Flood Risk Assessment and Drainage Strategy

Project: Officers' Meadow, Shenfield

Client: Croudace Homes

Reference: C86054-JNP-XX-XX-RP-C-1008

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1 INTRODUCTION

1.1 Terms of Reference

1.1.1 JNP Group has been commissioned by Croudace Homes to prepare a flood risk assessment for the proposed Officers' Meadow development in Shenfield, Brentwood, Essex, CM15 8SD.

1.1.2 This report assesses flood risk at the development site from all potential sources and describes the measures adopted in the master planning process to manage such risks, namely the proposed development's sustainable drainage strategy. It has been prepared in compliance with current national and local policies and best practices.

1.2 Policy Framework and Key Stakeholders

1.2.1 The *National Planning Policy Framework* (NPPF) (July 2021) sets strict tests to protect people and property from flooding which all local planning authorities are expected to follow. Where these tests are not met, national policy is clear that new development should not be allowed.

1.2.2 In areas at risk of flooding or for sites of one hectare (ha) or more, developers must undertake a site-specific flood risk assessment to accompany applications for planning permission (or prior approval for certain types of permitted development).

1.2.3 In decision-taking, local planning authorities must ensure a sequential approach to site selection and master planning is followed so that development is, as far as reasonably possible, located where the risk of flooding (from all sources) is lowest, taking account of climate change and the vulnerability of future uses to flood risk.

1.2.4 Where development needs to be in locations where there is a risk of flooding, local planning authorities and developers must ensure development is appropriately flood resilient and resistant, safe for its users for the development's lifetime, and will not increase flood risk elsewhere.

1.2.5 The Environment Agency (EA) is a statutory consultee on applications where there is a risk of flooding from the sea or main rivers.

1.2.6 Lead local flood authorities (unitary authorities or county councils) are responsible for managing local flood risk from ordinary watercourses, surface water or groundwater, and for preparing local flood risk management strategies. Local planning authorities work with lead local flood authorities to ensure local planning policies are compatible with the local flood risk management strategy.

1.2.7 Essex County Council (ECC) is the lead local flood authority (LLFA) and its strategy for managing local flood risk is set out in the *Local Flood Risk Management Strategy* (October 2018) and *The Sustainable Drainage Systems Design Guide for Essex*.

1.2.8 Brentwood Borough Council (BBC) is the local planning authority (LPA) and its policies on flood risk management are set out in the policies BE05 and NE09 of the *Brentwood Local Plan 2016-2033* (March 2022) and the local *Strategic Flood Risk Assessment* (SFRA) (November 2018).

1.2.9 Where relevant, local planning authorities and developers must also take advice from:

- Internal drainage boards, to identify the scope of their interests.
- Sewerage undertakers, to ensure they can assess the impact of new development on their assets and plan any required improvements. Anglian Water (AW) is the local sewerage undertaker.

- Reservoir undertakers, to avoid an intensification of development within areas at risk from reservoir failure and ensure they can assess the cost implications of any reservoir safety improvements required due to change in land use downstream of their assets.
- Navigation authorities, in relation to developments adjacent to, or which discharge into, canals (namely where these are impounded above natural ground level).

1.3 Sources of Information

1.3.1 This flood risk assessment has been based on the following sources of information:

- Bespoke topographic survey undertaken by Aworth Survey Consultants (January 2020).
- British Geological Survey's *Geoindex Tool*.
  (http://mapapps2.bgs.ac.uk/geoindex/home.html)
- Cranfield University's Soilscapes.
  (http://www.landis.org.uk/soilscapes/)
- DEFRA / EA's aquifer and source protection data.
  (https://magic.defra.gov.uk/MagicMap.aspx)
- JNP Group's *Combined Phase I & II Geoenvironmental Report* (September 2021) (ref. C86054-JNP-XX-XX-RP-G-1001 P0.).
- UK Centre for Ecology & Hydrology's (Flood Estimation Handbook) catchment and rainfall data.
  (https://fehweb.ceh.ac.uk/)
- EA's *Flood Map for Planning*.
  (https://flood-map-for-planning.service.gov.uk/)
- EA's *Long Term Flood Risk Information*.
  (https://flood-warning-information.service.gov.uk/long-term-flood-risk/map)
- ECC's *Local Flood Risk Management Strategy* (October 2018).
- BBC's *Strategic Flood Risk Assessment* (November 2018).
- AW's asset location plans and developer enquiry.
- JNP Group's *Flood Risk Modelling Report* (August 2023) (ref. C86054--NP-XX-XX-RP-C-1006).

2 DEVELOPMENT SITE

2.1 Location

2.1.1 The development site is located off Chelmsford Road, north of Shenfield, in Brentwood, Essex (Figure 2.1 and Table 2.1).

2.1.2 The development site forms part of the Strategic Site R03 allocated in the *Brentwood Local Plan* (March 2022). The site is the largest parcel of land, at 21.32 ha, which is being independently brought forward by Croudace Homes as part of the Development Framework for Site R03 alongside a consortium of developers including Redrow Homes, Countryside Properties and Stonebond Properties.

2.1.3 The development site is located to the north of Shenfield, a 20 minute walk and a 10 minute cycle to the Shenfield Town Centre. The site is bound to the north-west by Chelmsford Road, its associated dwellings, and their rear residential curtilages. Beyond Chelmsford Road lies the A12 (dual carriageway) and open farmland. The eastern boundary of the site is delineated by Ancient Woodland, an area of undesignated woodland and a railway line, beyond which lies additional areas of woodland, residential development, and further farmland.

2.1.4 The development site is constrained by Ancient Woodland, a TPO tree belt and a critical drainage area. To the north of the site lies a Grade II listed Millstone in the northern verge of Chelmsford Road opposite number 179 Chelmsford Road.

Table 2.1: Site Location

OS X	OS Y	National Grid Reference	Nearest Postcode
561870	196180	TQ 61870 96180	CM15 8SA

Figure 2.1: Site Location (Indicative Plan)

2.2 Topography

2.2.1 The available topographic information (Appendix A) shows that ground levels within the development site range between 56.1 m AOD and 67.2 m AOD, falling with a general slope of 1:60 (V:H) towards the unnamed watercourse crossing the site in an east to west direction.

2.3 Hydrology

2.3.1 The surface water features nearest to the development site are:

- The unnamed watercourse (hereafter referred to as the Shenfield watercourse) crossing the site in an east to west direction, between the railway line to the east and Chelmsford Road to the west. At its crossing of Chelmsford Road, the Shenfield watercourse defines a catchment area of approximately 2.6 km², which comprises a considerable proportion or urban area to the east of the railway line.
- The unnamed watercourse flowing south-west to north-east between Chelmsford Road and the A12. With an estimated catchment area of 0.5 km² at its confluence with the Shenfield watercourse, this is a relatively small hydraulic feature.
- The Chainbridge watercourse flowing south-west to north-east along the northern side of the A12 (in what seems to be a manmade diversion). A tributary of the river Wid, the Chainbridge watercourse defines an estimated catchment area of 12.9 km² at its confluence with the Shenfield watercourse.

2.4 Geology and Hydrogeology

2.4.1 According to the BGS' *Geoindex*, superficial deposits are not classified in the north-eastern half of the site, while the central and south-western parts of the site contain Head deposits (clay) and some Alluvium (silt). These deposits are underlain by the Claygate Member across north-eastern parts of the site and London Clay in the southwest.

2.4.2 Cranfield University's *Soilscapes* mapping describes the site's soils as "*slowly permeable seasonally wet loamy and clayey soils*".

2.4.3 DEFRA / EA's *MAGiC* classifies the site's superficial deposits as a Secondary (undifferentiated) aquifer and its bedrock is a Secondary A aquifer. Secondary (undifferentiated) aquifers are defined by the EA as "*aquifers where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type*". Secondary A aquifers are defined as "*permeable layers capable of supporting water supplies at a local rather than strategic scale, in some cases forming an important source of base flow to rivers*" and Secondary B aquifers are defined as "*mainly lower permeability layers that may store and yield limited amounts of groundwater through characteristics like thin cracks and openings or eroded layers*".

2.4.4 According to DEFRA / EA's *MAGiC*, the development site is not within a groundwater source protection zone.

2.4.5 Records of nine boreholes (TQ69NW49, TQ69NW5, TQ69NW50, TQ69NW51, TQ69NW52, TQ69NW53, TQ69NW6, TQ69NW54, and TQ69NW72) within 250 m of the site were obtained from BGS' *GeoIndex*. The boreholes identify varying thicknesses of made ground, topsoil, clay, silty clay, sandy clay, gravelly clay, loamy clay, and loamy sand, to depths up to 5.5 m below ground level (bgl).

2.4.6 The bespoke ground investigation undertaken by JNP Group in September 2021 (ref. C86054-JNP-XX-XX-RP-G-1001 P02) confirms the published record of geology and hydrogeology, identifying superficial deposits of Head and Alluvium underlain by Claygate Member and London Clay Formation bedrock. Instances of made ground have been identified in the eastern part of site.

2.4.7 Groundwater was found across the site at depths of 3 m to 4 m bgl. The ground investigation indicates that groundwater is confined to a thin (< 0.5 m thick) more permeable lens between thicker impermeable layers both above and below it. While the groundwater monitoring undertaken as part of the ground investigation suggests an elevated water table, this is deemed due to an artesian effect within the monitoring boreholes, which penetrated the confined water bearing lens. Nevertheless, where excavations exceed 3 m to 4 m bgl, the need for dewatering/groundwater management measures should be expected.

2.4.8 Falling head tests (BS 5930, 2015) were carried out in four boreholes during the site investigation (Summer 2021). Observed infiltration rates ranged between 4.3×10^{-6} m/s and 2.7×10^{-5} m/s (ref. C86054-JNP-XX-XX-RP-G-1001 P02). However, this infiltration is thought to occur into the confined permeable lens described above, which is not suitable for infiltration drainage due to the lens' presumed limited storage capacity and the potential for reemergence of infiltrated runoff.

3 PROPOSED DEVELOPMENT

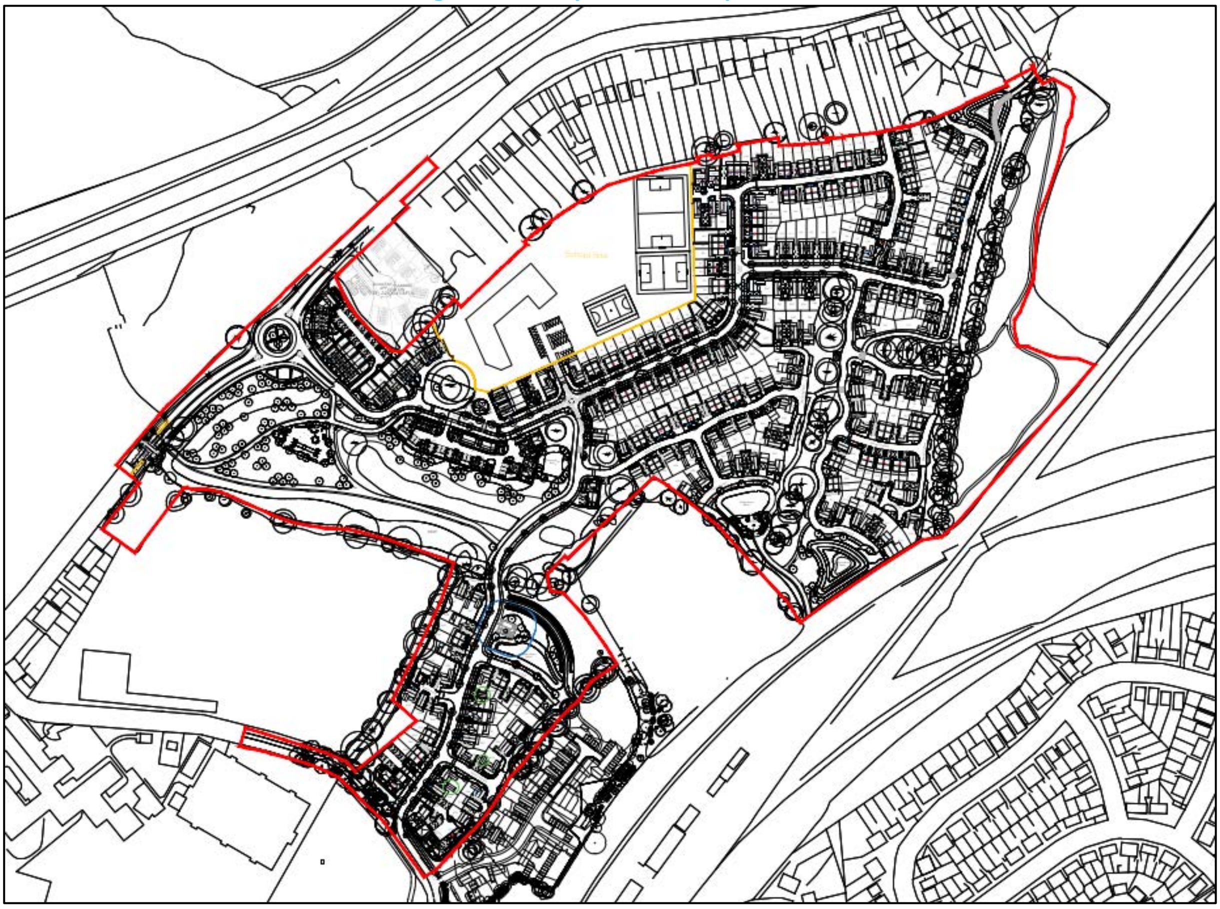
3.1.1 The proposed development (Appendix B) consist of 10.26 ha of residential coverage (i.e., developable area) and 11.06 ha of open spaces coverage. The 10.26 ha of developable area is to comprise 344 residential units – including 35% affordable housing –, safeguarded land (2.1 ha) for a 2FE primary school and early years facility, public open space, and associated landscaping, drainage, and highways infrastructure.

3.1.2 Where possible, the proposed development's landscape and external areas (e.g., public open spaces and formal play areas) have been designed to integrate water in a sustainable way, following current best practices with regards to sustainable drainage systems (SuDS) and master planning.

3.1.3 The areas to be made impermeable by the proposed development have been estimated at 4.217 ha of hard surfaces (i.e., roads, pavements, driveways, etc.), 0.333 ha of roofs not susceptible to urban creep (i.e., flats) and 1.718 ha of roofs susceptible to urban creep (i.e., houses).

3.1.4 Under *Table 2* of the *Flood Risk and Coastal Change Guidance* (March 2014), the proposed residential development is classified as 'more vulnerable'.

Figure 3.1: Proposed Development



4 FLOOD RISK ASSESSMENT

4.1 Overview

4.1.1 All potential sources of flood risk at the development site have been assessed based on the information listed in Section 1.3 and are summarised in Table 4.1. The key sources of flood risk to the proposed development are further described in the ensuing sections.

Table 4.1: Potential Sources of Flood Risk to the Development Site

Source	Flood Risk
Coastal	*No risk. Site levels > 56 m AOD.*
Fluvial	Very low risk in general, but up to high risk of fluvial flooding at the lower-lying part of the site along the Shenfield watercourse.
Surface Water	Very low risk in general, but up to high risk of surface water flooding at the lower-lying part of the site along the Shenfield watercourse (there is a significant overlap between fluvial and surface water flood risks at the site).
Groundwater	Low risk. No records of groundwater flooding in the borough. Groundwater water at the site is confined to a thin lens 3 m to 4 m bgl.
Sewers	*No risk. No existing sewers on site. Nearest existing sewers are located along Chelmsford Road, downslope of the site.*
Infrastructure Failure	*No risk. No reservoirs or canals upslope of the site.*

4.2 Climate Change

4.2.1 The NPPF sets out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. This includes demonstrating how flood risk will be managed now and over the development's lifetime, taking climate change into account.

4.2.2 In accordance with the EA's guidance *Flood Risk Assessment: Climate Change Allowances* (May 2022), the proposed development with anticipated life span into the 2070s~2080s epochs must take account of the following allowances (Combined Essex Management Catchment):

- Peak River Flows (2080s)
  - Central 25%
  - Higher 38%
  - Upper 72%
- Peak Rainfall Intensity (2070s)
  - Central 25%
  - Upper 45%

4.3 Fluvial Flood Risk

4.3.1 Fluvial flooding occurs when a catchment area receives greater than usual amounts of water (e.g., rainfall or snow melt). When the converging runoff exceeds the conveyance capacity of the receiving main channel, water spills onto the surrounding floodplains and fluvial flooding occurs.

4.3.2 Fluvial flooding usually occurs hours or days after heavy and/or prolonged rainfall and its effects often last several hours or days.

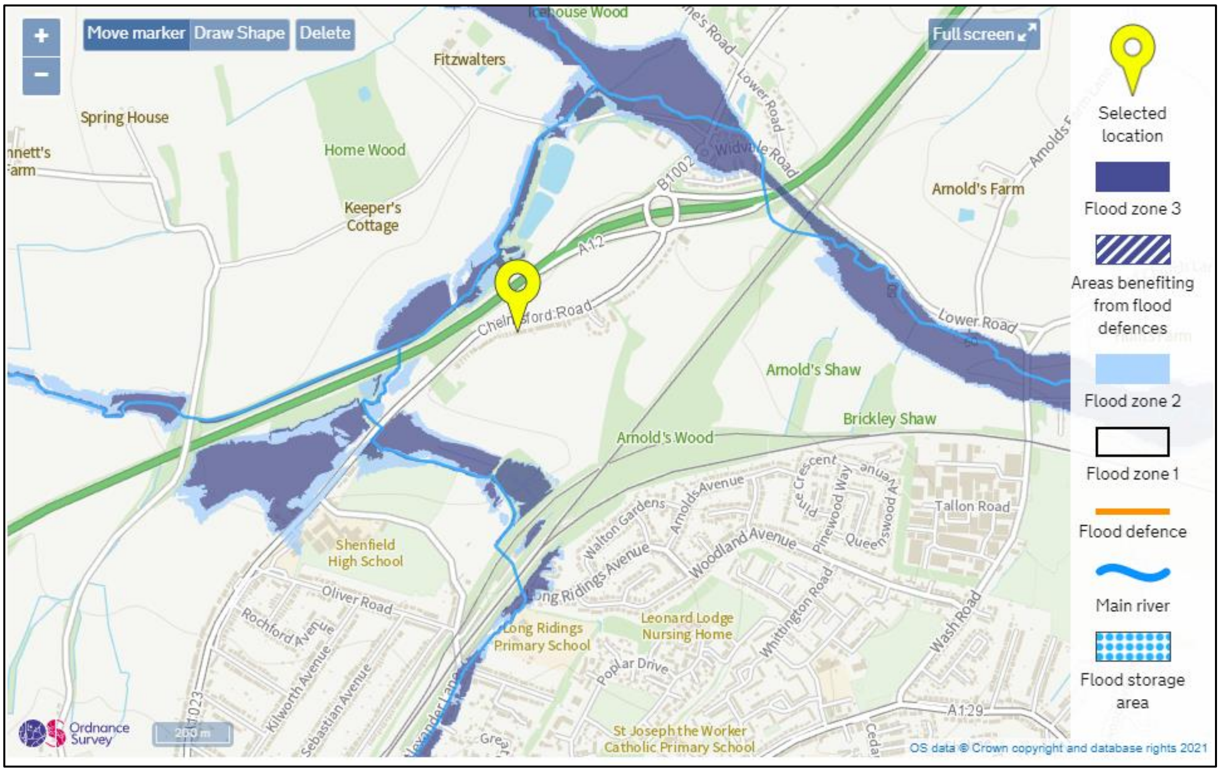
4.3.3 Besides posing a direct flood risk to floodplain areas, high water levels in watercourses can exacerbate other sources of flood risk by surcharging/locking outfalls, thus preventing the normal discharge of flows or even back flowing into tributary drainage systems.

4.3.4 According to the EA's *Flood Map for Planning* (Figure 4.1 and Appendix C), most of the development site is in Flood Zone 1 (< 0.1% AEP). However, the lower-lying area along the Shenfield watercourse is within Flood Zones 2 (0.1% to 1.0% AEP) and 3 (> 1.0% AEP).

4.3.5 ECC's *Local Flood Risk Management Strategy* and BBC's *SFRA* do not provide additional information regarding fluvial flood risk at the development site. The EA, ECC and BBC have no records of (fluvial) flooding at the site.

4.3.6 Site-specific modelling of (fluvial) flood risk was undertaken by JNP Group (August 2023) (ref. C86054-JNP-XX-XX-RP-C-1006) to better define fluvial flood extents at the development site and to steer master planning in compliance with the NPPF and local planning policies (refer to Section 5.2).

Figure 4.1: EA's *Flood Map for Planning*



4.4 Surface Water Flood Risk

4.4.1 Surface water flooding is a description for excessive overland flows that have yet to enter a natural or manmade receptor (e.g., aquifer, watercourse, or sewer). Surface water flooding also occurs when the amount of runoff exceeds the capacity of the collecting system and spills onto overland flow routes.

4.4.2 Surface water flooding is usually the result of very intense, short lived rainfall events, but can also occur during milder, longer lived rainfall events, when collecting systems are at capacity or the ground is saturated. It often results in the inundation of low points in the terrain.

4.4.3 According to the EA's *Long Term Flood Risk Information* (Figure 4.2 and Appendix C), the development site is mostly at very low (< 0.1% AEP) risk of surface water flooding. However, the lower-lying area along the Shenfield watercourse is at low (0.1% to 1.0% AEP), medium (1.0% to 3.3% AEP) and high (> 3.3% AEP) risk of surface water flooding.

Figure 4.2: EA's *Flood Risk from Surface Water*

4.4.4 ECC's *Local Flood Risk Management Strategy* and BBC's *SFRA* are based on the EA's *Long Term Flood Risk Information* and do not provide additional information regarding surface water flood risk at the development site.

4.4.5 It is clear from the available information that there is a significant overlap between fluvial and surface water flood risks at the development site, which will be managed by the same mitigation measures (refer to Section 5.2).

4.4.6 The risk of surface water flooding from runoff generated by the proposed development will be managed by the sustainable drainage strategy described in Section 6.

4.5 Groundwater Flood Risk

4.5.1 Groundwater flooding occurs when the level of water filling the pores and/or cracks in the underlying soil and/or rock (i.e., water table) rises and emerges on the surface. The level of the water table varies seasonally and depends upon long term rainfall, thickness and porosity of the underlying strata and groundwater abstraction.

4.5.2 Groundwater flooding is most common in areas where the underlying bedrock and superficial deposits are very porous, but it can also happen at locations where superficial layers of sand or gravel overlay impermeable bedrock.

4.5.3 Groundwater flooding usually occurs after days or weeks of prolonged rainfall and often lasts for days or weeks, as subsiding of the water table can be a very slow process.

4.5.4 Besides posing a direct flood risk to developments (particularly basements), high water table levels can exacerbate other sources of flood risk by preventing infiltration and/or leaking into drainage systems of poor integrity.

4.5.5 According to BCC's SFRA there are no historic records of groundwater flooding within the borough, noting that "*the areas of Thurrock and Tilbury to the south of the Borough are at risk from groundwater flooding due to high groundwater levels in the underlying chalk".*

4.5.6 The bespoke ground investigation undertaken by JNP Group (September 2021) (ref. C86054-JNP-XX-XX-RP-G-1001 P02) encountered groundwater across the development site at depths of 3 m to 4 m bgl. The ground investigation indicates that groundwater is confined to a thin (< 0.5 m thick) more permeable lens between thicker impermeable layers both above and below it. While the groundwater monitoring undertaken as part of the ground investigation suggests an elevated water table, this is deemed due to an artesian effect within the monitoring boreholes, which penetrated the confined water bearing lens. Nevertheless, where excavations exceed 3 m to 4 m bgl, the need for dewatering/groundwater management measures should be expected (refer to Section 5.2).

5 FLOOD RISK MANAGEMENT

5.1 Sequential and Exception Tests

5.1.1 A sequential, risk-based approach to the location and layout of development is designed to ensure that areas at little or no risk of flooding from any source are developed in preference to areas at higher risk. The aim is to keep development out of medium and high flood risk areas (Flood Zones 2 and 3) and other areas affected by other sources of flooding where possible.

5.1.2 Application of the sequential approach in the master planning process, in particular application of the *Sequential Test*, helps ensure that development can be safely and sustainably delivered, and developers do not waste resources promoting proposals which are inappropriate on flood risk grounds.

5.1.3 The *Sequential Test* ensures that a sequential approach is followed to steer new development to areas with the lowest probability of flooding i.e., Flood Zone 1 (areas with a low probability of sea or river flooding). Where there are no reasonably available sites in Flood Zone 1, local planning authorities in their decision making should consider the flood risk vulnerability of land uses and available sites in Flood Zone 2 (areas with a medium probability of sea or river flooding), applying the *Exception Test* if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should the suitability of sites in Flood Zone 3 (areas with a high probability of sea or river flooding) be considered, taking into account the flood risk vulnerability of land uses and applying the *Exception Test* if required.

5.1.4 *Annex 3* of the NPPF categorises different types of uses and development according to their vulnerability to flood risk. *Table 2* of the *Flood Risk and Coastal Change Guidance* (Table 5.1) maps these vulnerability classes against flood zones to indicate where development is appropriate and where it should not be permitted.

Table 5.1: Flood Risk Vulnerability and Flood Zone Compatibility

Flood Zone	Flood Risk Vulnerability				
	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test	✓	✓	✓
Zone 3a	Exception Test	×	Exception Test	✓	✓
Zone 3b	Exception Test	×	×	×	✓

Key:
✓ Development is appropriate
× Development should not be permitted

5.1.5 The same sequential approach should be taken by developers in the master planning of a development's layout. Because parts of the site can potentially overlap with Flood Zone 3 it is necessary that more vulnerable development, and access to it, avoids this high flood risk zone. Where this is not practical EA guidance allows development in Flood Zone 3a so long as it passes an *Exception Test*.

5.1.6 The *Exception Test* is a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available.

5.1.7 Essentially, the two parts of the *Exception Test* require proposed development to show that it will:

- Provide wider sustainability benefits to the community that outweigh flood risk.
- Be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.

5.1.8 The ensuing section describes how the sequential approach to the location of development within the site and, where necessary, the second part of the *Exception Test* have been implemented in the proposed development's master planning.

5.2 Flood Risk Management Measures

5.2.1 The following measures have been incorporated in the proposed development's master planning to manage flood:

- All 'more vulnerable' parts of the proposed development (i.e., residential dwellings and school) have been located in Flood Zone 1[†], at low (< 0.1% AEP) risk of flooding, following a sequential approach to development (Appendix D).
- Where possible, 'less vulnerable' parts of the proposed development (e.g., public open spaces and formal play areas) have been designed to integrate water in a sustainable way. The formal play areas located within the Shenfield watercourse floodplain and one of the proposed detention basins are only expected to flood 1 to 2 times each year, for less than 6 hours.
- Finished floor levels (FFLs) have been set at least 600 mm above the estimated 1.0% AEP + 32% climate change allowance flood levels.
- Safe access to the proposed development for storm events up to 0.1% AEP (including the 1.0% AEP + 32% and 78% climate change allowances) shall be provided (via Alexander Lane) via a new crossing of the Shenfield watercourse linking the northern and southern parts of the site. This is necessary for compliance with the second part of the *Exception Test*, as the proposed development's main access off a lower section of Chelmsford Road is susceptible to flooding and cannot be raised out of flood risk without affecting flood risk on site or elsewhere.
- Detailed modelling (ref. C86054-JNP-XX-XX-C-1006) shows that the afflux caused by the new crossing of the Shenfield watercourse will be restricted to undeveloped areas of the site immediately upstream of the feature. This afflux provides the additional storage volume necessary to compensate for the footprint of the new crossing. In addition to minimising the impact of the crossing in terms of floodplain volume, the two large (4 m wide) box-culverts crossing the embankment also provide a safe corridor for the movement of animals.
- The proposed surface water drainage strategy (Section 6 and Appendix E) has been designed so that flooding does not occur on any part of the site for all events up to 3.3% AEP (1 in 30 years) and flooding does not occur in any dwelling (or the school) for all events up to 1.0% AEP (1 in 100 years) + 45% climate change allowance.

[†] Flood Zone 1 as established by the site-specific flood risk modelling undertaken by JNP Group (August 2023) (ref. C86054-JNP-XX-XX-RP-C-1006).

- The proposed surface water drainage strategy has been designed in compliance with ECC's strict guidance to ensure (as far as reasonably possible) that runoff leaving the site post-development mimics pre-development (i.e., greenfield) conditions, thus not increasing surface water flood risk elsewhere for events up to 1.0% AEP (1 in 100 years) + 45% climate change allowance (and potentially reducing flood risk elsewhere for the most extreme storm events).
- FFLs of all 'more vulnerable' parts of the proposed development (i.e., residential dwellings and school) have been set at least 150 mm above surrounding external ground levels, which will be designed to safely route overland flows away from buildings and towards natural flow paths, using 'less vulnerable' parts of the proposed development such as public open spaces, parking areas and roads to convey and attenuate overland flows (Appendix E).
- The location and depth of the proposed SuDS features duly consider the available groundwater level information. Some of the deeper (foul and surface water) sewers proposed across the site are likely to be affected by groundwater within the confined lens located 3 m to 4 m bgl, in which case adequate dewatering/groundwater management measures will be required during construction. Extra care to ensure the water tightness of proposed sewers affected by the water table will be required.

6 SURFACE WATER DRAINAGE STRATEGY

6.1 Existing Drainage Regime

6.1.1 The undeveloped (greenfield) site does not benefit from a formal surface water drainage system. Runoff generated within the site is expected to infiltrate into the ground or flow off-site via natural overland flow routes.

6.1.2 Greenfield runoff rates for the undeveloped site (Table 6.1) have been established using the *IH124* methodology with *ICP SuDS* correction for small catchments as implemented in Micro Drainage's *Source Control* (Appendix E).

Table 6.1: Greenfield Runoff Rates

Return Period (AEP)	Runoff Rate (l/s/ha)
1 in 1 year (100.0%)	**3.1**
1 in 2 year (50.0%)	3.2
1 in 30 year (3.3%)	8.2
1 in 100 year (1.0%)	11.6

6.1.3 Greenfield runoff volumes for the undeveloped site (Table 6.2) have also been established using Micro Drainage's *Source Control* (Appendix E).

Table 6.2: Greenfield Runoff Volumes

Storm Duration (min)	Return Period (AEP)		
	1 in 2 year (50.0%)	1 in 30 year (3.3%)	1 in 100 year (1.0%)
	Runoff Volume (m³/ha)		
15	43.707	107.700	142.846
30	55.237	138.103	183.587
60	67.786	168.347	233.531
120	95.504	219.006	307.490
240	123.440	275.200	393.508
360	**138.461**	**305.926**	**444.859**
480	148.234	325.881	478.578
960	170.107	368.473	549.182
1440	183.048	390.841	582.576

6.2 General Drainage Principles

6.2.1 Given the unfeasibility of infiltration drainage at the site, the volume of runoff leaving the proposed development cannot be reduced to greenfield values and the excess volume must be discharged at a low rate that will not pose a flood risk downstream of the site.

6.2.2 In line with ECC's *The Sustainable Drainage Systems Design Guide for Essex*, post-development runoff volumes exceeding greenfield values must be discharged at a rate no higher than the 1 in 1 year runoff rate of 3.1 l/s/ha, while runoff volumes up to greenfield values (Table 6.2) may be discharged at a range of rates equivalent to greenfield values (Table 6.1).

6.2.3 It is important to note that this surface water drainage strategy assumes that the 2.1 ha school site will manage its own runoff, which will pass through the proposed drainage system towards the watercourse without any additional attenuation.

6.3 Sustainable Drainage Systems (SuDS)

6.3.1 In accordance with the *NPPF*, (major) developments should incorporate sustainable drainage systems (SuDS) unless there is clear evidence that this would be inappropriate. In addition to water quantity control, SuDS should consider opportunities to provide water quality and amenity/biodiversity benefits (i.e., multifunctional approach).

6.3.2 Table 6.3 shortlists SuDS deemed compatible with the site's characteristics and which inclusion in the proposed development must be continuously assessed as the design progresses.

6.3.3 It is important to note the need to remove silt from runoff prior to discharge into some SUDS features of off-site receptors. SuDS such as filter drains, swales, bioretention systems and pervious pavements are sustainable alternatives to proprietary treatment systems otherwise required to manage silt.

Table 6.3: Sustainable Drainage Systems (SuDS)

SuDS Component	Description and Opportunities
Swales	Swales are shallow, flat bottomed, vegetated open channels designed to treat, convey, and often attenuate surface water runoff. Swales can also provide aesthetic and biodiversity benefits. Swales can help reduce flow rates by facilitating infiltration and/or providing attenuation storage when flow at the outlet is controlled. Coarse to medium sediments and associated pollutants can be removed by filtration through surface vegetation and ground cover. Swales are well suited for managing runoff from linear features such as main roads/highways. Swales are generally difficult to incorporate into dense urban developments, where space is limited.
Bioretention Systems	Bioretention systems (including rain gardens) are shallow landscaped depressions that can reduce runoff rates and volumes and treat pollution. They also provide attractive landscape features and biodiversity. Bioretention systems can help reduce flow rates from a site by promoting infiltration/evapotranspiration and providing some attenuation storage. Bioretention systems can also provide very effective treatment functionality. Bioretention systems are a very flexible surface water management component that can be integrated into a wide variety of developments/densities using different shapes, materials, planting, and dimensions.
Pervious Pavements	Pervious pavements provide a pavement suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface and into the underlying structural layers. The water is temporarily stored beneath the overlying surface before use, infiltration to the ground or controlled discharge downstream. Pervious pavements help reduce flow rates from a site by providing attenuation storage. A flow control structure is required to constrain the rate of water discharged from the sub-base via an outlet pipe. Pervious pavement drainage has been shown to have decreased concentrations of a range of surface water pollutants, including heavy metals, oil and grease, sediment, and some nutrients. Pervious pavements are typically built as an alternative to impermeable surfaces and therefore require no extra development space for their construction.
Detention Basins	Detention basins are landscaped depressions that are normally dry expect during and immediately following (extreme) storm events. They can be on-line components where surface runoff from regular events is routed through the basin or off-line components into which runoff is diverted once flows reach a specific threshold. Detention basins can be vegetated depressions (providing treatment in on-line components) or hard landscaped storage areas. Off-line basins will normally have an alternative principal use (e.g., amenity or recreational facility or urban (hard) landscaping).

SuDS Component	Description and Opportunities
Attenuation Storage Tanks	Attenuation storage tanks are used to create a below-ground void space for the temporary storage of surface water before use, infiltration, or controlled release. Attenuation storage tanks can help reduce flow rates from a site by providing significant attenuation storage. Storage tanks do not provide any form of treatment of surface water runoff and therefore need to be combined in a "management train" with other methods that do provide suitable treatment of all relevant pollutants (coarse sediment must always be removed upstream of a storage tank). The inherent flexibility in size and shape of the typical attenuation storage tank systems means that they can be tailored to suit the specific characteristics and requirements of any site.

6.4 Proposed Surface Water Drainage Strategy

6.4.1 The proposed surface water drainage strategy has been designed in accordance with Water UK's *Design and Construction Guidance* (June 2022) and *The Building Regulations 2010 Part H: Drainage and Waste Disposal* and in compliance with the *NPPF*, ECC's *The Sustainable Drainage Systems Design Guide for Essex* and current best practices[‡], to collect, convey and attenuate runoff from all areas being made impermeable by the proposed development (6.440 ha)[§] (Appendix E) before discharge into the watercourse crossing the site.

6.4.2 The proposed surface water drainage strategy (Appendix E) has been designed so that:

- Flooding does not occur on any part of the site for all events up to 3.3% AEP (1 in 30 years).
- Flooding does not occur in any dwelling for all events up to 1.0% AEP (1 in 100 years) + 45% climate change allowance.

6.4.3 The performance of the proposed surface water drainage strategy has been tested for storm events with 50.0% AEP, 3.3% AEP and 1.0% AEP + 45% climate change and durations of 15 to 10080 minutes.

6.4.4 The results of the simulations are included in Appendix E and demonstrate how the proposed surface water drainage strategy can manage surface water flood risk at the development site without increasing flood risk elsewhere for storm events up to the 1.0% AEP + 45% climate change allowance.

6.4.5 Key discharge rates and volumes for a range of storm durations and return periods are summarised in Table 6.4 and confirm that (excess) runoff volumes from the proposed total impermeable area of 6.440 ha to be discharged at rates in exceedance of the 1 in 1 year greenfield rate of 19.4 l/s (3.1 l/s/ha) – but no higher than the equivalent greenfield runoff rates – will not exceed the equivalent greenfield runoff volumes.

6.4.6 Where possible, the proposed development's landscape and external areas (e.g., public open spaces and formal play areas) have been designed to integrate water in a sustainable way. During most (normal) storm events, flows within the proposed detention basins will be restricted to low-flow channels. Based on c.34 years of detailed rainfall data at *Nags Head Lane* (January 1989 to June 2023), widespread flooding of the proposed basins (namely the basin containing a formal play area) is expected to occur 1 to 2 times each year and to last less than 6 hours.

[‡] e.g., *Non-Statutory Technical Standards for Sustainable Drainage Systems* (March 2015) and *The SuDS Manual* (2015).

[§] The total impermeable area of 6.440 ha used in the design/modelling of the proposed surface water drainage strategy includes an urban creep allowance of 0.172 ha (i.e., 10% increase of the total roof area susceptible to urban creep, which excludes flats).

Table 6.4: Runoff Rates and Volumes (1 in 2 years)

Storm Duration (min)	Pre-Development (Greenfield)		Post-Development	
	Runoff Rate (l/s)	Runoff Volume (m³)	Runoff Rate (l/s)	Runoff Volume (m³)
15	20.0	274	19.0	0
30		346	19.2	
60		425		
120		599		
240		774		
360		868		
480		929		
960		1066		
1440		1147		

Table 6.5: Runoff Rates and Volumes (1 in 30 years)

Storm Duration (min)	Pre-Development (Greenfield)		Post-Development	
	Runoff Rate (l/s)	Runoff Volume (m³)	Runoff Rate (l/s)	Runoff Volume (m³)
15	51.4	675	19.2	0
30		866		
60		1055	20.2	4
120		1373	28.6	186
240		1725	32.6	453
360		1918	34.3	601
480		2043	36.7	703
960		2310	40.2	894
1440		2450	41.1	928

Table 6.6: Runoff Rates and Volumes (1 in 100 years)

Storm Duration (min)	Pre-Development (Greenfield)		Post-Development	
	Runoff Rate (l/s)	Runoff Volume (m³)	Runoff Rate (l/s)	Runoff Volume (m³)
15	72.7	895	19.2	0
30		1151	23.1	49
60		1464	30.6	268
120		1927	34.9	648
240		2467	45.1	1186
360		2788	49.8	1509
480		3000	52.3	1706
960		3442	55.1	2075
1440		3652	56.3	2211

Table 6.7: Runoff Rates and Volumes (1 in 100 years + 45%)

Storm Duration (min)	Pre-Development (Greenfield)		Post-Development	
	Runoff Rate (l/s)	Runoff Volume (m³)	Runoff Rate (l/s)	Runoff Volume (m³)
15	105.4	1298	28.0	166
30		1669	33.1	521
60		2122	40.0	962
120		2795	49.3	1689
240		3576	56.6	2509
360		4043	61.9	3015
480		4350	64.9	3340
960		4991	66.8	3972
1440		5295	71.6	4216

6.5 Exceedance Events

6.5.1 Finished floor levels have been set at least 150 mm above external ground levels and external ground levels have been designed to safely route overland flows away from buildings and towards natural/existing flow paths, using the 'less vulnerable' parts of the proposed development such as roads, parking areas and open spaces to convey and store overland flows.

6.5.2 Overland flows resulting from exceedance events are expected to leave the developed site as currently occurs (i.e., pre-development conditions), without posing any increased flood risk on site or elsewhere. The proposed overland flood routing plan is included in Appendix E.

6.6 Water Quality Management

6.6.1 The suitability of the proposed drainage strategy to manage the development's pollution risk has been assessed using the simple index approach in *The SuDS Manual* (2015), as summarized in Table 6.8.

Table 6.8: Surface Water Quality Management (Simple Index Approach)

Runoff Route / Treatment Train 1				
Land Use / SuDS	**Hazard Level**	**TSS**	**Metals**	**Hydro-Carbons**
Pollution Hazard Indices				
Residential Roofs	Very Low	0.20	0.20	0.05
Driveways, residential car parks and low traffic roads	Low	0.50	0.40	0.40
SuDS Mitigation Indices				
Detention Basin	-	0.50	0.50	0.60
Swale	-	0.50	0.60	0.60
Total SuDS Mitigation Index = Detention Basin Index + 0.5 (Swale Index)				
Total SuDS Mitigation Index	-	0.75	0.80	0.90
Total SuDS Mitigation Index ≥ Pollution Hazard Index (for each contaminant type)				

Runoff Route / Treatment Train 2				
Land Use / SuDS	**Hazard Level**	**TSS**	**Metals**	**Hydro-Carbons**
Pollution Hazard Indices				
Residential Roofs	Very Low	0.20	0.20	0.05
Driveways, residential car parks and low traffic roads	Low	0.50	0.40	0.40
SuDS Mitigation Indices				
Pervious Pavement	-	0.70	0.60	0.70
Swale	-	0.50	0.60	0.60
Total SuDS Mitigation Index = Pervious Pavement Index + 0.5 (Swale Index)				
Total SuDS Mitigation Index	-	0.95	0.90	1.00
Total SuDS Mitigation Index ≥ Pollution Hazard Index (for each contaminant type)				

Runoff Route / Treatment Train 3				
Land Use / SuDS	**Hazard Level**	**TSS**	**Metals**	**Hydro-Carbons**
Pollution Hazard Indices				
Residential Roofs	Very Low	0.20	0.20	0.05
Driveways, residential car parks and low traffic roads	Low	0.50	0.40	0.40
SuDS Mitigation Indices				
Swale	-	0.50	0.60	0.60
Total SuDS Mitigation Index ≥ Pollution Hazard Index (for each contaminant type)				

6.7 Operation and Maintenance

6.7.1 The function of the surface water drainage system must be understood by those responsible for maintenance, regardless of whether individual components are below ground or on the surface. In any system properly designed, monitored, and maintained, performance deterioration can usually be minimised.

6.7.2 The long-term operation and maintenance of the proposed surface water drainage strategy will be the responsibility of the entities, as detailed in Table 6.9. Appropriate legal agreements defining maintenance responsibilities and access rights over the lifetime of the proposed development must be established prior to construction.

Table 6.9: Entities Responsible for SuDS Maintenance

SuDS Component	Location	Function	Responsible Entity
Swales	Public open spaces	convey and treat runoff	Local authority or private management company
Pervious Pavements	Private roads/parking areas	Store & treat runoff	Owners or private management company
Detention Basins	Public open spaces	Store & treat runoff	Local authority, water company or private management company
Attenuation Storage Tank	Public open spaces	Store runoff	Private management company

6.7.3 Where the user/benefiter of a system is not responsible for maintenance, then it is important to ensure that they know when the SuDS is not functioning properly and who to contact if any issues arise.

6.7.4 Maintenance plans are required to clearly identify who is responsible for maintaining proposed SuDS as well as the maintenance regime to be applied. Maintenance plans can also form a useful tool for public engagement with SuDS and understanding their wider benefits. The maintenance requirements of the proposed surface water drainage strategy are summarised in Table 6.10.

Table 6.10: Typical Operation and Maintenance Requirements

Operation and Maintenance Activity	SuDS Component			
	Swale	Pervious Pavement	Detention Basin	Attenuation Storage Tank
Regular Maintenance				
Inspection	■	■	■	■
Litter and debris removal	■	■	■	□
Grass cutting	■	□	■	□
Weed and invasive plant control		□	□	
Shrub management (including pruning)	□	□	□	
Shoreline vegetation management			□	
Aquatic vegetation management			□	
Occasional Maintenance				
Sediment management	■	■	■	■
Vegetation replacement	□		□	
Vacuum sweeping and brushing		■		
Remedial Maintenance				
Structure rehabilitation/repair	□	□	□	□
Infiltration surface reconditioning	□	□		

Key:
■ Will be required
□ May be required

6.8 Drainage During Construction

6.8.1 Drainage is typically an early activity in the construction of a development, taking form during the earthworks phase. However, the connection of piped drainage system to SuDS components should not take place until the end of construction works, unless a robust strategy for silt removal prior to occupation of the site is implemented.

6.8.2 Silt-laden runoff from construction sites represents a common form of waterborne pollution and cannot enter SuDS components not specifically designed to manage this, as it can overwhelm the system and pollute receiving water features. Any gullies and piped systems should be capped off during construction and fully jetted and cleaned prior to connection to SuDS components.

6.8.3 The three principal aspects of drainage during construction are conveying runoff, controlling runoff and trapping sediments:

- Conveyance of runoff can be achieved through small ditches / swales, channels and drains. Runoff control measures should be implemented to ensure that runoff does not overwhelm the temporary drainage system causing flooding on site or elsewhere.

- Control of runoff can be achieved through perimeter ditches or appropriate grading to ensure that any runoff from the construction site stays on site. Runoff rates leaving the site should be managed so they do not exceed pre-development conditions.
- Construction runoff should be directed to dedicated infiltration basins with adequate upstream sediment and pollution control such as sediment basins, silt fences and straw bales prior to infiltration or off-site discharge.

6.8.4 Additional conveyance, control and treatment measures should be installed as needed during grading. Slope stability needs to be considered when using open water features to convey, control and treat runoff across the site. Any necessary surface stabilisation measures should be applied immediately on all disturbed areas where construction work is either delayed or incomplete.

6.8.5 Maintenance inspections should be performed weekly, and maintenance repairs should be made immediately after periods of rainfall.

6.8.6 All drainage infrastructure (namely underground features) must be protected from damage by construction traffic and heavy machinery through the implementation of measures such as protective barriers and storing construction materials away from the drainage infrastructure.

7 FOUL WATER DRAINAGE STRATEGY

7.1.1 Sewerage undertakers have a legal obligation under the *Water Industries Act 1991* to accept all foul water flows from approved developments. The *Water Industries Act 1991* also contains safeguards to ensure that flows resulting from new developments do not cause detriment to the existing public sewerage networks by imposing a duty on sewerage undertakers to carry out works required to accommodate additional foul flows into their networks.

7.1.2 The undeveloped (greenfield) site does not benefit from a formal foul water drainage system, but in accordance with records obtained from AW (Appendix F), there is a public foul water sewer along Chelmsford Road.

7.1.3 In response to a Developer Enquiry, AW confirmed acceptance of the proposed connection to the public foul water sewer along Chelmsford Road (Appendix F).

7.1.4 As invert levels of the existing public foul water drainage network are not deep enough to allow gravity drainage from the southern part of the site (south of the watercourse), on site pumping of foul flows will be required. The proposed foul water drainage strategy (Appendix F) envisages a pumping station (designed to adoptable standards, with a cordon sanitaire of 15 m to all dwellings) in the southern part of the site.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1.1 This report assesses flood risk at the development site from all potential sources and describes the measures adopted in the master planning process to manage such risks, namely the proposed development's sustainable drainage strategy. It has been prepared in compliance with current national and local policies and best practices.

8.1.2 All potential sources of flood risk at the development site have been assessed based on the information available. The key sources of flood risk to the proposed development are summarised in the following paragraphs.

8.1.3 According to the available information, most of the development site is in Flood Zone 1 (< 0.1% AEP). However, the lower-lying area along the Shenfield watercourse is within Flood Zones 2 (0.1% to 1.0% AEP) and 3 (> 1.0% AEP).

8.1.4 Site specific modelling of (fluvial) flood risk was undertaken by JNP Group (ref. C86054-JNP-XX-XX-RP-C-1006) to better define fluvial flood extents at the development site and to steer master planning in compliance with the NPPF and local planning policies.

8.1.5 According to the available information, the development site is mostly at very low (< 0.1% AEP) risk of surface water flooding. However, the lower-lying area along the Shenfield watercourse is at low (0.1% to 1.0% AEP), medium (1.0% to 3.3% AEP) and high (> 3.3% AEP) risk of surface water flooding. It is clear from the available information that there is a significant overlap between fluvial and surface water flood risks at the development site.

8.1.6 According to BCC's SFRA, there are no historic records of groundwater flooding within the borough. The bespoke ground investigation undertaken by JNP Group (ref. C86054-JNP-XX-XX-RP-G-1001 P02) encountered groundwater across the development site at depths of 3 m to 4 m bgl. The ground investigation indicates that groundwater is confined to a thin more permeable lens between thicker impermeable layers both above and below it. While the groundwater monitoring undertaken as part of the ground investigation suggests an elevated water table, this is deemed due to an artesian effect within the monitoring boreholes, which penetrated the confined water bearing lens.

8.1.7 The following measures have been incorporated in the proposed development's master planning to manage flood:

- All 'more vulnerable' parts of the proposed development have been located in Flood Zone 1, at low (< 0.1% AEP) risk of flooding, following a sequential approach to development.
- Where possible, 'less vulnerable' parts of the proposed development (e.g., public open spaces and formal play areas) have been designed to integrate water in a sustainable way. The formal play areas located within the Shenfield watercourse floodplain and one of the proposed detention basins are only expected to flood 1 to 2 times each year, for less than 6 hours.
- Finished floor levels (FFLs) have been set at least 600 mm above the estimated 1.0% AEP + 32% climate change allowance fluvial flood levels.

- Safe access to the proposed development for storm events up to 0.1% AEP shall be provided (via Alexander Lane) via a new crossing of the Shenfield watercourse linking the northern and southern parts of the site. This is necessary for compliance with the second part of the *Exception Test*, as the proposed development's main access off a lower section of Chelmsford Road is susceptible to flooding and cannot be raised out of flood risk without affecting flood risk on site or elsewhere.
- Detailed modelling (ref. C86054-JNP-XX-XX-C-1006) shows that the afflux caused by the new crossing of the Shenfield watercourse will be restricted to undeveloped areas of the site immediately upstream of the feature. This afflux provides the additional storage volume necessary to compensate for the footprint of the new crossing. In addition to minimising the impact of the crossing in terms of floodplain volume, the two large (4 m wide) box-culverts crossing the embankment also provide a safe corridor for the movement of animals.
- The proposed surface water drainage strategy has been designed so that flooding does not occur on any part of the site for all events up to 3.3% AEP and flooding does not occur in any dwelling (or the school) for all events up to 1.0% AEP + 45% climate change allowance.
- The proposed surface water drainage strategy has been designed in compliance with ECC's strict guidance to ensure (as far as reasonably possible) that runoff leaving the site post-development mimics pre-development (i.e., greenfield) conditions, thus not increasing surface water flood risk elsewhere for events up to 1.0% AEP (1 in 100 years) + 45% climate change allowance (and potentially reducing flood risk elsewhere for the most extreme storm events).
- FFLs of all 'more vulnerable' parts of the proposed development (i.e., residential dwellings and school) have been set at least 150 mm above surrounding external ground levels, which will be designed to safely route overland flows away from buildings and towards natural flow paths, using 'less vulnerable' parts of the proposed development such as public open spaces, parking areas and roads to convey and attenuate overland flows.
- The location and depth of the proposed SuDS features duly consider the available groundwater level information. Some of the deeper (foul and surface water) sewers proposed across the site are likely to be affected by groundwater within the confined lens located 3 m to 4 m bgl, in which case adequate dewatering/groundwater management measures will be required during construction. Extra care to ensure the water tightness of proposed sewers affected by the water table will be required.