A2Dominion Developments Ltd

North West Bicester

Exemplar Local Centre

Flood Risk Assessment and Drainage Strategy

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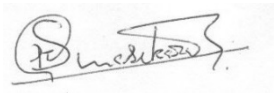
Checker	Renuka Gunasekara	
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CONTENTS

1 SUMMARY

The table below provides an overview of the flood risk and drainage strategy for the Local Centre Site on the NW Bicester Exemplar development.

Item	Response
Site Location	The Site of the proposed Local Centre is on the north west perimeter of Bicester, Oxfordshire.
Size and Current Land Use	The Site has a total site area of approximately 6.4ha and is existing open agricultural land.
Environment Agency Flood Zone	The Site is within Flood Zone 1: Low Probability. Areas of Flood Zone 2 and 3 are located adjacent to watercourses outside the proposed Local Centre Site boundary where no development is proposed other than green buffers and blue corridors as part of the remaining Exemplar Development.
Fluvial Flood Risk	Low risk of fluvial flooding.
Tidal Flood Risk	No risk of tidal flooding.
Surface Water Flood Risk	Low risk of surface water flooding.
Sewer Flood Risk	The Site itself is not at risk of flooding from sewers. However, an appropriate drainage strategy is required to ensure that the development does not exacerbate downstream flood risk.
Groundwater Flood Risk	Low Risk of groundwater flooding with suitable mitigation.
Artificial Sources Flood Risk	Low risk of flooding from artificial sources.
Historical Flooding	No records of historical flooding.
Proposed Development	Nursery, Community, Retail, Pub, Offices, and associated services and infrastructure.
NPPF Flood Risk Vulnerability	More vulnerable land use.
Sequential and Exception Tests	The proposed development types are permitted within Flood Zone 1 and therefore pass the Sequential Test. The Exception Test is not required.

2 INTRODUCTION

2.1 Terms of reference

Hyder Consulting (UK) Limited (HCL) were appointed by A2Dominion Developments Ltd to produce a Flood Risk Assessment (FRA) and Drainage Strategy to inform a detailed planning application for the Local Centre on the NW Bicester Exemplar site.

2.2 Background

Planning permission was granted by Cherwell District Council (CDC) in 2012 (Ref 10/01780/HYBRID) for the development of some 21 ha of land within the NW Bicester Masterplan area as an 'Exemplar phase'.

This permission included detailed consent for some 393 residential homes, roads and infrastructure including an Energy Centre. It also granted outline permission for a neighbourhood centre comprising non-residential uses including community facilities, local retail, pub and office space, referred to throughout this report as the "Local Centre"; as well as a new primary school.

2.3 Previous studies

A FRA and Drainage Strategy was produced by HCL in 2010 (reports 3501-UA001881-UU41R-01 and 7501-UA001881-UP21R-02) to support the Environmental Statement (ES) for the Exemplar phase (report 0505-UA001881-UP31R-01, 2010).

Following the submission of the 2010 ES, changes to the Masterplan altered the response of the development in term of flood risk and hydrology elements. The development layout was revised which led to changes to the surface water drainage layout. There were also alterations to the river corridor that changed the landform, enhanced the landscape and removed minor obstructions on the watercourse.

Additionally, the hydrology used in the FRA model was updated using information from the Environment Agency's (EA's) River Bure model – whilst the gauging data and the EA's hydrology report were not available in time for this modelling, the EA's peak flows outputs were used to refine the FRA model.

An updated FRA report was therefore produced in 2011 (report 3501-UA001881-UU41R-03). This was included in the 2011 revision to the ES (report 0513-UA001881-UP31R-01) which was submitted to support the hybrid planning application.

Following the approval of the hybrid planning application in 2012, additional assessment has been carried out to facilitate detailed design and discharge the planning conditions relevant to flood risk and drainage, notably a 2012 update to the Drainage Strategy (report 7513-UA001881-UP33R-03) for the Spine Infrastructure and Phase 1 of the Exemplar site, which included the proposed Local Centre area.

The 2012 Drainage Strategy confirmed the drainage network philosophy and SuDS storage volumes required to drain this area of the Exemplar site covering the Local Centre in keeping with the principles laid out within the Exemplar FRA.

The purpose of this FRA and Drainage Strategy for the Local Centre is to present an updated position with regards to site data, hydrology and the existing and planned drainage infrastructure being constructed in the adjacent residential areas of the Exemplar development, to support the detailed planning application for the Local Centre.

3 WIDER DEVELOPMENT CONTEXT

3.1 Exemplar site description

The Local Centre Site is situated across 6.4ha of greenfield land approximately 1.5 km to the northwest of Bicester with a National Grid Reference of (SP 57871 24770). The Site is bordered by agricultural land. The Local Centre Site is located within the south of the wider Exemplar site which is located north of the A4095 which forms the current boundary of Bicester, west of the B4100, east of the B4030 and south of Bucknell, encompassing Crowmarsh Farm.

The Local Centre area was classified as Grade 3 agricultural land, the River Bure is located approximately 35m to the northwest of the Site. The Site is located within first phase of a wider development; part of the 'Exemplar Phase' that is currently under construction; and all of the Site is currently occupied as a temporary construction compound, materials lay down and handling area in accordance with the approved Construction Environmental Management Plan relative to the existing planning permission (Ref 10/01780/HYBRID).

The extents of the Exemplar site and the Local Centre are shown on Figure 3-1.

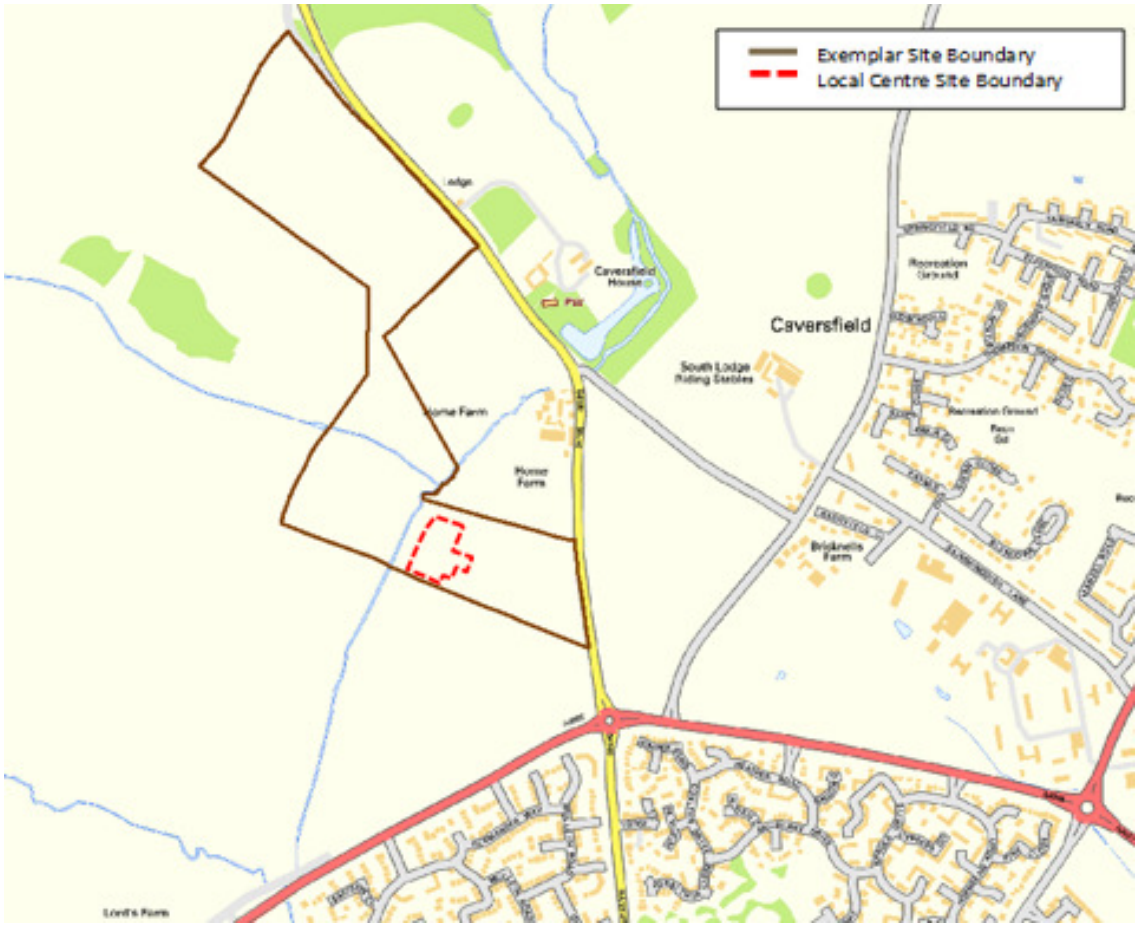

Figure 3-1 Exemplar Site and Local Centre Location

3.2 Planning Context

This assessment has been undertaken in accordance with current international and national legislation, and national, regional and local plans and policies. A summary of the relevant legislation and policies and the requirements of these policies are provided below:

3.3 National Planning Policy Framework (NPPF)

The NPPF and its accompanying Technical Guidance set out Government planning policy for England. The principal aim of the NPPF is to contribute to the achievement of sustainable development. This includes ensuring that flood risk is taken into account at all stages of the planning process, avoiding inappropriate development in areas at risk of flooding and directing development away from those areas where risks are highest. Where development is necessary in areas at risk of flooding, the NPPF aims to ensure that it is safe, without increasing flood risk elsewhere.

Early adoption of and adherence to the principles set out in the NPPF and its Technical Guidance, with respect to flood risk, can ensure that detailed designs and plans for developments take due account of the importance of flood risk and the need for appropriate mitigation, if required.

A sequential risk-based approach to determining the suitability of land for development in flood risk areas is central to the NPPF and should be applied at all levels of the planning process to avoid inappropriate development.

This sequential approach is applied through the application of two tests:

The Sequential Test

The risk-based Sequential Test should be applied at all stages of planning. Its aim is to steer new development to areas at the lowest probability of flooding (Flood Zone 1).

The EA's Flood Zones are the starting point for the sequential approach. These Flood Zones (Table 3-1) refer to the probability of sea and river flooding only, ignoring the presence of existing defences.

Flood Zone	Annual Probability of Flooding (%)	Corresponding Annual Chance of Flooding (1 in x)
1. Low Probability	Fluvial and Tidal <0.1%	>1,000
2. Medium Probability	Fluvial 0.1-1.0% Tidal 0.1-0.5%	1,000-100 1,000-200
3a. High Probability	Fluvial >1.0% Tidal >0.5%	<100 <200
3b. The Functional Floodplain	Fluvial and Tidal >5.0%* *Starting point for consideration. LPAs should identify Functional Floodplain, which should not be defined solely by rigid probability parameters.	<20

Table 3-1 Summary of NPPF Flood Zones

The overall aim of decision-makers should be to steer new development to Flood Zone 1. Where there are no reasonably available sites in Flood Zone 1, decision-makers determining applications for development at any particular location should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should decision-makers consider the suitability of sites in Flood Zone 3, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required.

The NPPF provides guidance on the suitability of each land use classification in relation to each of the Flood Zones as summarised in Table 3-2.

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

Key:

✓ Development is appropriate

× Development should not be permitted

Table 3-2 NPPF Flood Risk Vulnerability Classification

The Exception Test

This is applied where is it has not been possible to locate the required type of development in an appropriate Flood Zone.

For the Exception Test to be passed the following conditions must be met:

- It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment (SFRA) where one has been prepared.
- The development should be on previously-developed land or, if it is not on previously developed land, there should be no reasonably alternative sites on developable previously-developed land.
- An FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

The approach is therefore a staged one:

- Categorisation of the site within the Environment Agency Flood Zones.
- Application of the Sequential Test, i.e. consideration of the site by the Local Authority to assess if the development can be relocated to an area of lower flood risk.
- Where a particular type of development cannot be relocated to an appropriate Flood Zone, the Exception Test may be required. This involves an evaluation of the site to ensure that the initial requirements of the test are met and a detailed assessment of flood risk from all sources is undertaken and an FRA is produced.

Flood Zone categorisation of the site

The Environment Agency flood map indicates that the proposed Local Centre development Site is located within Flood Zone 1 - classified as having a low probability of fluvial flooding. Modelling undertaken for the Site also indicates that areas at high risk of fluvial flooding are confined to the river corridors outside the red line boundary of the Local Centre (see Section 5 for further details). All development will occur within the low risk Flood Zone 1.

Flood risk vulnerability

Under the NPPF, the proposed use of the Site (Local Centre) is classified as Less Vulnerable, with the exception of the nursery which is classified as More Vulnerable. Both classes of development is considered appropriate in Flood Zones 1, 2 and 3a providing that the Sequential and Exception Tests are passed.

Sequential and Exception Tests

As the developable area of the Site is located within the low risk Flood Zone 1 it is considered that the scheme would pass the Sequential Test applied by the Local Authority and the Exception Test need not be applied.

3.4 The Water Framework Directive (2000/60/EEC)

The Directive provides a framework for the protection of surface (fresh) water, estuaries, coastal water and groundwater. The objectives of the Directive are to enhance the status, and prevent further deterioration, of aquatic ecosystems, promote the sustainable use of water, reduce pollution of water (especially by ‘priority’ and ‘priority hazardous’ substances) and ensure progressive reduction of groundwater pollution. Among the main features of the Directive are that all inland and coastal waters within defined river basin districts must reach at least good ecological status by 2015. The Development will aim to attain the highest achievable level of water quality standards. This will be achieved by the incorporation of Sustainable Drainage Systems (SuDS) within the design to improve the quality of the runoff from the Site.

3.5 The Flood and Water Management Act (2010)

The Flood and Water Management Act provides better, more comprehensive management of flood risk for people, homes and businesses. It also helps tackle bad debt in the water industry, improves the affordability of water bills for certain groups and individuals, and helps ensure continuity of water supplies to the consumer. The Flood and Water Management Act encourages the use of sustainable drainage in new developments and re-developments. Through the preparation of the FRA and the Drainage Strategy, the Development will incorporate SuDS within the design. It has been concluded that the Development will not be exposed to an unacceptable degree of flood risk nor increase the flood risk to third parties.

3.6 Cherwell Local Plan Submission (2014) Policy

The emerging Cherwell Local Plan 2006 - 2031 identifies land to the north-west of Bicester as a strategic site for the provision of an eco-development under Policy Bicester 1: North West Bicester Eco-Town. This policy aims to embed the criteria of the PPS1 Supplement in local policy. The Cherwell Local Plan 2006 - 2031 is not yet adopted. Therefore, the NPPF and PPS1 Supplement are the principal planning documents against which the proposals should be considered.

4 SITE AREA AND DEVELOPMENT PROPOSAL

4.1 Site description

The Local Centre Site is located on the north western edge of Bicester, and access to the Site will be from the B4100 to the east of the site. Figure 4-2 below shows the location of the proposed Site (marked in red).

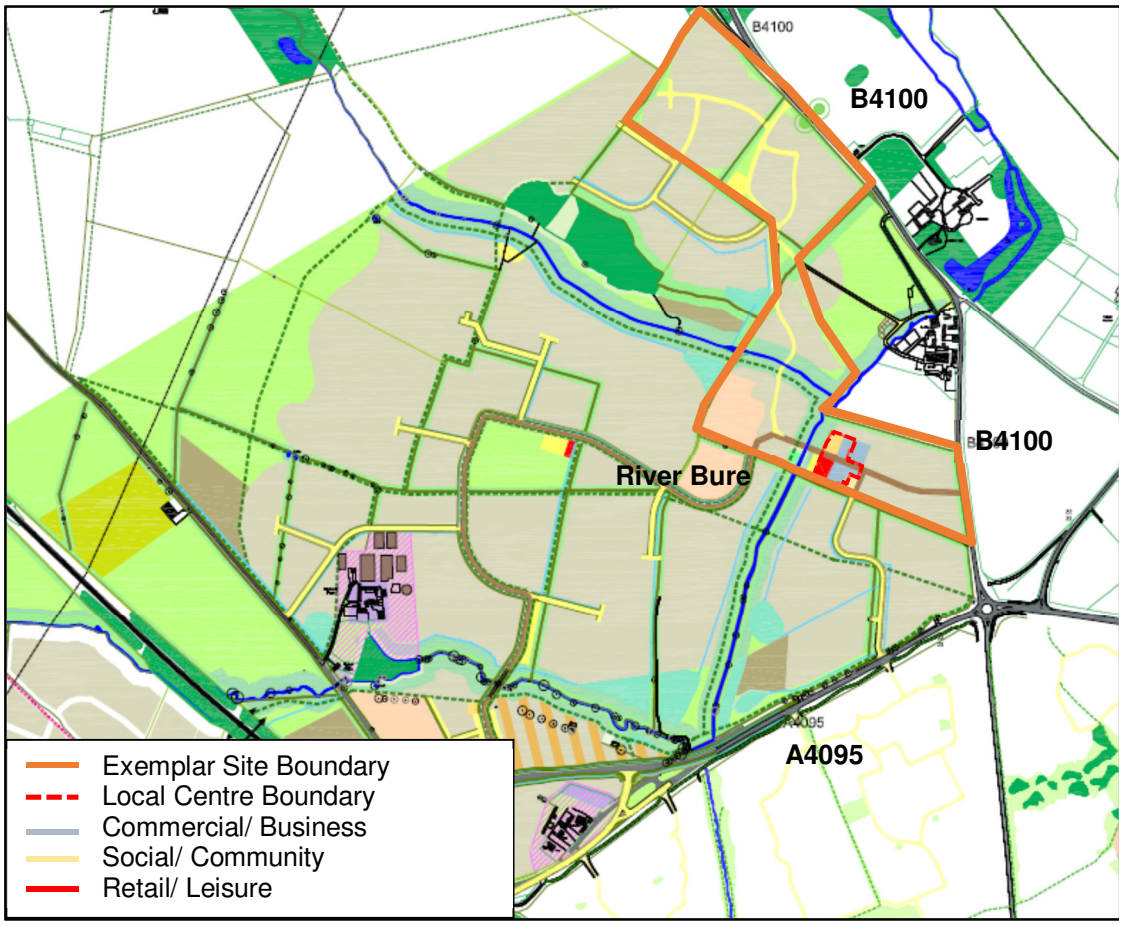

Figure 4-2 Exemplar Local Centre Application Overall Layout

4.2 Site topography

A topographic survey was undertaken for the Exemplar Site in 2011. Levels fall from the east of the Site towards the River Bure at the west, which is located approximately 35 m from the western boundary of the Site.

The existing ground levels along the eastern boundary of the Site are approximately 88.50 m AOD and the levels fall gradually to the west, and levels are approximately 85.50 m AOD along the western boundary of the Local Centre Site. The ground levels then continue to fall towards the River Bure within the wider Exemplar Site and levels adjacent to the watercourse are approximately 83.6 m AOD.

4.3 Existing drainage features

The Site is Greenfield and surface water runoff currently infiltrates into the ground and drains to the River Bure at the west.

Information obtained from Thames Water indicates that urban areas to the south east of the Local Centre Site are drained by a positive drainage network of surface water pipes and manholes which discharge to nearby watercourses. These urban areas drain away from the proposed Site.

The highway to the east of the Site and wider Exemplar Site shed surface water to their grassed verges, from where it infiltrates the ground.

4.4 Ground conditions

The British Geological Survey online mapping indicates that the site is underlain by the Cornbrash Formation, which is a limestone sedimentary bedrock.

The online Environment Agency maps indicate that the bedrock below the Site is designated as a Secondary A Aquifer, and a groundwater vulnerability 'Minor Aquifer High Zone'. This is described as 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers'.

There are no Groundwater Source Protection Zones (SPZ) in the vicinity of the Site. Consultation with CDC has not identified any private water supply boreholes within the Site although four boreholes are located within 1.5 km of the Site.

Ground conditions for the Exemplar Site were originally assessed within a desk study (Phase 1 Desk Study, document 2501-UA001881) and a factual report summarising the findings of onsite ground investigation (Exemplar Site Factual Report, document 2504-UA001881) in 2010.

Additional site investigation was conducted in July and August 2012 and detailed within a supplementary report (Supplementary Ground Investigation & Geotechnical Design Report, 0001-UA004014-UP32R-01-GI-F).

In summary, the investigations indicate that the site comprises stratum of sand and gravel overlying clay bands and limestone, with no significant contamination issues or risks identified.

A number of machine excavated trial pits were undertaken across the site, and soakway tests undertaken at selected pits. To determine ground infiltration rates that reflect the likely depth of soakaway features, the soakaway tests were conducted at depths of approximately 1 m below ground level.

The results indicate that ground infiltration is feasible within the superficial deposits and that soakage will also be feasible between depths of 1-2 m below ground level. Of particular interest to the Local Centre site are SP3 from the 2010 investigations, and TP56B and TP57 from the 2012 investigations.

SP3 was the nearest of the 2010 trial pits to the Local Centre site, located approximately 20 m to the west of the site boundary. Soakaway testing at SP3 revealed a range of permeability from 1.77x10-5 to 3.90x10-5 m/s.

TP56B is located in the vicinity of the northern plot of the Local Centre. This trial pit encountered layers of sandy and gravelly clay, with very weak limestone encountered at a depth of 1.50 m.

The limestone stratum was observed to be very fractured, with the fractures infilled with sand. The trial pit terminated at a depth of 1.65 m with no groundwater encountered.

TP57 is located in the vicinity of the southern plot of the Local Centre. This trial pit encountered layers of sand, gravels and clay, with very weak limestone encountered at a depth of 1.95 m. The limestone stratum was observed to be very fractured, with the fractures infilled with sand. The trial pit terminated at a depth of 2.00 m with no groundwater encountered.

Soakaway testing at TP56B revealed a range of permeability from 1.06x10-5 to 2.53x10-5 m/s. No soakway testing was undertaken at TP57.

To ensure a conservative design approach, the calculations undertaken to support the Drainage Strategy for the Local Centre (see Section 7) have assumed an infiltration rate of 38 mm/s, equivalent to the minimum permeability observed at TP56B.

4.5 Development proposal

The Local Centre Site comprises land within the NW Bicester eco-development area and includes (GEA) a 503 m² convenience store, 444 m² of retail units, 664 m² pub, 523 m² community hall, 869 m² nursery, and 614 m² of commercial units with associated access, servicing, landscaping and parking.

The Site planning application will be submitted in detail with all development to be accordance with the Application Plans and Development Parameters Schedule. Appendix 1 illustrates the proposed Masterplan for the Site.

Figure 4-3 below shows the layout of the proposed Site (marked in red).

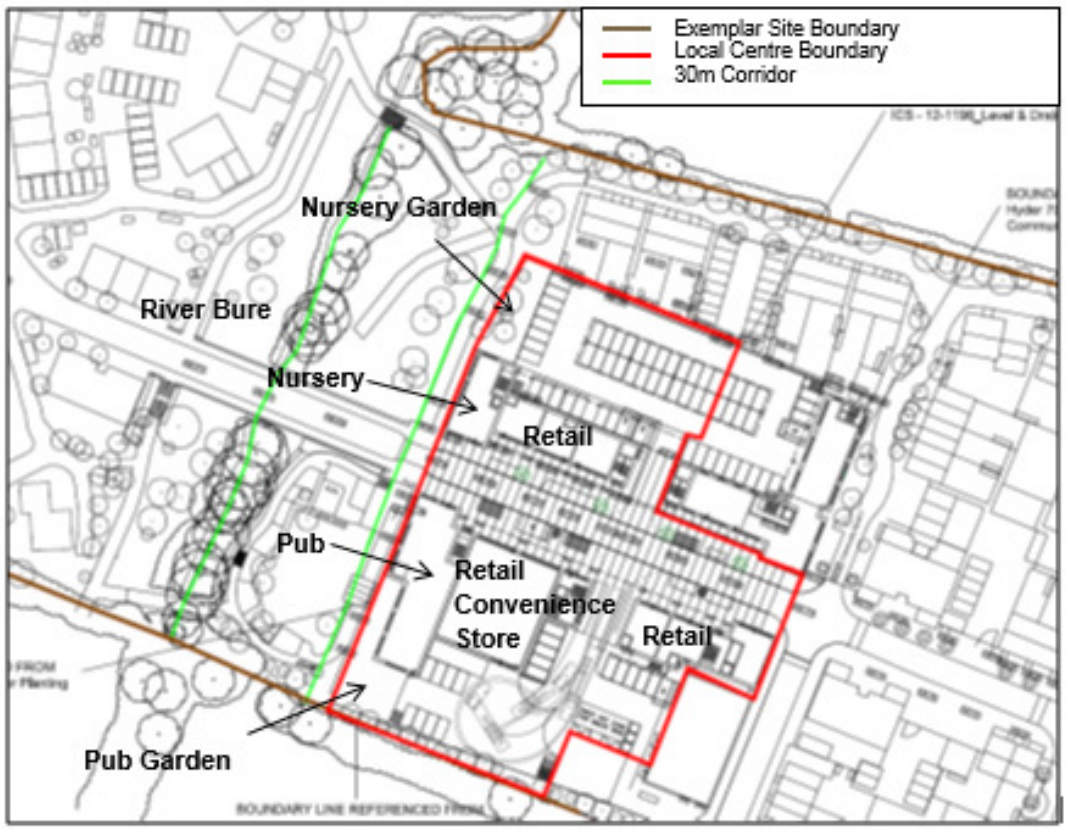

Figure 4-3 Local Centre Site Plan

As part of the permitted 'Exemplar Phase' (Ref 10/01780/HYBRID) construction work on-site has already commenced which also has some adjustments to the existing ground levels.

Construction on-site has included the main 'spine' road through the middle of the Local Centre; the Energy Centre and terminal foul water pumping station are located immediate outside the eastern boundary of the red line area. Some residential properties are also proposed immediately to the north of the red line area. The red line area excludes the Eco-Business Office which also forms part of the Local Centre at the north eastern corner. However, the plans and drawings presented as part of this application include this area for illustrative purposes to demonstrate how this office space fits seamlessly with this application.

The above Exemplar site development proposals have effectively set the construction platform level for the Local Centre, which provides back of footway levels (north side) of ranging from 88.55 m (at the east) to 86.96 m AOD falling westwards at the boundary along the Primary Road corridor.

5 ASSESSMENT OF THE FLOOD RISK

5.1 Historical flooding

As the existing Site is undeveloped, it is considered unlikely that any flooding would have been reported. A review of the Oxfordshire Preliminary Flood Risk Assessment (PFRA) did not highlight any flooding within the Site boundary although some surface water flooding has occurred within Bicester town.

There are no historical records of flooding within or around the Site from either the EA or the SFRA.

5.2 Sources of flood risk

The Technical Guidance to NPPF requires that an FRA should 'assess the risks of all forms of flooding to and from the development'; therefore, this section presents a review of all potential sources of flood risk to the proposed development Site.

North West Bicester Master plan – Flood Risk Assessment (FRA) produced by Hyder Consulting Ltd in February 2014 (5003-UA005241-BMR-05) looked at these sources of flooding in detail. They are summarised in this section and in detail applicable to the Exemplar Local Centre Application Site.

5.2.1 Rivers

Flood risk to the proposed Site displayed on the online EA flood maps are based upon a coarse DTM and JFLOW modelling and these maps are not considered suitable to delineate the flood plain in sufficient detail to inform a FRA in support of a planning application. Therefore a hydraulic model was constructed to confirm the floodplain extents across the Site in 2011. The detailed hydraulic modelling was undertaken as part of the FRA produced by Hyder Consulting in 2011.

A detailed ISIS hydraulic model has been used as a baseline to define fluvial flood plains for a 5% Annual Exceedance Probability (AEP), 1% AEP, 1% AEP plus climate change and 0.1% AEP events at the Exemplar Local Centre Site. Plans contained within Appendix 2 show the modelled flood extent for the 1% and 0.1% AEP events (i.e. Flood Zones 3 and 2 respectively).

Examination of the modelling results using the LiDAR and modelled cross sections show that the existing flood extents to the west of the Local Centre are contained within the 30 m wide green corridor buffer zone already incorporated in the wider Exemplar master plan design.

The modelled flood extent also shows that flooding occurs predominantly on the flatter land around the confluence between the River Bure and the Langford Brook approximately 4 km downstream of the proposed Site. Away from this main confluence, flooding is confined to the relatively narrow valley of the watercourses, and the two confluences between the River Bure and the tributary watercourses located 80 m upstream, and 550 m downstream, of the Local Centre Site.

Therefore, the ISIS model predicts that floodwater is generally confined to the valleys in which the watercourses flow, with ponding occurring at the existing confluences and upstream of

constricting structures. The ISIS model does not predict any overland flow occurring but this risk is assessed separately using a TUFLOW model as discussed in Section 5.2.3 below.

The model results have confirmed that the Local Centre Site is located within the Low Flood Risk Zone (Flood Zone 1), with small areas of Medium and High risk restricted to areas immediately adjacent to the River Bure watercourse corridor to the west. All proposed development has been located within the areas of Low risk, and therefore the development is considered to be at low risk of flooding from fluvial sources.

Section 6 below confirms that the post development fluvial flood risk is further reduced once proposed ground raising at the Local Centre and minor floodplain enhancements have also been accounted for.

5.2.2 Sea

The Exemplar Local Centre Site is located significantly inland approx. 150km away from the sea therefore it is considered to be at low risk of Tidal Flooding.

5.2.3 Surface water

The existing Site is Greenfield and used for agricultural purposes, therefore there is no surface water drainage infrastructure associated with the Site.

The Site is located on a slope which drains to the River Bure at the west. As the Site is currently farmland, there may be small land drains that also outlet to the River Bure.

A direct rainfall model was produced in TUFLOW to assess existing key overland flow routes and surface water flood risk as part of wider NW Bicester Masterplan submitted in 2014. Full details of this modelling work was reported in Flood Risk Assessment (5003-UA005241-BMR-05) dated February 2014.

The surface water modelling results around the Exemplar site is extracted and presented in Appendix 2, which confirm that currently there is no noticeable surface water flood risk to the Local Centre Site for the 1% AEP event plus climate change.

The proposed Exemplar Local Centre Site will incorporate surface water management measures to ensure that the runoff rates across the Site are maintained at the existing Greenfield rates. This will ensure that the flood risk from surface water runoff to the Site and surrounding land is maintained at the baseline level.

As within any development, if appropriate SuDS design measures are not incorporated within the proposals, surface water flooding issues may potentially develop where impermeable areas are increased. Based on the existing surface water runoff regime and providing that, as described above, appropriate SUDS measures are incorporated within the proposed development, it is considered that the Site is at low risk of surface water flooding.

Details on the proposed surface water management arrangements for the Site are discussed further in Section 7.

5.2.4 Groundwater

Maps of Areas Susceptible to Groundwater Flooding (AStGWF) were included within the SFRA. These maps were released by the Environment Agency in 2011 and show the proportion of each 1 km grid square where geological and hydrogeological conditions indicate that

groundwater might emerge. The maps show that to the north east of the railway line, where the Exemplar site is located, the percentage of each 1km square that could potentially be subject to groundwater flooding is 25%. To the south west of the railway line, no groundwater flood susceptibility has been defined.

The SFRA and PFRA indicate some potential for groundwater flooding in the area. The currently available ground investigation suggests that the risk of groundwater flooding is likely to be small. Groundwater monitoring carried out by Hyder in 2010 showed standing water levels between 3.1 and 6.3 m below ground level did not encounter groundwater indicating generally low groundwater flood risk to the to the proposed building foundations in the Local Centre.

As explained in Section 4.4 none of the trial pits undertaken in 2010 and 2012 encountered groundwater strikes up to 2 m depth below ground in the vicinity of the Local Centre. However, excavations taken within the surrounding area and after heavy rain encountered shallower groundwater levels above the limestone. Therefore, if foundations are based at shallow level on top of the limestone, some groundwater flooding may be expected following heavy rain.

As explained in Section 7, the drainage strategy for the Exemplar site will include infiltration of surface water as part of its SuDS design to maintain the existing hydrological design and avoid increased discharges to the watercourses. This will slightly change the local groundwater regime by displacing current infiltration from the building footprint to new infiltration areas. The groundwater data available suggests that the groundwater levels will permit infiltration across most of the Exemplar site including the Local Centre.

Although the Site is to be considered at low risk of groundwater flooding consideration to potential mitigation measures can be given to address any residual groundwater flooding risk, which may include:

- Additional site specific ground investigations to inform the general site and SuDS detailed design process
- Consideration of local conditions to ensure that infiltration is feasible and that discharge of water to superficial aquifers does not present a groundwater flood risk
- The provision of preferential flow paths away from the buildings to the surface water drainage system;
- Location of buildings outside the areas of highest risk following detailed site investigations; and
- The provision of damp proof courses and tanking it if required.

With the incorporation of mitigation measures and a SuDS strategy, the Site can be considered to be at low risk of groundwater flooding.

5.2.5 Sewers

There is a low risk of flooding from sewers once the Site is developed. The design of the foul water connection from the Local Centre and wider Exemplar Site into the existing Bicester sewerage network has been developed to the satisfaction of Thames Water, with discharge rates restricted to prevent any increase in the risk of sewer flooding further downstream.

5.2.6 Artificial Sources

The Site is located within small catchment, in which no artificial sources (which include but are not limited to canals/reservoirs) have been identified. It is therefore considered that the Site is at low risk of flooding from artificial sources.

5.3 Specific flood risk concerns and considerations

5.3.1 Third Party Flood Risk

All development in the Local Centre will be sited within Flood Zone 1 and compensatory storage has also been provided as part of the wider Exemplar Site proposals to alleviate the small restriction to flow caused by the new bridges crossing the watercourses. Therefore, there will be no loss of floodplain storage caused by the proposed development.

Any increased peak surface water run off caused by the development will also be attenuated to Greenfield rates. Therefore, there will be no change in third party flood risk as a result of the development.

5.3.2 Site Access and Egress

As stated in Section 5.2.1 above, all development will be sited within Food Zone 1, and any roads crossing watercourses has been raised above flood levels. Therefore, emergency access routes will not be affected by flooding.

5.3.3 Residual Risk

It is essential that the risk of flooding is minimised over the lifetime of the development (100 years) in all instances. It is important to recognise, however, that flood risk can never be fully mitigated, and there will always be a residual risk of flooding. The NPPF states that the residual risks are those remaining after applying the sequential approach and taking mitigation actions.

The residual risks to the development Site are considered to be:

- A fluvial flood event in excess of those currently modelled; and
- A storm event which exceeds the capacity of the onsite drainage systems.

6 FLUVIAL FLOOD RISK ASSESSMENT

This section outlines the modelling methods used to determine the fluvial flood risk to the Site, the results of the modelling, and the impacts of the fluvial flood risk on the proposed development, Local Centre on the NW Bicester Exemplar site.

6.1 Hydrological assessment

The hydrology used in the eco development model was the same used on the EA's River Bure Model in 2011. Our recent telephone consultations with the EA (Lesley Tims – Planning Specialist) and their subsequent response received on 20 April 2015 (email sent from Jean Fulker – Customers & Engagement Officer) have confirmed that the most up to date modelling the EA has in the Bicester area is still from their Langford Brook (Bicester) and Pringle Back Bure 2010 model.

As explained in Section 2.3 and Section 5.2 before, our latest NW Bicester ISIS model has already incorporated the relevant hydrological inputs from the EA's latest models. This included the flood flow estimates for the River Bure and its tributaries (T1 – T3) that were mainly derived applying the FEH statistical method but matched with the peak flows from the latest EA models to ensure consistency and best available local gauging data usage.

Summary of the peak flows used in the NW Bicester model are shown in Table 6-3.

Annual Exceedance Probability (AEP)	T1-3014	T2-2266	T3-0770
1 in 20 (5%)	0.65	0.44	1.36
1 in 100 (1%)	0.94	0.64	1.96
1in 100 + CC (1% + CC)	1.13	0.77	2.35
1in 1000 (0.1%)	1.70	1.16	3.54

Table 6-3 Modelled Design Events (Flows, m^3/s)

6.2 Hydraulic assessment

Full details of the hydraulic modelling process are provided in the original Exemplar Hydraulic Modelling Report produced in 2011. The original ISIS model was slightly updated in 2013/2014 as part of the wider Masterplan development work to include a small tributary (Hawswell Tributary) on the Langford Brook within the wider development.

The assessment of fluvial flood risk was made using ISIS model (Halcrow, V3.3) of the River Bure and its tributaries. The model was run to simulate the following Annual Exceedance Probability Events (AEP):

- 1 in 20 (5%)
- 1 in 100 (1%)
- 1 in 100 plus climate change with 20% increase in flows (1% + CC)
- 1 in 1000 (0.1%)

6.3 Baseline flood risk

The aim of the study is to gain an understanding of the degree of flood risk for the Local Centre development on the Exemplar site and confirm the potential flood mechanisms that could lead to inundation.

As shown in Figure 6-4 below, the proposed Local Centre Site is located in Flood Zone 1 whilst green and blue corridors have also been incorporated within Flood Zone 2 and 3 as part of the wider Exemplar Masterplan development. Watercourse cross sections from the 1D-ISIS model have been used to estimate the fluvial flood extents in the Exemplar Local Centre Site and the surrounding area.

Climate change is predicted to increase the modelled flood extents by only a small amount as shown in Appendix 2. The increased flood risk for 1% AEP event due to climate change is also fully contained within the green corridor along the Local Centre Site. Similarly, the increased flood extents for the NW Bicester development immediately surrounding the Local Centre Site is also contained within the allocated 30 m wide green corridors on each river bank.

However, modelling indicates that further away from the Local Centre Site the 1% AEP plus Climate Change flood extents could marginally exceed the general 30 m wide green corridor buffer zone (Figure 6-4) but this can be easily addressed through the wider development proposals.

For example, at T2-0462 the flood extents exceed the 30 m green corridor by 3 m on the right bank but there is sufficient space to extend the green corridor in this location if needed, or set back development accordingly. This section is located approx. 120 m downstream of the Site. Therefore, the Site is not directly affected.

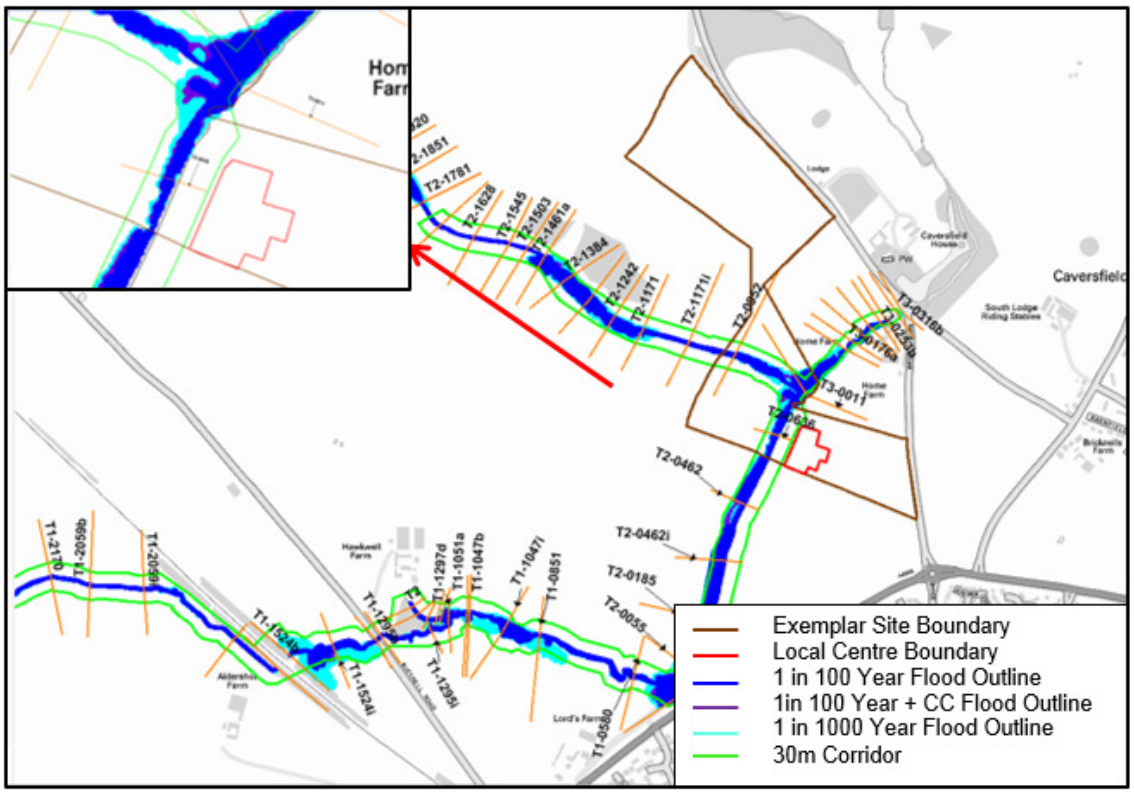

Figure 6-4 Baseline Modelled Fluvial Flood Extents

The ISIS model Bicester_V41 (2013) has been used to extract the baseline modelled water levels.

Table 6-4 below also shows the modelled peak water levels near the development Site for each AEP event. Cross-section locations are shown on Figure 6-4.

Node Label	1 in 20 Year (5% AEP)	1in 100 Year (1% AEP)	1 in 100 Year with climate change (1% AEP)	1 in 1000 Year (0.1% AEP)
T3-0011	83.250	83.338	83.377	83.485
T2-0636	82.673	82.764	82.813	82.911
T2-0462	81.436	81.547	81.596	81.689
T2-0462i	Na	80.811	80.809	80.845
T2-0185	78.822	79.872	79.918	80.007

Table 6-4 Modelled Water Levels Summary - Baseline

The river modelled water levels mostly likely to be affected by the proposed Local Centre are: T3-0011 (Upstream), T2-0636 (near the Site) and T2-0462 (downstream).

The above modelled peak 1 in 1000 Year (0.1% AEP) shows the highest water level near the Site. Along the river edges, water levels vary from 83.485 m AOD at the model node T3-0011 down to 81.689 m AOD at T2-0462, with a water level of 82.911 m AOD at the nearest point to the development Site (at T2-0636).

Figure 6-5 below also shows the modelled baseline flood levels in relation to the ground levels cross section at the model node T2-0636.

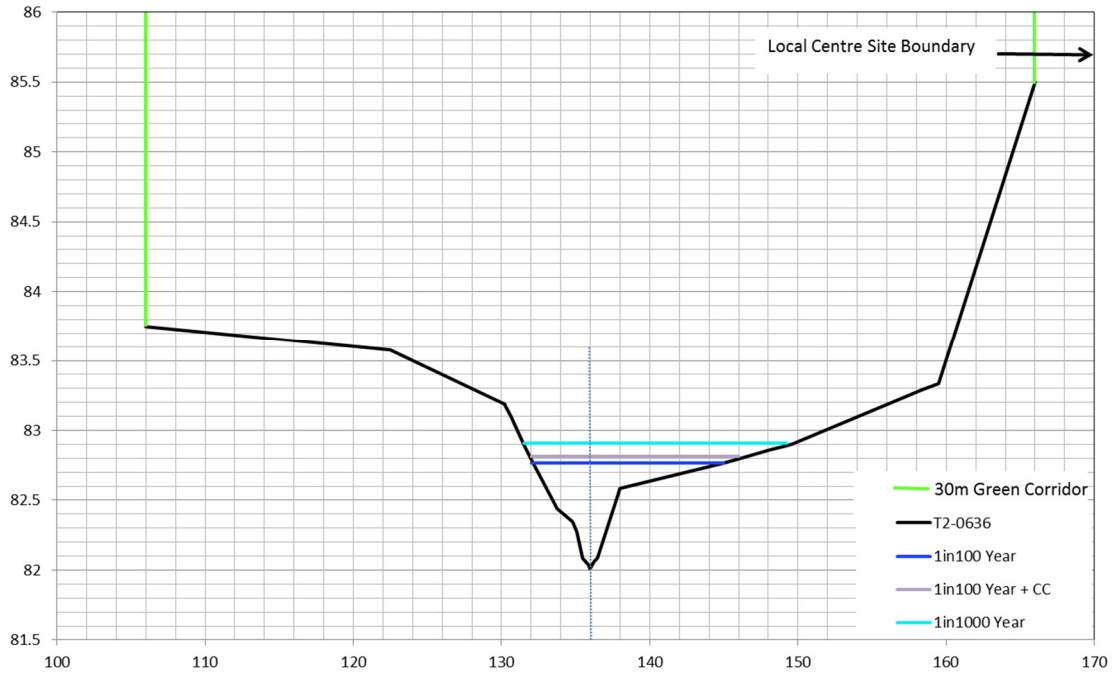

Figure 6-5 Baseline Modelled Fluvial Flood Levels at the Modelled River Section T2-0636

Inundation maps for the different design events: 1 in 100yr, 1 in 100yr + cc, and 1 in 1000yr can also be found in Appendix 2.

The above information clearly demonstrates that the flood extents for all modelled fluvial events are fully contained within the 30 m green corridor near the Site for the baseline case. Therefore, the developable area of the Site is not predicted to be at risk of fluvial flooding during the development lifetime, including the potential impacts of climate change.

Section 6.5 below confirms that the available freeboard will be further increased for the post development case once the increased ground levels and floodplain modifications are accounted for.

6.4 Sensitivity analysis

The hydraulic model was approved by the Environment Agency (EA) in 2011. The EA has also acknowledged that no further modelling has been made since 2011, therefore the model sensitivity tests undertaken then, to determine the level of uncertainty in the predicted water levels associated with key model parameters still stand for the current Exemplar Local Centre Site FRA.

A full description of the sensitivity analysis undertaken and the model results can be found in the Hydraulic Modelling Report undertaken previously for the Exemplar FRA.

6.5 Post-development modelling

The model predicts that floodwater is generally confined to the valleys in which the watercourses flow, with ponding occurring at confluences and upstream of constricting structures. The ISIS model does not predict any overland flow occurring.

ISIS model Bicester_V36-1000yr_postdev_V5F (2013) has been used to extract post development modelled water levels.

Table 6-5 below shows the difference in modelled peak water levels between the baseline and post development scenarios.

Node Label	Baseline 1 in 1000 Year (0.1% AEP)	Post development 1 in 1000 Year (0.1% AEP)	Differences in Water levels (m)
T3-0011	83.485	83.371	-0.114
T2-0636	82.911	83.037	+0.126
T2-0462	81.689	81.69	+0.001
T2-0462i	80.845	80.846	+0.001
T2-0185	80.007	80.007	0.000

Table 6-5 Comparison of modelled water levels 1 in 1000 Year (%0.1 AEP): Baseline and Post Development

Table 6-5 shows a comparison of modelled flood levels before and after the development. There is a small increase of approx. 126 mm immediately upstream of the proposed bridge (T2-0636), and a small decrease of approx. 114 mm at the confluence with an unnamed tributary (T3-0011) further upstream.

However, any increase in flood extents is contained within the allocated 30 m green corridor and there is no increase in flood levels downstream of the Site. This indicates that the alterations made to the river corridor as part of the wider Exemplar site proposals have very little impact on modelled peak levels.

The bridge crossing over the River Bure (T2-0636) has been designed such that the soffit is well in excess of the EA's recommended 600 mm minimum clearance above the modelled peak 1 in 100 Year (1% AEP) plus climate change water level; the proposed bridge soffit level is 85.39 m AOD giving a freeboard of 2.577 m.

The proposed bridge finished deck level is 86.5 m AOD which is approx. 3.69 m higher than the 1% AEP plus climate change flood level of 82.813 m AOD. Therefore, the proposed bridge design will ensure that it will not increase flood risk to the Site or to third parties whilst ensuring safe emergency access and egress routes during extreme events.

The Exemplar Local Centre Site is currently located on a higher ground east of the river. In addition, significant ground raising has been proposed within the Site towards the western boundary and the proposed ground levels falls down from the Site towards the river therefore it is very unlikely for the Site to be flooded for 0.1% AEP event.

At the Western boundary of the Local Centre Site, the back of proposed footpath levels along the Primary Road ranges from 86.962m AD (northern footpath) to 87.032 m AD (southern footpath), which will provide approx. 4m freeboard above the 0.1% AEP modelled level of 82.911m AD at the bridge crossing. The remainder of ground levels at the western Site boundary along the river frontage will also be designed to generally match with these footpath levels within the Local Centre, which will virtually eliminate any fluvial flood risk from the River Bure from the west.

Flood Outlines for baseline and post development are shown in Figure 6-6.

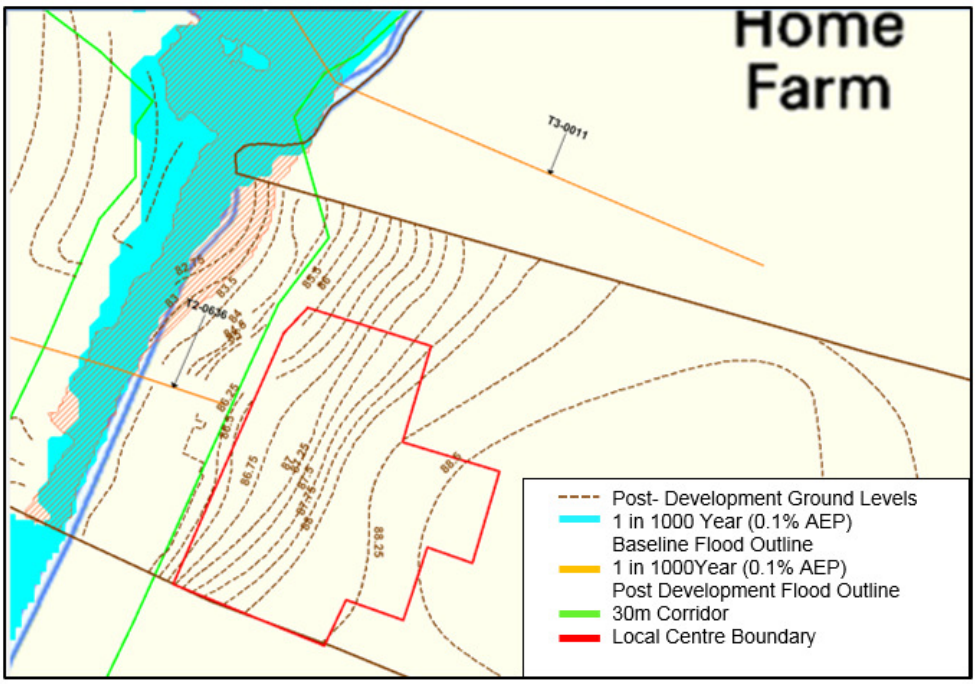

Figure 6-6 Comparison of modelled water Levels Pre and post Development

Figure 6-6 and the proceeding text show that the modelled water levels for the different return period rest well below the finished levels of the Exemplar Local Centre Site.

The model results have confirmed that the proposed development Site is located within Flood Zone 1, and therefore the development is considered to be at low risk of flooding from the fluvial sources.

In general, it is also recommended that the minimum finished floor levels of buildings should be a minimum of 300 mm above surrounding ground levels by suitable ground re-profiling, to account for protection against surface water ponding during a storm event that generates runoff which exceeds the design capacity of the drainage system.

6.6 Assumptions and limitations

The hydraulic model has been constructed using the best available data, and from range of sources. Whilst some checks have been made to confirm the suitability of the data. Hyder Consulting cannot be held responsible for errors in third party works.

The model is considered the best representation of reality within the current constraints of modelling; accuracy is inherently related to the quality and extent of data available.

7 DRAINAGE STRATEGY

This Section provides an update to the existing drainage strategy, to account for changes in planned building layouts and the drainage philosophy of the surrounding residential proposals.

The purpose of this Section is to verify that the detailed Local Centre application remains aligned with the overall drainage strategy, as previously developed via the Exemplar Flood Risk Assessment and Drainage Strategy, and illustrate the effectiveness of the proposed SuDS elements required within the application area.

7.1 Greenfield runoff rate

The greenfield runoff rate is used to define limits on the permitted maximum discharge rates from the developed site.

The proportion of rainfall discharging as surface water runoff across the surface of the predevelopment site to watercourses was estimated during the Exemplar FRA using the IoH124 method as recommended by the Environment Agency and set out within the SuDS Manual for sites up to 200 ha.

These results are expressed as greenfield runoff rates and were agreed with the Environment Agency

The results agreed with the Environment Agency are illustrated in Table 7-6 below. Further details of their derivation are provided within the 2011 Flood Risk Assessment (document 3501-UA001881).

Return Period	Greenfield runoff	
	(l/s/ha)	(l/s)
Mean Annual	2.29	40.1
1 in 30 year	5.12	89.6
1 in 100 year	7.29	127.6

Table 7-6 Greenfield runoff rates for the predevelopment Exemplar site

The 2012 Drainage Strategy was developed to ensure that the peak discharge from the Exemplar site would be reduced during the 1 in 100 year rainfall event (including an allowance for climate change) from 127.6 l/s to 40 l/s.

In order to achieve this reduction across the site, it was determined that the peak discharge to the watercourse from the Catchment 9 area (see Section 7.2) should be limited to 5 l/s for storms up to and including the 1 in 100 year (plus climate change) event.

7.2 Existing surface water strategy

The 2012 Drainage Strategy for the Exemplar site considered the entirety of the Exemplar site as a number of discrete catchments. As illustrated in Figure 7-7, the Local Centre site is located in Catchment 9, with surface water drainage tending to flow from east to west.

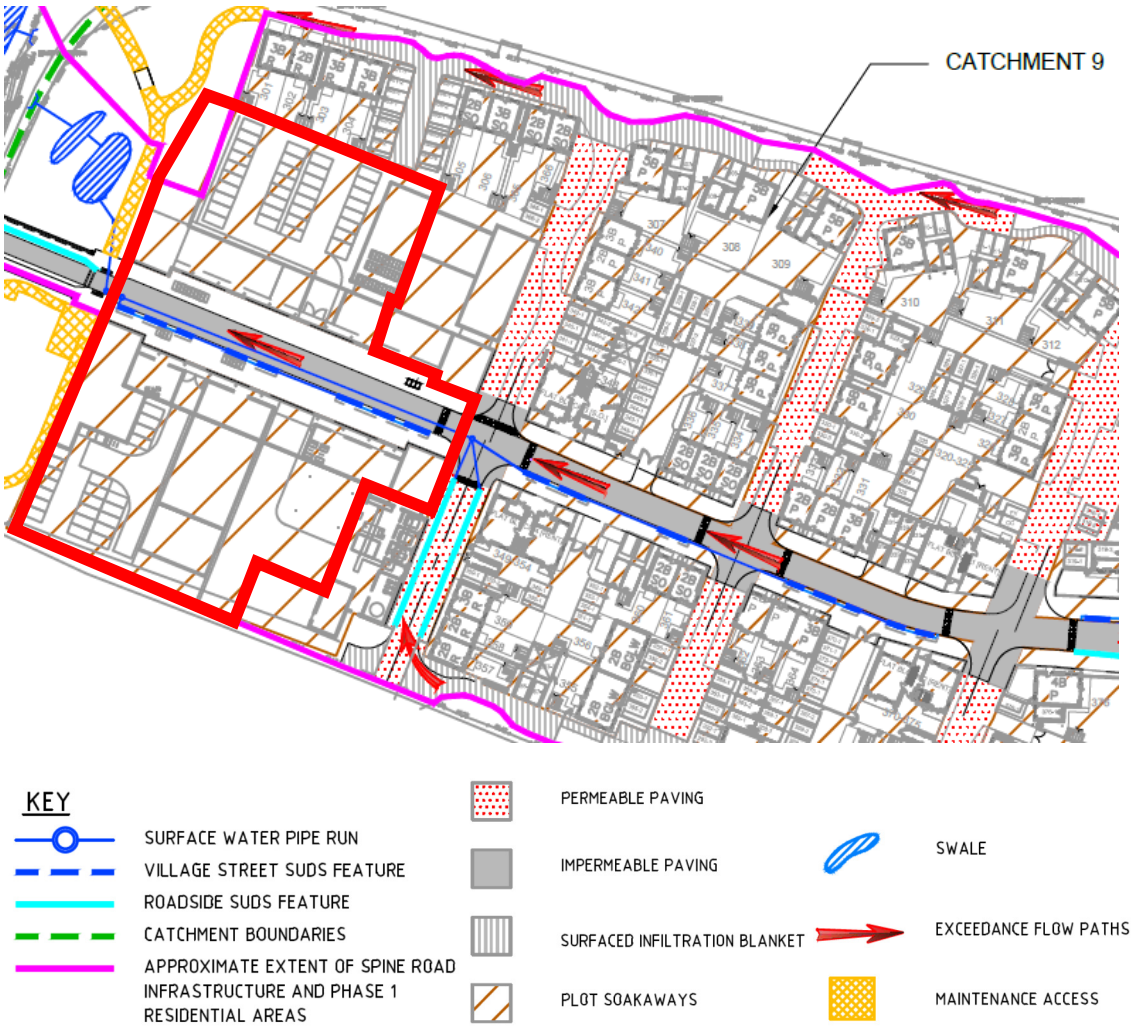

Figure 7-7 2012 Drainage Strategy relevant to application area

The 2012 Drainage Strategy proposed that highway run-off from Catchment 9 would be drained via a mix of permeable paving, roadside SuDS features, village street SuDS, enhanced swales, with overflows via online storage in oversized pipes with flow control outlets.

Run-off from roofs and on plot hardstanding/ car parking was intended to be drained via on plot soakaways, in the form of infiltration blankets. These infiltration blankets will be constructed beneath the hard surfaced areas. Surface water runoff will enter the infiltration blankets either via a permeable surface layer, of via channels/ gullies at the edge of the hard paving, and from downpipes serving the roof areas, which would discharge to the infiltration blanket below. The infiltration blanket comprises a layer of highly voided material such as coarse stone, providing a storage medium for runoff whilst gradually discharging to ground through infiltration.

This strategy was primarily based on discharge via ground infiltration, in accordance with the drainage hierarchy, minimising surface water discharges to nearby watercourses and the risk of flooding due to surface water. Ground conditions are suitable for use of ground infiltration methods, as previously outlined in Section 4.4.

The SuDS systems proposed comprise chains of linked SuDS components which complement one another and combined to form a treatment train to ensure discharges are of appropriate quality.

This strategy was verified, and SuDS elements indicatively sized using MicroDrainage software as part of the latest work undertaken for the Local Centre.

The strategy was developed to ensure no flooding during 1 in 100 year rainfall events (with a variety of durations), including a 30% increase to represent potential climate change impacts, and limit the peak discharge to the watercourse to the agreed 5 l/s/ha (see Section 7.3 below).

7.3 Revised surface water strategy

7.3.1 On-plot drainage

MicroDrainage calculations have been undertaken to verify that the strategy to drain the roof and hardstanding on-plot areas via infiltration blankets remains viable.

It is proposed that the Local Centre roof top areas are constructed as green roofs, with downpipes connecting into the infiltration blankets under the adjacent hardstanding areas. This will provide initial treatment to the rooftop drainage, which generally would be expected to include some sediment and organic matter. No allowance had been made in the calculations of the flow attenuation effect green roofs can offer – this is a conservative approach, which assumes that the green roofs have already been saturated by a preceding rainfall event.

It is proposed that the southern hardstanding areas are surfaced with impermeable materials, with run-off being collected by a network of channels and gullies and then routed into the infiltration blanket underneath. Impermeable surfacing is considered to be a more robust solution in this area to account for the loading from the planned HGV turning area.

Additionally, an impermeable surface served by gullies allows improved prevention of contamination during operation/ maintenance and possible future refurbishment of the foul water pumping station.

As the runoff filters through the infiltration blanket, it is expected this will provide a high level of treatment in terms of suspended solids, fines and dissolved, heavy metals and nutrients.

It is proposed that the northern hardstanding areas are surfaced with permeable materials, to allow surface water to enter directly through to the infiltration blanket below. In terms of water quality, this process provide an additional stage of treatment as the run-off filters through the surfacing and sub-base into the underlying infiltration blanket.

The roof and hardstanding areas to be drained on the northern and southern plots of the Local Centre site have been calculated based on the preliminary building layouts.

The northern plot has a contributing area (including roofs and hardstanding) of 2,793 m^2. This includes the proposed Eco Business Centre, which whilst not included within the Detailed Application for the Local Centre, is planned to drain via this route.

The southern plot has a contributing area (including roofs and hardstanding) of 3,336 m^2. This includes the foul water pumping station and Energy Centre, which whilst already under construction following a separate detailed approval, are planned to drain via this route.

The contributing areas, and the proposed infiltration blanket areas to serve these areas, are illustrated on drawing 7710 in Appendix 3.

To be effective soakaways, the infiltration blankets must be able attenuate the design event within their proposed depth, and must have a half drain time of less than 24 hours.

The MicroDrainage calculations for the southern and northern on-plot infiltration blankets are included in Appendix 3. These include a factor of safety of 10.

The calculations show that the southern infiltration blanket requires an effective depth of 0.603 m to allow attenuation of the 1 in 100 year (+ 30% for climate change) rainfall event, and that the half drain time for this volume is 23 hours and 48 minutes.

Currently a 0.75 m depth blanket is to be constructed in the southern plot as part of the foul water pumping station and energy centre construction, which represents a robust infiltration layer when compared with the above calculations.

It can therefore be concluded that an effective on-plot infiltration blanket can be provided to serve the southern plot of the Local Centre, including the surface water drainage from both the foul water pumping station area and the Energy Centre.

The calculations show that the northern infiltration blanket requires an effective depth of 0.390 m to allow attenuation of the 1 in 100 year (+ 30% for climate change) rainfall event, and that the half drain time for this volume is 15 hours and 31 minutes.

It can therefore be concluded that an effective on-plot infiltration blanket can be provided to serve the northern plot of the Local Centre, including the surface water drainage from the proposed Eco Business Centre.

7.3.2 Road and footpath drainage

During the detailed design of the surrounding residential area, the drainage strategy for the road immediately to the east of the Local Centre site was modified to allow more space for access/ public realm. Roadside SuDS features here have been replaced with combined kerb drainage systems, with flows directed into the oversized pipe system under the spine road. Control of the discharge from this system is via a flow control device, with treatment being provided via an enhanced swale prior to discharge to the watercourse.

Similarly, during detailed design of the Local Centre, the requirement to allow good access to disabled parking bays, and provide a loading layby to serve the retail units, restricts the area available for village street SuDS features along the spine road.

The drainage strategy has therefore been revised to include positive drainage of these areas via road gullies on both the northern and southern road edge, with oversized pipes underneath to provide the necessary storage to attenuate the design event.

It is intended that these pipes discharge via separate flow control devices, and that the outflows from these converge with the existing oversize pipe (1050 mm) which serves the adjacent residential areas. The discharge from this collective drainage system to the enhanced swale, and then the watercourse, is limited to 4 l/s by the flow control device.

A schematic of the road drainage in this area in included on drawing 7711 in Appendix 3.

The use of sub-surface storage (via the oversized pipes) will slow flows, allowing some treatment of suspended solids, fines and dissolved, and heavy metals. Additional treatment of the discharge will be provided via the enhanced swale at the discharge point.

The exact arrangement of gullies or kerb drainage systems will be confirmed during detailed design and through consultation with OCC. However, MicroDrainage calculations have been undertaken to verify that the proposed oversized pipe storage and flow control arrangement

provides the necessary storage to attenuate the 1 in 100 year (+30% for climate change) rainfall event. These calculations are included in Appendix 3.

The calculations show that, in order to sufficiently attenuate the 1 in 100 year (+30% for climate change) rainfall event, a 35 mm length of 300 mm diameter pipe is required along the northern road edge, and that a 73 m length of 1050 mm diameter pipe is required along the southern road edge. Exact arrangements will be confirmed during detailed design.

7.4 Design for exceedance

To accommodate rainfall events in excess of the design events and normal design consideration, which could result in flooding, the existing drainage strategy was developed to provide overland flow paths for flood waters, directing water away from properties via the road network, towards the enhanced swale and watercourse.

This strategy remains the same for the section of road through the Local Centre. Flows exceeding the capacity of the drainage system will primarily be contained within the carriageway. These flows will be routed east to west towards the watercourse, due to road levels falling from east to west.

The proposed levels for both the northern and southern plots of the Local Centre result in exceedance flow paths generally towards the spine road. As above, overland flows here would then be routed towards the watercourse corridor due to the proposed road levels.

Detailed design of the drainage network and hardstanding areas will confirm the likely overland flow routes are in accordance with this strategy.

7.5 Drainage maintenance, management and adoption

The on-plot infiltration blankets, and associated gullies/channels serving the buildings will become the responsibility of a private maintenance company.

The proposed highway drainage, including flow controls and the enhanced swale and any associated pipework and structures will be adopted by OCC.

7.6 Foul water strategy

The 2012 Drainage Strategy confirmed the intention to construct a foul water pumping station on the Exemplar site, connected into the Thames Water sewer network. This strategy included an allowance for the foul water from the Local Centre site.

The discharge into the existing sewer network was agreed with Thames Water in 2011, with a peak discharge restriction of 10 l/s stipulated during dry weather, and a complete restriction of flows should their receiving sewer network be at capacity due to a storm event.

The peak foul water discharge from the entirety of the Exemplar site was estimated as 5.97 l/s. Nine hours' worth of foul water flow storage is required at the pump station to allow the discharge conditions to be met.

Construction of the foul water system has already begun, and will be completed this year. The approved design includes the necessary pump capacity to convey all the Exemplar foul water flows (including those from the Local Centre), and the attenuation volume to meet the discharge flow limit to the existing network.

It can therefore be concluded that the necessary foul water infrastructure will be in place ahead of the development of the Local Centre site.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

- The flood risk for the proposed Local Centre Site has been assessed in accordance with NPPF and accompanying Technical Guidance.
- The Local Centre Site comprises approx. 6.4ha of land, the development proposals for the Site include provision of Nursery, Community Hall, Retail, Store, Offices and commercial areas with associated access, servicing, landscaping and parking.
- The proposed Site is identified in the emerging Cherwell Local Plan 2006 - 2031.
- Hydraulic modelling results from previous FRA (2011) have been used to delineate the flood plain across the Site and ensure that the development will not lead to the increase in flood risk elsewhere. The hydraulic modelling confirms that the area where the Local Centre is proposed is located entirely in low risk fluvial Flood Zone 1 for both predevelopment and post development situations.
- The flood extents to the west of the Site are contained within the 30m wide green corridor buffer zone already incorporated in the wider master plan design.
- An assessment of the potential impacts of climate change has been made by adding 20% to the estimate 1 in 100 Year (1% AEP) flows. The proposed development is predicted to remain flood free during the 1 in 100 Year (1% AEP) plus climate change event.
- The proposed bridge crossing at part of the wider Exemplar development will ensure safe and dry access and egress routes to and from the Site.
- The Site is also considered to be at low risk from tidal, sewers, ground and surface water sources within or upstream of the Site.
- The proposed surface water drainage strategy for the Local Centre has demonstrated that the appropriate drainage design can achieve the current Greenfield run off rates or less whilst maximising the local infiltration and source control where feasible. The drainage features have been designed to accommodate 1% AEP event including a 30% allowance for climate change.
- Treatment of surface water runoff is provided by a mixture of infiltration, storage and the provision of an enhanced swale.
- An allowance for the foul water flows from the Local Centre site has been included in the design of the new foul water pumping station, and rising main connection to the existing sewer network, which is currently being constructed to serve the wider Exemplar site. The necessary foul water infrastructure will therefore be in place ahead of the development.
- Based on this assessment is concluded that the proposed development can be undertaken in a sustainable manner without increasing the flood risk either at the Site or elsewhere.

8.2 Recommendations

- Any significant changes in the development Site layout will be subject to additional flood risk review.
- The recommendations of FRAs undertaken for the separate North West Bicester Exemplar and wider development should also be implemented as part of the overall development proposals, including the need for incorporation of sufficient green corridors to fully contain the flood risk extents and compensation of any small amount of lost flood plain volume due to key road infrastructure.

Appendix 1

Site Plan

Appendix 2

Mapped Flood Extents

Appendix 3

Proposed Updated Drainage Strategy for the Local Centre