CC, 100yr +70%CC and 1000yr Flowroute modelled maximum flood extents;
- with reference to 1m open-source LiDAR data, proposed finished floor levels will be no less than 180mm above the estimated flood level; and
- flood proof mitigation measures will be recommended up to 600mm above the flood level of 82.93mAOD;

7.8 Ambiental subsequently consider that it would be onerous for floor levels to require further raising.

7.9 As such, the following mitigation measures are recommended up to 600mm above the 100 year +35%CC flood level (82.93mAOD):

- Exterior ventilation outlets, utility points and air bricks to be fitted with removable waterproof covers;
- Non-return valves on any new sewer connections to prevent back-flow;