Appendix 11.1
Flood Risk Assessment

Land at Haverhill
Suffolk

Flood Risk Assessment

Hallam Land Management Ltd & Mrs Pelly

Brookbanks

Document Control Sheet

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Contents

Appendix

1 Introduction

1.1 Brookbanks Consulting Limited is commissioned by Hallam Land Management (HLM) and the landowner to provide technical advice on delivery of the proposed residential development to the north east of Haverhill, Suffolk.

1.2 The objective of the study is to demonstrate the development proposals are acceptable from a flooding risk and drainage viewpoint.

1.3 This report summarises the findings of the study and specifically addresses the following issues in the context of the current legislative regime:

- Flooding risk
- Surface water drainage
- Foul water drainage

1.4 Plans showing the existing and proposed development are contained within the appendices.

2 Background Information

Location & Details

2.1 The proposed development site covers approximately 168.34ha and lies to the north east of Haverhill urban area nearby Great Wilsey Farm. The site is bounded by the urban edge of Haverhill to the south, the north of the site is bounded by Haverhill Road (A143), with Coupals road to the south and lies within the County of Suffolk.

2.2 The land is currently undeveloped and is not thought to have been historically subject to build development. The site location and boundary is shown indicatively on Figure 2a, below:

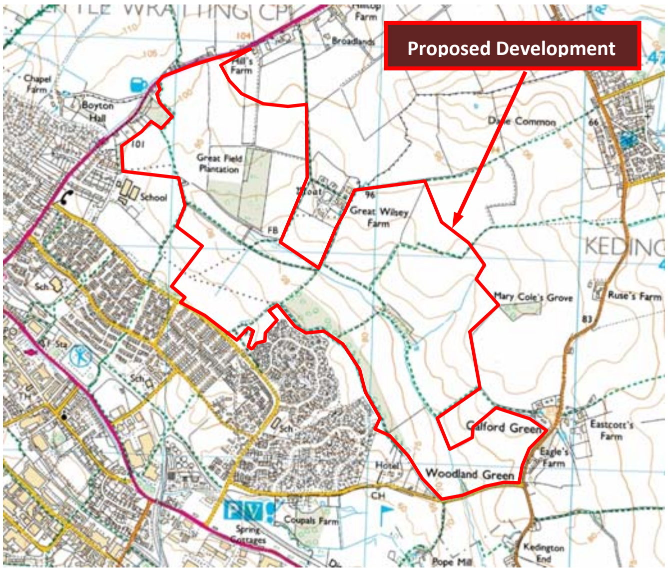


Figure 2a: Site location

Development Criteria

2.3 It is proposed to develop up to 2500 residential units, two schools, employment land, care home and two local centres within the circa 168.34ha site.

Sources of Information

2.4 The following bodies have been consulted while completing the study:

- Anglian Water - Storm & foul water drainage
- Environment Agency - Flood risk and storm drainage

2.5 The following additional information has been available while completing the study:

- Mastermap Data - Ordnance Survey
- Published Geology - British Geological Survey
- Level 1 Strategic Flood Risk Assessment (SFRA) - Rother District Council, August 2008
- Level 2 Strategic Flood Risk Assessment (SFRA) - Rother District Council, June 2008

Topography & Site Survey

2.6 The site generally falls from north and south towards a small valley in which an unknown watercourse runs. Levels range from approximately 100 AOD on the northern boundary and 90m AOD on the southern boundary down to approximately 80m AOD along the watercourse.

2.7 The existing site is green field with very little areas of hard standing and impermeable surfaces. The proposed development is like to have a significant amount of impermeable land.

Ground Conditions

2.8 Reference to the British Geological Survey maps indicates the prevalent superficial deposit of the area to be boulder clay. With some pockets of head (clay, silt sand and gravel) around the watercourse. The boulder clay deposits are unlikely to have sufficient permeability for surface water disposal, but pockets of sands and gravel may have sufficient permeability to allow water infiltration drainage methods to be adopted for part of the site. The geological mapping shows the bedrock to be a chalk formation across the entire site, which is indicated as having high permeability.

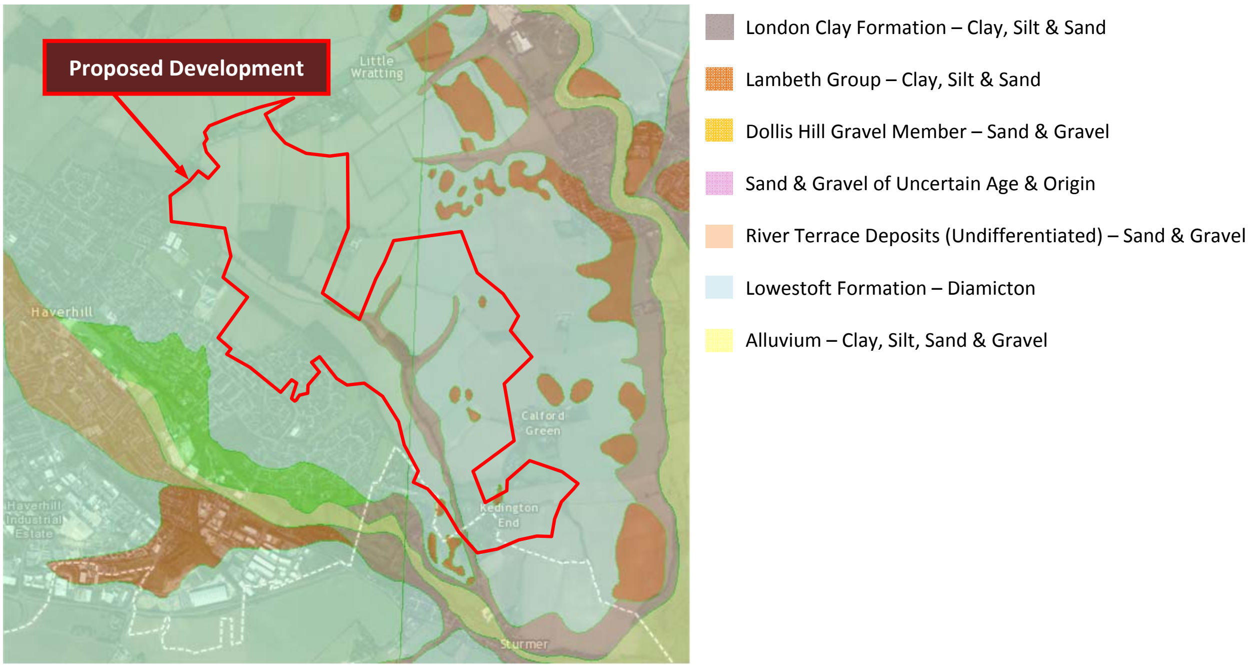


Figure 2b: BGS Published Geology

Watercourse Systems & Drainage

2.9 The unnamed watercourse is a tributary of the River Stour, located approximately 1km to the west of the proposed development site. The FEH v3 dataset CD shows the unknown watercourse to have a catchment of 2.81km^2 at the downstream boundary extending north eastwards from the confluence of the River Stour. In accordance with the FEH, the catchment may be described as *"essentially rural"*.

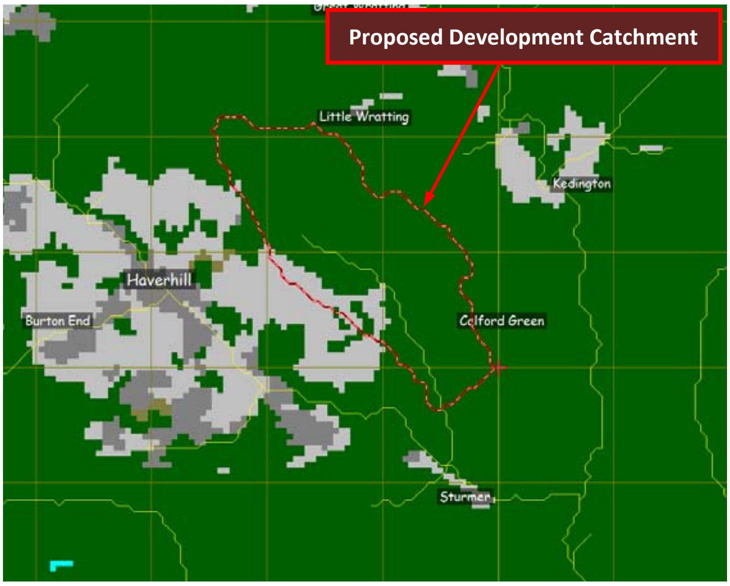


Figure 2c: FEH reported catchment.

2.10 Figure 2d below shows most of the catchment of the unnamed watercourse in relation to the study area and site boundary.

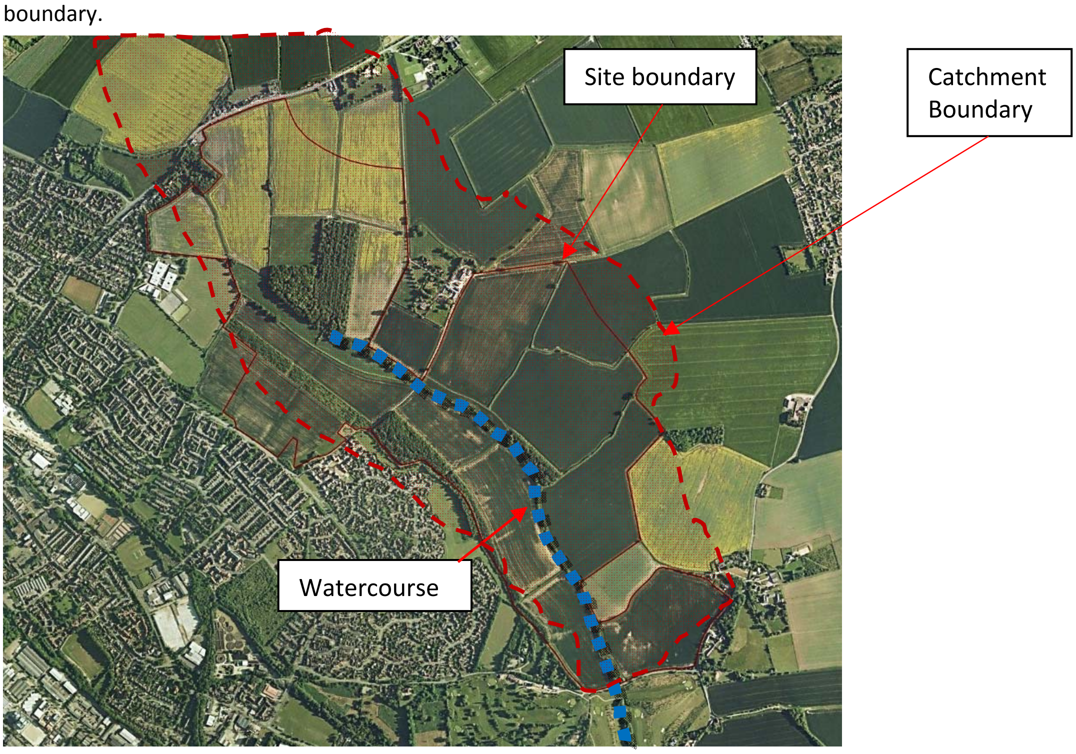


Figure 2d: Unnamed watercourse.

2.11 It is noted that the northern most extents of catchment situated to the north of Haverhill Road lies within land allocated as the North West Growth Area (NWGA).

2.12 Only the built development catchment for Great Wilsey Park has been considered within the attenuation calculations contained within this report.

2.13 It is assumed that the wider catchment under the NWGA control will be attenuated in due course via their own onsite attenuation solution.

3 Flooding Risk

National Planning Context

3.1 Planning Policy Statement 25 (PPS25) was first published in December 2006 and sets out Governmental Policy on Development and Flood Risk. The allocation of development sites and local planning authorities' development control decisions must be considered against a risk based search sequence, as provided by the document.

3.2 The PPS25 document has now been replaced by the National Planning Policy Framework (NPPF) guidance, effective from March 2012. The recommendations contained within the NPPF document are consistent with the guidance previously published as PPS25.

3.3 Allocation and planning of development must be considered against a risk based search sequence, as provided by the NPPF guidance. In terms of fluvial flooding, the guidance categorises flood zones in three principal levels of risk, as follows:

Flood Zone	Annual Probability of Flooding
Zone 1: Low probability	< 0.1 %
Zone 2: Medium probability	0.1 – 1.0 %
Zone 3a / 3b: High probability	> 1.0 %

Figure 3a: NPPF Flood Risk Parameters

3.4 The Guidance states that Planning Authorities should *"apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change."*

3.5 According to the NPPF guidance, residential development at the proposed site, being designated as a "More Vulnerable" classification, should lie outside the envelope of the predicted 1 in 100 year (1%) flood, with preference given to sites lying outside the 1 in 1,000 (0.1%) year event and within Flood Zone 1.

3.6 Sites with the potential to flood during a 1 in 100 (1%) year flood event (Flood Zone 3a) are not normally considered appropriate for proposed residential development unless on application of the "Sequential Test", the site is demonstrated to be the most appropriate for development and satisfactory flood mitigation can be provided. Additionally, proposed residential developments within Flood Zone 3a are required to pass the "Exception Test", the test being that:

- The development is to provide wider sustainability benefits
- The development will be safe, not increase flood risk and where possible reduce flood risk

Regional & Local Policy

3.7 **Strategic Flood Risk Assessment:** To support local planning policy, NPPF guidance recommends that local planning authorities produce a Strategic Flood Risk Assessment (SFRA). The SFRA should be used to help define the Local Plan and associated policies; considering potential development zones in the context of the sequential test defined in the guidance.

3.8 St Edmundsbury Borough Council published its Level 1 Strategic Flood Risk Assessment in August 2009. The document outlines the results of a review of available flood risk related policy and data across the region and sets out recommendations and guidance in terms of flood risk and drainage policy that generally underpin national guidance.

3.9 **Development Flood Risk Assessment:** This document forms a Flood Risk Assessment (FRA), to accord with current guidance and addresses national, regional and local policy requirements in demonstrating that the proposed development lies within the acceptable flood risk parameters.

Flood Mechanisms

3.10 Having completed a site hydrological desk study and walk over inspection, the possible flooding mechanisms at the site are identified and presented in Figure 3b:

Mechanisms	Potential?	Comment
Fluvial	N	A small watercourse runs generally from west to east through the site, but this is not thought to pose a risk of flooding.
Coastal & tidal	N	No tidal watercourses lie within an influencing distance of the proposed development.
Overland flow	Y	The risk of overland flow relates primarily to the developed land to the south of the site and does not lie within an influencing distance of the proposed development.
Ground water	Y	Geology underlying the site is of a potentially low permeability. No groundwater flooding was identified within the SFRA and therefore the risk is considered low.
Sewers	N	Investigations with Anglian Water have revealed no evidence of present or historic sewer flooding
Reservoirs, Canals etc	N	There are no artificial sources in close proximity to the site and therefore no associated risks from this form of flooding

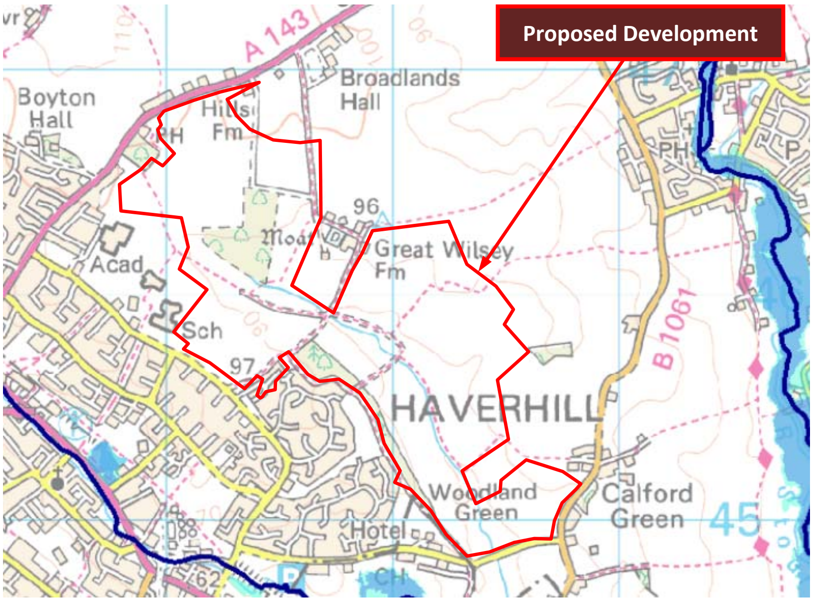
Figure 3b: Flooding mechanisms

3.11 Where potential risks are identified above in Figure 3b, more detailed assessments have been completed and are outlined below. Further background is also outlined below.

Fluvial Flooding: C4

3.12 The Environment Agency's (EA) National Generalised Modelling (NGM) Flood Zones Plan indicates predicted flood envelopes of Main Rivers across the UK. In many circumstances, the NGM is based on basic catchment characteristic data and modelling techniques. Where appropriate, more accurate Section 105 / SFRM models are produced using more robust analysis techniques.

3.13 The mapping shows that the site lies within Flood Zone 1; being an area of Low Probability of flooding, outside both the 1 in 100 (1% AEP) and 1 in 1,000 (0.1% AEP) year flood events. The EA Flood Zone plan reprinted as Figure 3c below, shows the unknown watercourse having no risk of fluvial flooding.



Flooding from rivers without defences – 1 in 100 year (1%) event (Zone 3)

Extent of extreme flood – 1 in 1,000 year (0.1%) event (Zone 2)

Flood defences

Areas benefiting from flood defences

Figure 3c: EA Flood Zone Plan showing 1 in 100 & 1 in 1,000 year floodplains

3.14 In addition to this, in order to provide a robust assessment of the likely flood risk implications of the ordinary watercourse tributary of the River Stour, a 1D computational flood model has been developed using ISUS software to simulate flows along the proposed channel

3.15 ISIS is an actively developed windows based product that is approved by the Environment Agency for watercourse modelling purposes.

3.16 The main inputs required by the model are flow hydrology, downstream control, channel roughness and geometric data as series of cross sections to define the layout of the watercourse and structures. The following paragraphs outline development of the model and the outputs.

3.17 **Hydrology:** Hydrology for the assessment has been established using the FEH V3 Dataset and ReFH methodology for hydrograph generation.

3.18 Catchment Descriptors from the FEH V3 CD were analysed, each value was reviewed individually and, where necessary, modified in accordance with FEH handbook guidelines. The catchment descriptors and associated adjustments are contained in the Appendix. Boxes highlighted yellow show the characteristics that were altered as necessary to reflect the changes to the catchment.

3.19 Hydrology for the catchment was then generated using the Flood Estimation Handbook (FEH), Supplementary Report No.1; being the Revitalised FSR / FEH Rainfall Run-off Method and employing the ReFH model to generate flood flow hydrographs employing the modified catchment descriptors. The ReFH assessments are contained in the Appendix. This initial work focused on a design criteria of a 1 in 100 year + Climate Change event storm.

3.20 **Geometry:** Geometry of the existing channel has been taken from the detailed topographical survey and photographic records. Channel cross sections were derived along the reach of the existing channel within the site boundary to accurately define the geometry at all stages. The extent of the model is shown below in Figure 3d below

Figure 3d: Model extents

3.21 **Channel Roughness:** Given the proposed maintained nature of the channel, a Manning's 'n' roughness value of 0.035 has been taken for the existing banks and overbanks.

3.22 **Discussion of Results:** The assessments show that with climate change taken into account, there is no flooding of the watercourse and no further modelling will be done at this stage.

3.23 A summary of the peak water levels for the 1 in 100 year event + climate change is provided in the Appendix.

Hydraulic Modelling

Fluvial Risk Summary

3.24 Reference to information contained in the SFRA, the EA Flood Zone mapping and discussions with EA, SoA DC and WCC do not identify any significant flooding problems within the boundary of the site.

3.25 As the proposed development lies a significant distance from the main sources of potential fluvial flood risk and a robust SFRA has been published supporting the assertion that the site lies within Fluvial Flood Zone 1, no further flood risk hydrological modelling will be completed in support of the FRA at this outline stage.

3.26 Due to the strategic nature of the site there is potential for the proposed development to provide significant benefits to the wider area in terms of fluvial flood risk by implementing a drainage strategy which reduces rates of run-off to the surrounding areas.

Coastal Flooding C5

3.27 The site lies a significant distance from the nearest tidal watercourse and the coast. As such there is no risk of tidal or coastal flooding at this location.

Overland Flow: C6

3.28 Overland flow mechanisms result from the inability of unpaved ground to infiltrate rainfall or due to inadequacies of drainage systems in paved areas to accommodate flow directed to gullies, drainage downpipes or similar. In minor cases, local ponding may occur. In more extreme events, flows accumulate and may be conveyed across land following the topography.

3.29 The Environment Agency has recently produced a series of surface water flood maps for many parts of the UK. The plan containing the proposed site is reprinted as Figure 3d below and shows that the majority of the site has a *low risk* of flooding from surface water:

Figure 3d: Environment Agency Surface Water Flood Mapping

However the EA mapping identifies small areas within the site boundary with a *low – medium risk* of surface water flooding. These areas primarily form around lower lying ground, along the unknown watercourse running through the middle of the site.

3.35 In 2010 the Flood and Water Management Act defined 'surface runoff' as:

"Surface runoff" means rainwater (including snow and other precipitation) which—
(a) Is on the surface of the ground (whether or not it is moving), and
(b) Has not entered a watercourse, drainage system or public sewer."

3.36 Generally, the type of flooding shown by the Flood Map for Surface Water (FMfSW) produced by the Environment Agency, fits with the definition in the Act and shows the flooding that takes place from the 'surface runoff' generated by rainwater.

3.37 Two rainfall events, one with a 1 in 30 and the other with a 1 in 100 chance of occurring in any year, are modelled and mapped. For each rainfall probability, the mapping provides two layers of information which can be used individually to indicate:

- Surface Water Flooding' (flooding greater than 0.1m deep);
- Deeper Surface Water Flooding' (flooding greater than 0.3m deep).

3.30 The 0.3m threshold is chosen as it represents a typical value for the onset of significant property damages when property flooding may start (above doorstep level) and because it is at around this depth that moving through floodwater (driving or walking) may become more difficult; both of which may lead users to consider the need to close roads or evacuate areas

3.31 Recognising the risk of overland flow mechanisms, published guidance in the form of Sewers for Adoption 7th Edition and the Environment Agency document *Improving the Flood Performance of New Buildings: Flood Resilient Construction, et al* advocate the design of developments that implement infrastructure routes through the development that will safely convey flood waters resulting from sewer flooding or overland flows away from buildings and along defined corridors. Further to protect the proposed development, current good practice measures defined by guidance will be incorporated.

3.32 Given the baseline site characteristics and further mitigating measures to be implemented residual flood risk from an overland flow mechanism is considered of a low probability.

Ground Water: C7

3.33 Ground water related flooding is fortunately quite rare, although where flooding is present, persistent issues can arise that are problematic to resolve. Such mechanisms often develop due to construction activities that may have an unforeseen effect on the local geology or hydrogeology.

3.34 Positive drainage systems incorporated into the proposed development will further reduce the risk as a result of permeable pipe bedding materials and filter drains incorporated within elements of the built development.

3.35 Given the baseline site characteristics and further mitigating measures to be implemented, residual flood risk from a ground water mechanism is considered of a low probability.

Sewerage Systems: C8

3.36 Investigations with Anglian Water provide no evidence of present or historic sewer flooding at the site.

3.37 Positive drainage measures incorporated on site, coupled with sustainable drainage systems (SuDS) will ensure that no increase in surface water will result from the site. Flood risk associated with sewer flooding is therefore considered to be a low probability.

Artificial Water Bodies - Reservoirs & Canals: C9

3.38 Non-natural or artificial sources of flooding can include reservoirs, canals and lakes where water is retained above the natural ground level and flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure. There are no artificial sources in close proximity to the site and therefore no associated risks from this form of flooding.

Summary

3.39 In terms of fluvial and tidal flood risk, the proposed development can be seen to lie within Flood Zone 1, and hence has a low probability of flooding from these mechanisms.

3.40 Assessment of other potential flooding mechanisms shows the land to have a low probability of flooding from overland flow, ground water and sewer flooding.

3.41 Accordingly, the proposed development land is in a preferable location for residential development when appraised in accordance with the NPPF Sequential Test and local policy. The site should be considered preferable to other potential developments that may lie wholly within Flood Zone 2 or Flood Zone 3.

Objectives

3.42 The key development objectives that are recommended in relation to flooding are:

- Compliance with SFA 7th Edition and EA guidance in relation to flood routing through the proposed development in the event of sewer blockages.
- Implementation of a 150mm slab freeboard above the level of the proposed flood routes, to protect buildings in the event of a localised blockage.

4 Storm Drainage

Background

4.1 Anglian Water sewerage network records indicate that there are no public sewers or other assets owned by Anglian Water within the boundary or overlapping the development site.

4.2 The site is presently not serviced by a positive storm water drainage network. It is believed that storm water currently discharges to the stream on site.

Drainage Options

4.3 The following paragraphs in this section outline the proposed drainage strategy to meet national and local design requirements and guidance.

4.4 Current guidance[1] requires that new developments implement means of storm water control, known as SuDS (Sustainable Drainage Systems), to maintain flow rates discharged to the surface water receptor at the pre-development 'baseline conditions' and improve the quality of water discharged from the land.

4.5 It is proposed to implement a SuDS scheme consistent with local and national policy at the proposed development.

The SFRA accords with national guidance on the provision of storm water drainage, encouraging the use of sustainable means of drainage at new developments.

4.6 When appraising suitable storm water discharge options for a development site, Part H of the Building Regulations 2002 (and associated guidance) provides the following search sequence for identification of the most appropriate drainage methodology.

"Rainwater from a system provided pursuant to sub-paragraphs (1) or (2) shall discharge to one of the following, listed in order of priority -

(a) an adequate soakaway or some other adequate infiltration system; or where that is not reasonably practicable,

(b) a watercourse; or where that is not reasonably practicable,

(c) a sewer. "

4.7 Dealing with the search order in sequence:

(a) Source control systems treat water close to the point of collection, in features such as soakaways, porous pavements, infiltration trenches and basins. The use of some can have the benefit of discharging surface water back to ground rather than just temporarily attenuating peak flows before discharging it to a receiving watercourse or sewer.

As source control measures generally rely upon the infiltration of surface water to ground, it is a prerequisite that the ground conditions are appropriate for such. Site ground investigations carried out by GEG (whose report is included in the appendices) indicate that infiltration is not appropriate for this site, and therefore

[1] NPPF, CIRIA C522, C609, C697 et al.

source control measures will be primarily restricted to detention and conveyance systems placed close to source by way of measures such as lined permeable pavements and conveyance strips.

(b) Next in the search sequence, defined by Part H, is discharge to a watercourse or suitable receiving water body. Where coupled with appropriate upstream attenuation measures, this means of discharge can provide a sustainable drainage scheme that ensures that peak discharges and flood risk in the receiving water body are not increased.

The ditches along the sites perimeter are considered an appropriate receptor for storm water discharge and as such, have the potential to receive flows from the proposed development once restricted to the pre-existing 'greenfield' rates of run-off.

(c) Last in the search sequence is discharge to a sewer. In the context of SuDS this is the least preferable scheme as it relies on 'engineered' methods to convey large volumes of water from development areas, has a higher likelihood of flooding due to blockage and provides less intrinsic treatment to the water.

4.8 The search sequence outlined above indicates that the existing Unknown watercourse running along the middle of the site is the most appropriate receptor of storm water from the proposed development, having the potential to employ source control measures and detention features to control peak discharges to no greater than the baseline conditions. The stream enters the application area through the southern boundary.

4.9 Proposals have been developed to inform the strategic drainage network across the development. It is proposed that the drainage system for the site utilises a multi SuDS system including detention features and where appropriate, source control in the form of porous paving as the primary storm water management scheme.

4.10 Accordingly, a plan showing the Illustrative Surface Water Drainage Strategy for the site is contained within the Appendix as drawing 10319/DR/04.

4.11 Coupled with the storm water control benefits, the use of SuDS can also provide betterment on water quality. National guidance in the form of CIRIA 609 outlines that by implementing SuDS, storm water from the site can be polished to an improved standard thus ensuring the development proposals have no adverse effects on the wider hydrology.

4.12 The following paragraphs outline the potential SuDS features appropriate for use on site and their place within a multi-tiered system.

Primary Drainage Systems (source control)

4.13 At the head of the drainage network, across the site, source control measures will be implemented to reduce the amount of run-off being conveyed directly to piped drainage systems. Site specific infiltration testing confirms that 'it is considered that the strata beneath the site (within 4.00m of ground level) are generally unsuitable for soakaway drainage'. Therefore, source control will be limited to detention type systems, albeit these will be unlined and therefore provide for an element of infiltration.

4.14 Through work on other similar strategically sized projects, BCL has shown that peak discharges of circa 15% in residential areas can readily be achieved without unacceptable reductions in net developable land or prohibitive financial implications.

4.15 Through consultations at outline planning stage, it has been agreed that the nature of source control measures to be implemented will need to remain flexible, providing a 'toolkit' of options to reach an agreed target for peak discharge reduction and water treatment. The following paragraphs describe a number of options available.

Filter Strips

4.16 Filter strips have been used in the drainage of highways for many years. The absence of traditional pipe work in such a system frees the drainage design to employ shallow gradients on both channels and drains, which in turn also act as a means of passive treatment to improve water quality.

4.17 Highways within the development could potentially incorporate filter drains. Alternatively, filter strips can be used to collect flows from areas such as a group of houses. Figure 4b shows an example of a filter strip in a road corridor.

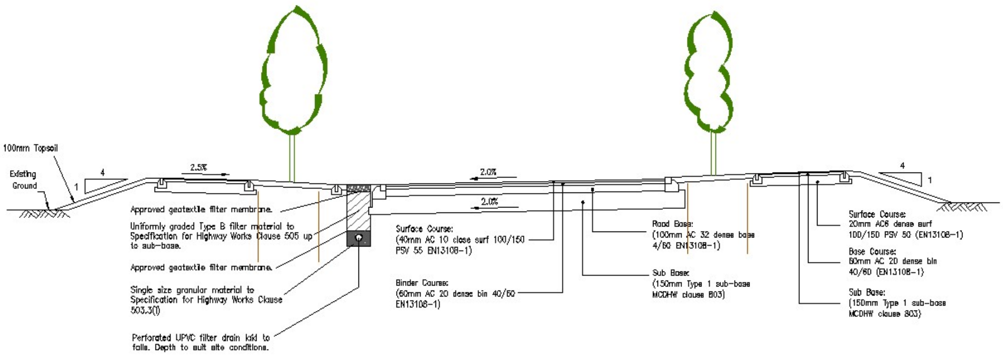


Figure 4b: Filter Strip along highway

Ditches

4.18 Ditches may be used along highways and in common areas to infiltrate, attenuate and convey flows from hard surfaces across the development before being discharged in to the secondary system. Linear features, such as ditches and filter strips provide an efficient means of improving water quality.

Swales

4.19 While swales implemented at development parcel level can be very land hungry, costly to maintain and provide difficulties with frontage access, the opportunity potentially exists to implement swales on the west to east road corridors through the development. Green space being incorporated along the highways could be designed to allow 'over the edge' flows to be directed into the swale for infiltration, attenuation and conveyance. A typical highway swale is show in Figure 4c below:

Figure 4c: Swale along road corridor

Attenuation Drainage Systems

4.20 Attenuation drainage systems collect partially treated excess water from the primary source control systems at a local level, thereafter providing both flow and water quality attenuation and flow conveyance through the site towards the main outfall.

4.21 It is anticipated that basins will be utilised and designed to primarily be dry with permanently wet low flow channels to convey run-off in periods of low rainfall, which will in turn provide the passive treatment benefits offered within the remainder of the surface water management network.

4.22 The primary aims of the basin will therefore be:

- Final flow and water quality conditioning
- Provide landscaping, amenity and ecological benefits

Figure 4d: Storage Basin

Preliminary Drainage Proposals

4.23 Preliminary assessment of the requirements for storm drainage have been based on the following criteria:

Application Site Area:	168.34 ha
Developed Area:	81.3 ha
Landscaped Area:	86.1 ha
Impermeability – Residential:	0.55
Impermeability – Commercial:	0.85
Impermeability – School:	0.45
Sewer design return period (2)	1 in 1 years
Sewer flood protection (2)	1 in 30 years
Fluvial / Development flood protection (1)	1 in 100 years
M5-60(3)	20.60 mm

Ratio r (2)	0.436
Minimum cover to sewers (1)	1.2 m
Minimum velocity (1)	1.0 m/sec
Pipe ks value (1)	0.6 mm
Allowance for climate change (4)	30%

4.24 National policy[1] requires that new developments control the peak discharge of storm water from a site to the baseline, undeveloped, site conditions. Over very large development areas, the baseline rate of run-off is normally estimated using the FEH methodologies. However, Paragraph 3.1.2 of the FEH guidance states:

"The frequency estimation procedures can be used on any catchment, gauged or ungauged, that drains an area of at least 0.5km². The flood estimation procedures can be applied on smaller catchments only where the catchment is gauged and offers simple flood peak or flood event data"

4.25 On undeveloped and ungauged catchments of less than 0.5km² in area, it is correct to complete baseline site discharge assessments using the nationally accepted IoH124 methodology for small rural catchments. Local policy is to employ IoH124 in a manner set out by CIRIA C697. This methodology requires that, for catchments of less than 50ha, the IoH assessment is completed for a 50ha area with the results linearly interpolated to determine the flow rate value based on the ratio of the development to 50ha.

4.26 The overall application boundary is below the 50ha threshold, thus the IoH124 methodology is therefore the most appropriate for appraising the baseline run-off from the development.

4.27 The baseline IoH run-off rates are shown on Figure 4e below.

Event	IoH 124 (50ha)	IoH 124 Scaled to 1ha
1 in 1 year (l/s)	123.6	2.47
Qbar (l/s)	142	2.84
1 in 100 year (l/s)	505.7	10.11

Figure 4e: IoH124 baseline discharge rates

4.28 In order to determine the permitted rates of run-off from the development, the future impermeable catchment areas must be derived. This has been based on a BCL measured ratio from previous projects. Calculations below show these ratios and areas and how these correlate to the rates of discharge.

4.29 In accordance with the SFRA document and NPPF guidance, it is proposed to implement a drainage strategy that provides attenuation of peak storm water discharges from the developed land to the baseline rate determined using IoH124 methodology.

4.30 However, the development proposals have the potential to provide betterment to the surrounding area by reducing the peak run-off from the proposed development. Coupled with the mitigation of increased volume of run-off associated with built development, by reducing peak flows in the 1 in 100 year event to the mean annual flow (Qbar) it is possible for the development to achieve circa 72% betterment in stormwater run-off. The calculations for this are shown in Figure 4f below:

[2] Sewers for Adoption 7th Edition
[3] Wallingford Report
[4] NPPF requirements for residential development

Catchment	Land Use	Developable Area (ha)	Impermeable Area (ha)	Existing 100 Year Run-off (l/s)	Proposed 100 Year Run-off (l/s)	Volume of Storage m^3	Area of Basin m^2
A	Residential	10.25	5.64	57.0	16.0		
	Commercial	0.70	0.60	6.0	1.7		
	School	2.20	0.99	10.0	2.8		
	Total	13.15	7.22	73.0	20.5	5275	5630
B	Residential	7.9	4.35	43.9	12.3	3160	3240
C	Residential	11.80	6.49	65.6	18.4	4720	4280
D	Residential	2.70	1.49	15.0	4.2		
	School	1.50	0.68	6.8	1.9		
	Total	4.20	2.16	21.8	6.1	1600	1730
E	Residential	4.30	2.37	23.9	6.7	1720	2080
F	Residential	4.00	2.20	22.3	6.2	1600	1770
H	Residential	10.20	5.61	56.7	15.9		
	Commercial	0.60	0.51	5.2	1.4		
	Total	10.80	6.12	61.9	17.4	4450	4300
I	Residential	14.70	8.09	81.8	23.0	5900	5550
J	Residential	10.40	5.72	57.9	16.2	4160	3900
Totals		**81.25**	**44.71**	**452.2**	**127.0**	**32585**	**32480**

Figure 4f: Run-off calculation

4.31 Using these methods, development at the site will comply with the requirements set out in paragraph 9 of the Technical Guide to the National Planning Policy Framework (NPPF), with the discharge of surface water from the proposed developments not exceeding that of the existing greenfield sites, thus ensuring that there is no material increase in the flood risk to surrounding areas.

4.32 The figures above show an estimated 452 l/s would be generated from the development if no flow attenuation were provided. This is reduced to 127 l/s following attenuation and Source Control.

4.33 A preliminary masterplan for the proposed development is available in Appendix TBC.

4.34 Assessments have thereafter been completed to determine the characteristics of proposed SuDS features to be situated within the development. Best practice methods have been employed by performing detention routing calculations for the 1 in 100 year inlet and outlet return periods using the WinDES Source Control module. The summary calculations are contained in the Appendix.

Catchment A

4.35 Calculations demonstrate that storm water detention storage extending to maximum 5275m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 20.5l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a significant reduction on peak Greenfield rates. Figure 4g, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	Proposed 1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
13.15	7.22	20.5	5275	Detention Basin

Figure 4g: Summary run-off & detention assessment output

Catchment B

4.36 Calculations demonstrate that storm water detention storage extending to maximum 3160m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 12.3 l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a significant reduction on peak Greenfield rates. Figure 4i, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	Proposed 1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
7.9	4.35	12.3	3160	Detention Basin

Figure 4i: Summary run-off & detention assessment output.

Catchment C

4.37 Calculations demonstrate that storm water detention storage extending to maximum 4720m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 18.4 l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a significant reduction on peak greenfield rates. Figure 4j, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

4.38

Catchment Area (ha)	Impermeable Area (ha)	Proposed 1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
11.80	6.49	18.4	4720	Detention Basin

Figure 4j: Summary run-off & detention assessment output

Catchment D

4.39 Calculations demonstrate that storm water detention storage extending to maximum 1600m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 4.2 l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a significant reduction on peak Greenfield rates. Figure 4k, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	Proposed 1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
4.20	2.16	6.1	1600	Detention Basin

Figure 4k: Summary run-off & detention assessment output.

Catchment E

4.40 Calculations demonstrate that storm water detention storage extending to maximum 1720m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 6.7l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a significant reduction on peak greenfield rates. Figure 4l, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	Proposed 1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
4.30	2.37	6.7	1720	Detention Basin

Figure 4l: Summary run-off & detention assessment output.

Catchment F

4.41 Calculations demonstrate that storm water detention storage extending to maximum 1600m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 6.2 l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a significant reduction on peak Greenfield rates. Figure 4m, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	Proposed 1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
4.00	2.20	6.2	1600	Detention Basin

Figure 4m: Summary run-off & detention assessment output.

Catchment H

4.42 Calculations demonstrate that storm water detention storage extending to maximum 4450m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 17.4 l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a significant reduction on peak greenfield rates. Figure 4n, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	Proposed 1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
10.80	6.12	17.4	4450	Detention Basin

Figure 4n: Summary run-off & detention assessment output.

Catchment I

4.43 Calculations demonstrate that storm water detention storage extending to maximum 5900m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 23.0 l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a significant reduction on peak Greenfield rates. Figure 4o, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	Proposed 1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
14.70	8.09	23.0	5900	Detention Basin

Figure 4o: Summary run-off & detention assessment output.

Catchment J

4.44 Calculations demonstrate that storm water detention storage extending to maximum 4160m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 16.2 l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing a significant reduction on peak greenfield rates. Figure 4p, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
10.40	5.72	16.2	4160	Detention Basin

Figure 4p: Summary run-off & detention assessment output.

4.45 In accordance with legislative requirements, the detention proposals have been assessed for the potential effects of climate change. The 1 in 100 year (1% AEP) return events have been modelled for 30% climate change (including peak rainfall intensity). Calculations for the climate change scenarios are contained within the Appendix. Climate change assessments show the detention feature to perform adequately by retaining the additional flows within the system without overflow.

4.46 A schematic layout for the drainage system has been developed that shows the strategic conveyance and detention features close to the existing water bodies, this can be found in the Appendix. Open channels are proposed where appropriate to act as conveyance systems and to enhance the SuDS management train. The system has been designed so that it remains operational in times of flood.

4.47 The basins, being an above ground naturally landscaped feature, will be designed to enhance the biodiversity and landscape character of the site, while also acting as functional features to control storm discharges from the site and improve water quality. The basin will cover an area on site of approximately 4.2ha.

4.48 The storm water management system will provide features that are designed to provide extended detention of storm water collected from within the development. This approach will maximise the passive treatment characteristics of the system and improve water quality discharged to the wider river catchment. Source control by way of permeable pavements may be employed, where appropriate, in high risk parking areas that provide for the efficient removal of silts and hydrocarbons ahead of discharge to the proposed network.

4.49 Furthermore, based on FRA work undertaken to support previous applications, it is recognised and accepted that in addition to the developments strategic attenuation basins, the implementation of source control measures can achieve a minimum 25% betterment in peak run-off from each development parcel, thus should this be a viable option, a further betterment may be achieved.

4.50 The proposed strategic drainage masterplan is shown illustratively on drawing 10173/DR/04 contained in the Appendix.

Water Quality

4.51 Impermeable surfaces collect pollutants from a wide variety of sources including cleaning activities, wear from car tyres, vehicle oil and exhaust leaks and general atmospheric deposition (source: CIRIA C609). The implementation of SuDS in development drainage provides a significant benefit in removal of pollutant from development run-off.

4.52 In most cases, contaminants become attached to sediment particles either before entering the water body or upon entry. CIRIA 609 reports that up to 90% of certain contaminants, usually trace elements, are transported in this way leaving a dissolved concentration of circa 10%.

4.53 Many SuDS systems rely on the infiltration of water through the ground layer into permeable sub soils or through sedimentation in low flow storage basins. This settling and filtering of contaminated run off through a fine grained matrix separates the suspended contaminated sediment from the body of water subsequently causing the water to leave the SuDS device in a more polished form than how it entered; porous paving is a prime example of this.

4.54 Furthermore, by implementation of SuDS feature, it is possible to optimize overall pollutant removal as water will undergo this process of filtering before being discharged to an appropriate receptor. The overall percentage of removal can be calculated individually for each differing SuDS technique, this is shown by the formula below:

Overall pollutant removal = (TPLxC1) + (RPLxC2) + (RPLxC3) +.....for each other control in series

Where: TPL – Total Pollutant Load
RPL – Remaining Pollutant Load (after previous treatment(s))
C(x) – Suds Control removal efficiency

Figure 4q: Pollutant removal formula as set out in CIRIA C609

4.55 At present, the site and surrounding area does not benefit from any additional measures of stormwater treatment, except for the existing drainage ditches around the site boundary.

4.56 Due to the need to provide wider sustainability benefits and view the development at a strategic level, SuDS will be implemented to treat run off from the development so as to have a positive impact on the surrounding natural environment.

Implementation Proposals

4.57 The conceptual drainage proposals have been developed in a manner that will allow the site wide system to be designed to encourage passive treatment of discharged flows and to improve the water quality by removing the low level silts, oils and metal associated with urban run-off. Final design will provide for appropriate geometry and planting to maximise this benefit. The detention features will provide open channel outfalls to the ordinary watercourse receptors.

4.58 The storm water management features will be constructed and operational prior to the first occupation of dwellings across the site.

4.59 The storm water management features to be implemented will be designed to enhance the biodiversity and landscape character of the site, while also providing amenity space and acting as a functional feature to control storm discharges from the site and improve water quality.

4.60 It has previously been the case that the functionality of the storm water management system would be ensured by ongoing maintenance, completed by the Local Authority, Drainage Authority, or a private maintenance company as appropriate.

4.61 It was usual for a maintenance regime to be implemented:

Frequency	Operation
Post major storm events	Inspection and removal of debris.
Every two months	Grass mowing (growing season) & litter removal.
Annual	Weeding & vegetation maintenance. Minor swale clearance. Sweeping of permeable pavements.
2 years	Tree pruning.
5-10 years	Desilting of channels. Remove silt around inlet and outlet structures.
15-20 years	Major vegetation maintenance and watercourse channel works.

Figure 4r: Framework maintenance of detention / retention system

4.62 The Floods and Water Management Act gained royal assent in April 2010. This confers the responsibility to adopt and maintain the SuDS systems to the Local Authority by requiring SuDS Approving Bodies (SAB's) to be set up within each council.

4.63 The SAB will have a duty to adopt the drainage systems and in accordance with Schedule 3; Para 22 of the Floods and Water Management Act:

"22 (1) Where an approving body adopts a drainage system it becomes responsible for maintaining the system.
(2) In maintaining the system the adopting body must comply with national standards for sustainable drainage."

4.64 The SAB will therefore be responsible for developing their framework management plan for maintenance and operation procedures; adjusting the nature of the processes and timing as necessary to ensure the successful operation of the drainage systems.

4.65 The conceptual drainage masterplan proposals outlined in this report will be used for final drainage design and detailing. The storm water management system will be constructed and operational in full prior to occupation of the relevant phase of development.

Summary

4.66 A strategy for storm drainage at the site has been developed to meet both national and local policy. The above options outline the viability of the site to employ means of drainage to comply with NPPF guidance, together with the SFRA and other national and local guidance.

4.67 The development drainage system will manage storm water by way of a SuDS management train and ensure peak discharges from the developed land are reduced to circa 61% below the appraised baseline rates. The system will also provide improvements to the quality of water discharged from the development.

Objectives

4.68 The key objectives for the site drainage will be:

- Implementation of a sustainable drainage scheme in accordance with current national and local policy together with principles of good practice design.
- Control of peak discharges from the site to a rate below the baseline conditions, during all storm events.
- Development of storm water management proposals that improve water quality and biodiversity of the site.
- Implementation of the storm water management system prior to first occupation of dwellings.

5 Foul Drainage

Background

5.1 To understand the baseline provision for foul drainage in the area, a copy of the Anglian Water sewerage network records has been obtained. No public sewers run through the site.

Design Criteria / Network Requirements

5.2 Peak design discharges have been calculated based on the current development criteria as described in Section 2 of this report and for the following:

Domestic peak = 4,000 litres / dwelling / day (peak) (5)

5.3 Assessed in accordance with SFA 7th Edition requirements, the development will have a design peak discharge of approximately 116 l/s.

Network Requirements / Options

5.4 Discussions with Anglian Water have identified that a direct connection to the public foul sewerage system adjacent to the site is likely to have a detrimental effect on the existing sewerage network.

5.5 Anglian Water have confirmed a solution by providing a new and direct connection to the Haverhill Water Recycling Centre (WRC). With this means of connection there is no requirement for off-site mitigation.

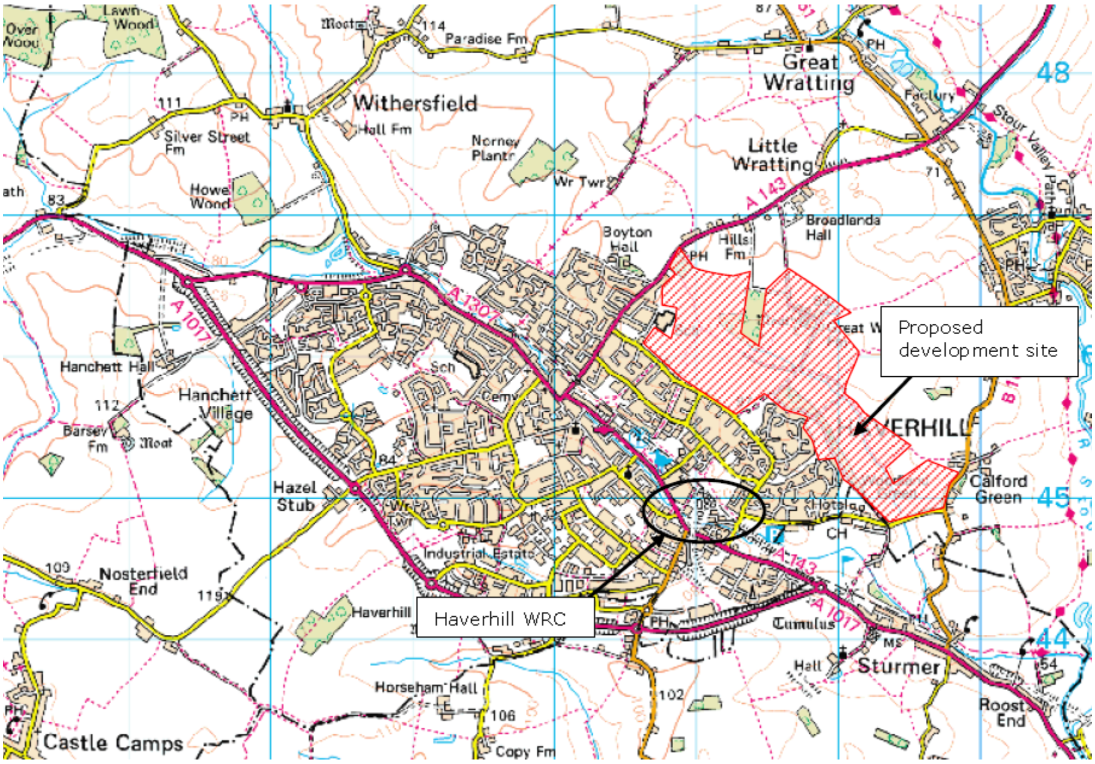


Figure 5a: Haverhill Water Recycling Centre and development location

5.6 Conveyance of flows from the development site to the connection point is considered to be via a pumped arrangement. The flow assumptions are set out in Appendix 1.

5.7 Water companies have a statutory obligation through the Water Industry Act 1991, 2003 *et al*, to provide capital investment in strategic treatment infrastructure to meet development growth. This investment planning is managed and regulated by OFWAT through the Asset Management Plan (AMP) process. The five yearly cyclical process requires that water companies allocate finances to a range of strategic projects to meet their statutory obligations.

5.8 Where development programming requirements necessitate the reinforcement of facilities ahead of allocation in an AMP period, mechanisms are available to ensure the infrastructure can be delivered in a timely fashion, to the meet the development programme.

Implementation Proposals

5.9 Due to the topography of the site, a pumping station will be required to pump the flows towards the Haverhill WRC. This is indicatively identified at a low point in the north of the site.

5.10 Anglian water has stated that, “On-site pumping station rated at 42.4l/s, with a 1.45km long 250mm diameter rising main will be needed”.

5.11 The predicted capital scheme cost for the proposed conveyance of flows from the development directly to the Haverhill WRC is £1,119,244. The indicative cost chargeable to the developer following the offsetting of expected future revenue is predicted to be £279,967.

5.12 The proposed drainage network across the site will be designed to current Sewers for Adoption 7th Edition Standards, employing a point of connection agreed with Anglian Water. The system will be offered for the adoption of Anglian Water under S104 of the Water Industry Act 1991.

Summary

5.13 The study concludes that the development will cause detriment to the capacity of the sewer system immediately adjacent to the proposed development site therefore, in order to accommodate the development a proposed connection direct to the Haverhill WRC via a pumped conveyance is proposed.

5.14 It is recommended that an application is made under Section 98 of the Water Industry Act. This will enable a detailed design and robust cost to be generated and the scheme to be delivered.

5.15 Once development is complete, the network and pumping station conveying flows from the site will be adopted by Anglian Water and be maintained as part of their statutory duties.

Objectives

5.16 The key development objectives required for the site drainage scheme are:

- Implementation of a drainage scheme to pump and convey foul water to the Haverhill WRC Water network which is designed and maintained to an appropriate standard.

[5] Sewers for Adoption 7th Edition

6 Summary

6.1 This FRA has identified no prohibitive engineering constraints in developing the proposed site for the proposed residential usage.

6.2 Assessment of fluvial flood risk shows the land to lie in Flood Zone 1 and hence be a preferable location for residential development when considered in the context of the NPPF Sequential Test. Assessment of other potential flooding mechanisms shows the land to have a low probability of flooding from overland flow, ground water and sewer flooding.

6.3 Means to discharge storm and foul water drainage have been established that comply with current guidance and requirements of Anglian Water.

6.4 Storm water discharged from the development will be directed to the existing ditches along the perimeter of the site. Foul water is proposed to discharge to the Haverhill Water Recycling Centre.

6.5 The site is fully able to comply with NPPF guidance together with associated local and national policy guidance.

7 Limitations

7.1 The conclusions and recommendations contained herein are limited to those given the general availability of background information and the planned usage of the site.

7.2 Third party information has been used in the preparation of this report, which Brookbanks Consulting Ltd, by necessity assumes is correct at the time of writing. While all reasonable checks have been made on data sources and the accuracy of data, Brookbanks Consulting Ltd accepts no liability for same.

7.3 The benefits of this report are provided solely to Hallam Land Management (HLM) and the landowner for the proposed development on land at Haverhill only.

7.4 Brookbanks Consulting Ltd excludes third party rights for the information contained in the report.

Appendix