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I. Drainage Strategy - 1174/DRA/001
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EXECUTIVE SUMMARY

1.1 The site, (OSGR 633740 309760), with a total area in the region of 4.42 ha (10.9 acres), lies to the north of the Yarmouth Road and to the south of the A47 Norwich to Gt. Yarmouth bypass in Blofield, Norfolk. It is currently arable land, irregular in shape, with access being provided via a previous residential development known as Wyngates.

1.2 This report has been compiled to assess the existing level of flood risk in accordance with the National Planning Policy Framework (NPPF). It assesses the impact that the site will have on surrounding areas and recommends the drainage design for the proposed residential development, so far as it is possible, given the prevailing situation regarding changes under way in current legislation. The report demonstrates that it is viable to produce a sustainable drainage system that replicates the existing hydrology and does not increase the level of flood risk to others.

1.3 The Indicative Flood Map, as shown on the Environment Agency’s Web Site, confirms that the site is not at risk of fluvial or tidal flooding, being in Flood Zone 1, as defined by the Technical Guidance to the National Planning Policy Framework.

1.4 Anglian Water has confirmed in a pre-development enquiry report Ref 1002/SP190 (001) dated 13th February 2012 that the foul drainage from this development is in the catchment of Whitlingham Sewage Treatment Works, which has capacity available for these flows.

1.5 The sewerage network, at present, also has available capacity for gravity flows from the proposed development site. However, to obviate the need to construct a pumping station to deal with foul flows from the northern extremity of the development, it will be necessary to relay the existing sewer within Wyngates at a greater depth to facilitate a gravity connection to the sewer in Yarmouth Road.

1.6 Ground conditions at the surface precludes the use of normal shallow soakaways for surface water disposal, but the use of deep borehole soakaways would, if necessary, provide a satisfactory drainage solution, subject to approval by the Environment Agency. However, there is an existing highway drain available within Wyngates providing a positive outlet for the site, albeit with a limited discharge. With the use of oversized pipes and additional off-line storage, and utilising the appropriate SuDS techniques wherever practical, it is possible to deal with the surface water from all impermeable areas.

1.7 An existing surface water run-off problem which affects the rear gardens of properties along Yarmouth Road will be addressed by remodelling of site levels in that area, together with the construction of a French drain along the southern boundary of the site intercepting any residual flows.
2 INTRODUCTION

Legislation and Policy (Flooding and Surface Water)

National Planning Policy Framework (NPPF)

2.1 Government policies on land use planning in England in respect to flood risk are contained within the National Planning Policy Framework, published by the Department for Communities and Local Government in March 2012, which states the following:

2.1.1 Flood Risk must be taken into account in the planning process.
2.1.2 Development should not occur in Flood Zones 2 and 3 unless there are no other reasonably available sites elsewhere.
2.1.3 Sequential and Exception testing may be required.
2.1.4 The development in Zones 2 and 3 must have wider sustainable benefits.
2.1.5 The development must be safe over its lifetime.
2.1.6 Sites must be supported by a Flood Risk Assessment.
2.1.7 Development must reduce flood risk through the appropriate application of SuDS optimised in line with current best practice.

Flood and Water Management Act (2010)

2.2 The Flood and Water Management Bill (April 2010) also brings significant changes to the way in which surface water and flood risk are managed. The basic principles, however, remain the same, as outlined in the NPPF. The relevant sections of the Act are not due to come into force until 1st October 2013, at the earliest, but will then require applicants to obtain approval from the SuDS Approving Body (SAB).

Water Industry Act 1991

2.3 The main existing piece of legislation outside the planning process is the Water Industry Act 1991. It is this legislation that allows discharge of surface water to a public sewer and grants water companies their statutory powers. Important aspects of this act, including rights of connection to sewers, will be amended by Section 42 of the Flood and Water Management Act (FWMA), and the role of Water Companies will be significantly altered by the FWMA.

The Private Sewers Transfer Regulations (PSTR)

2.4 The Private Sewer Transfer Regulations is a guidance document for ‘The Water Industry (Schemes for Adoption of Private Sewers 2011) Regulations.’ As of 1st October 2011, all privately owned sewers and lateral drains which connected in to an existing public sewer became the responsibility of the sewerage undertaker for the area.
Current Approval and Adoption arrangements

2.5 A delay in the implementation of changes brought about by the new FWMA has resulted in the current position regarding approval and adoption of surface water infrastructure (including SuDS) still being unclear.

2.6 However, because of these delays and uncertainties over the transition of powers and responsibilities to the SuDS Approving Bodies (SABs), Anglian Water has agreed to consider adoption on a site by site basis if designs accord to their ‘Sustainable drainage systems (SuDS) adoption manual’. This is an interim arrangement and is subject to change as events relating to the FWMA progress.

Guidance

2.7 In the Technical appraisal of surface water management there are several key documents, described below, and this report has been carried out in accordance with these documents:

*Preliminary rainfall runoff management for developments, R & D Technical Report W5-074/A/TR/1*

2.8 Published jointly by Defra and the Environment Agency, this document is referenced by PPS 25 through the practice guide, but as PPS25 is no longer current, it is unclear what role this document has. It is not referred to in the National Planning Policy Framework (NPPF). It contains details of procedure philosophy and technical information, guidance and calculation methods for carrying out flood risk assessments that are still relevant.

*The SuDS Manual (C697)*

2.9 This document, published by CIRIA, is a comprehensive guide to the use and design of SuDS features. This document is likely to form the basis of the technical standards that will be adopted by SuDS Approving Bodies, including Norfolk County Council.

*The Code for Sustainable Homes (CfSH)*

2.10 This document, published by the BRE on behalf of the Department for Communities and Local Government, is becoming increasingly important in the design of surface water systems. The principles of the code are the same as the above documents and will be mandatory through the Building Regulations from 2013. The current technical guidance document (November 2010) outlines the requirements for achieving the Mandatory SUR1 and SUR2 elements and remains current, running in parallel with the NPPF and the National SuDS Standards.

*Sewers for Adoption (SFA)*

2.11 The long awaited 7th Edition of ‘Sewers for Adoption’ finally came into force October 2012 and dictates the design and hydraulic performance of adoptable sewerage systems. The changes caused by the implementation of Section 42 of the FWMA have resulted in several important changes to Sewers for Adoption, including the automatic adoption of sewers serving more than one property and the introduction of the Mandatory Build Standards.
2.12 It had been anticipated that Sewers for Adoption 7th Edition would cover only the future adoption of foul water sewers. However, this has not proved the case, and not only is the adoption of both foul and surface water sewers covered by the new guide but also lateral drains, being that part of the drain from the boundary of the property it serves through to the sewer.

National Standards for Sustainable Drainage Systems

2.13 Draft standards were published for consultation in December 2011 with a view to implementing the Sustainable Drainage Regulations from 1st October 2012. As discussed, it may be some time after this date that the approval and adoption process will be in place. SuDS Approving Bodies will also need to produce their own full technical standards comparable with Sewers for Adoption and the Civil Engineering Specification for the Water Industry (CESWI). It is understood that some SuDS Approving Bodies are working together to produce common standards for Regional Areas.

2.14 The Government has also published several documents in response to the growing hazard of flood risk exemplified by the floods of 2007. The Pitt Review addressed these floods specifically and has led to numerous recommendations and a shift in attitudes towards surface water management. Additional Government policies relating to surface water management, not specific to the planning process, can be found in ‘Making Space for Water’, published by Defra.

Scope of Assessment

2.15 This report has been compiled to assess the existing level of flood risk for a proposed housing development off Yarmouth Road, Blofield in accordance with the National Planning Policy Framework (NPPF). It also assesses the impact that the site will have on surrounding areas. The report recommends the drainage design for the proposed residential development, so far as it is possible, given the prevailing situation regarding changes under way in current legislation.

2.16 The approval, and adoption, of surface water infrastructure is currently being done through special agreements with Anglian Water under the agreed ‘interim arrangements’ available until implementation of the Flood and Water Management Act. This report demonstrates that it is viable to produce a sustainable drainage system that replicates the existing hydrology and does not increase the level of flood risk to others.

2.17 Such an approach is entirely consistent with the general principles of flood risk assessment contained within the NPPF.
3 EXISTING HYDROLOGY, DRAINAGE AND FLOOD RISK

Description of the Site

3.1 The site, (OSGR 633664 309877), with a total area in the region of 4.42 ha (10.9 acres), lies to the north of the C485 Old Yarmouth Road and to the south of the A47 Norwich to Gt. Yarmouth bypass in Blofield, Norfolk. It is currently arable land, roughly rectangular in shape, with access being provided via a previous residential development known as Wyngates. The location plan is shown below, and as Appendix A.

Site Location Plan

3.2 The western boundary abuts an area of tree lined grounds belonging to the Manor House, and then further residential development on Manor Ridge. Wyngates (U51242) itself is accessed from the C485 Old Yarmouth Road.

3.3 There are no water features on the site and no evidence of any positive surface water outfall from the site. The nearest watercourse is the River Yare, some 2km to the south, which together with its tributaries drains most of the district before flowing eastwards to the coast at Great Yarmouth.
In accordance with the Environment Agency directive that surveys can no longer be accepted where heights are obtained using the old, now unsupported, Ordnance Survey Benchmark System, Anglia Survey & Design carried out a full topographical survey of the site in June 2012 with all levels related to OSTN02, using GPS positioning with real-time data correction (Appendix B). Station ASD1, situated at the end of the existing highway at Wyngates, with coordinates of 633741.919 Easting, 309762.987 Northing has a value of 24.939m AOD.
3.5 The land rises gently from the south from a level of around 25.10m AOD to a maximum level of 25.80m AOD in the centre of the site, before falling again to a level of 25.07m AOD along the northern boundary. There is a slight depression in the north-west corner which has a base level around 24.07m AOD.

3.6 Although the site overall is approximately 4.435 ha (10.92 acres), and suitable for around 105 properties at a density of 30 dwellings/hectare, assuming 20% allowance for open space and surface water drainage provision, the proposal is to use only sufficient land to facilitate up to 65 properties. This will amount to around 2.45 ha, being land owned by Norfolk Homes Ltd coloured red below, and an approximately equal area of Option land (Messrs. Rope), shown coloured blue.
3.7 Norfolk Homes Ltd is therefore proposing to develop the site for up to 65 residential dwellings in accordance with a potential layout as shown below, and as Appendix C. The housing site area amounts to 2.447ha whilst the total Open Space area is 1.987ha, with the majority located to the north of the development.
Existing Flood Risk

3.8 The Indicative Flood Map, as shown on the Environment Agency’s Web Site, confirms that the site is not at risk of fluvial or tidal flooding, being wholly located within Flood Zone 1, as defined by the National Planning Policy Framework (See Table 1 below and Appendix D). As such, it automatically satisfies the requirements of the Sequential Test, as outlined within the Technical Guidance of the NPPF.

<table>
<thead>
<tr>
<th>Zone 1 - low probability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td>This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding (&lt;0.1%).</td>
</tr>
<tr>
<td><strong>Appropriate uses</strong></td>
</tr>
<tr>
<td>All uses of land are appropriate in this zone.</td>
</tr>
<tr>
<td><strong>Flood risk assessment requirements</strong></td>
</tr>
<tr>
<td>For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a flood risk assessment. This need only be brief unless the factors above or other local considerations require particular attention.</td>
</tr>
<tr>
<td><strong>Policy aims</strong></td>
</tr>
<tr>
<td>In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage systems.</td>
</tr>
</tbody>
</table>

Table 1: Flood Zones. Extract from the Technical Guidance to the National Planning Policy Framework
Greenfield Runoff (GFR)

3.9 The proposed area to be developed for housing is approximately 2.45ha. The ICP SuDS function in the Micro Drainage software has been used to calculate the Green Field Runoff rate (GFR). This software uses the IOH 124 method for 50ha, adjusted pro-rata by area for specific sites, as recommended by the Environment Agency and the Interim Code of Practice for Sustainable Drainage Systems. The results are summarised below:

<table>
<thead>
<tr>
<th>Annual Probability Event</th>
<th>Greenfield Runoff Rate (l/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% (1in1yr)</td>
<td>6.1</td>
</tr>
<tr>
<td>33.3% (1in30yr)</td>
<td>16.8</td>
</tr>
<tr>
<td>1.0% (1in100yr)</td>
<td>24.8</td>
</tr>
</tbody>
</table>

3.10 In addition to the ICP SuDS runoff values, the FEH CD-ROM has also been used to derive runoff characteristics based on the catchment. These are not unique to the site but cover the entire catchment in which the site is located. The FEH file confirms that the SAAR is 602 mm/yr and SPRHOST is 16.0. This suggests that only 16.0% of rainfall leaves the site as runoff, implying good permeability, which is not borne out by the site investigation. Appendix E

Site Investigation

3.11 A preliminary site investigation and desk study were originally undertaken in February 1997 on behalf of Norfolk Homes Ltd, but only for the initial 1.2 ha site immediately off Wyngates. A factual report, Ref. S96/97:148, was produced by the Transportation and Engineering Services Laboratory, being then the Highways and Transportation Consultancy of Norfolk County Council. The report described the expected geology of the region, the fieldworks carried out and the actual ground conditions encountered. Appendix F

3.12 On the 15th January 1997 a series of six machine excavated trial holes were carried out to a maximum depth of 4.20 metres. The cohesive nature of the deposits found on site in all of the trial pits led to it not being possible to carry out soakage tests in accordance with BRE Digest 365. In general, it would not be possible to use conventional soakaways or swales on this site; experience suggesting that the Cromer Till will have permeability in the order of $1 \times 10^{-8}$ m/s. However, infiltration rates of this order are suitable for permeable paving with under-drains, and this will be covered further in the Surface Water Management section under ‘Permeable Paving’.
3.13 The preliminary site investigation indicated that any housing development was likely to be founded on either Cromer Till or Silt. Where founded on Cromer Till deposits these are recorded as ranging from soft to stiff and there is a slight risk of shrinkage due to desiccation if precipitation is prevented from reaching the soil. Silt was found in all trial pits to a depth of between 0.65 and 0.75 metres (except in Trial Pit 3 where its base was penetrated at 2.10m) and this material should be excavated from beneath any foundations.
3.14 In order to investigate the use of deep borehole soakaways, which would extend down into the Glacial Sand and Gravel beneath the Cromer Till, three boreholes were drilled on site between 4th and 29th May 2012, Ref NHOM0046. Falling head permeability testing was carried out by Norfolk Partnership Laboratory within sand horizons at various levels in the boreholes to enable indicative infiltration rates to be calculated.

3.15 Based upon the information obtained, a deep borehole soakaway system could be designed for the development. In general terms, the site comprises between 10.5 to 12.0 metres of clay soils overlying sand. The results of the falling head tests are shown below:
3.16 A standpipe piezometer was installed in BH21 to enable changes in groundwater levels to be monitored. During the drilling process the water levels were recorded as shown below:

<table>
<thead>
<tr>
<th>Borehole No</th>
<th>Layer depth (m)</th>
<th>Test depth (m)</th>
<th>Infiltration Rate (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>12.0 - 15.8</td>
<td>12.9 – 13.7</td>
<td>2.1 x 10^-4</td>
</tr>
<tr>
<td>21</td>
<td>17.5 – 20.5</td>
<td>17.5 – 18.0</td>
<td>6.3 x 10^-5</td>
</tr>
<tr>
<td>21</td>
<td>17.5 – 20.5</td>
<td>19.5 – 20.0</td>
<td>2.9 x 10^-5</td>
</tr>
<tr>
<td>22</td>
<td>13.0 – 16.5</td>
<td>14.5 – 15.0</td>
<td>3.8 x 10^-5</td>
</tr>
<tr>
<td>22</td>
<td>16.5 – 20.0</td>
<td>16.5 – 17.5</td>
<td>1.0 x 10^-5</td>
</tr>
<tr>
<td>23</td>
<td>10.0 – 12.8</td>
<td>12.0 – 13.0</td>
<td>1.7 x 10^-5</td>
</tr>
<tr>
<td>23</td>
<td>12.8 – 20.0</td>
<td>16.5 – 17.0</td>
<td>2.0 x 10^-4</td>
</tr>
</tbody>
</table>

3.17 An initial discussion with Richard Walters, Groundwater & Contaminated Land Section of the Environment Agency, has confirmed that although there is a presumption against deep boreholes, provided there is no viable alternative, and there is no direct discharge to the aquifer, then deep boreholes would be acceptable as a means of surface water disposal.

3.18 Pollution prevention devices would be required for roads and car parking areas, and there should be more, rather than deeper, boreholes to achieve the desired design. There should also be 2m of unsaturated soil between the bottom of the borehole and the aquifer, and the boreholes should be as shallow as possible. The site is within Source Protection Zone 3 which is the least stringent.

3.19 To provide the storage and attenuation of flows before discharging into the ground it would be necessary to provide either crates beneath the public open space or a lined attenuation lagoon, with the boreholes situated off-line.
4 FOUL DRAINAGE

4.1 According to Anglian Water’s sewer records there is a 150mm foul sewer within Wyngates, with a manhole constructed within the site entrance to afford an easy connection. There is also a 150mm pipe within Manor Road to the north-west of the site. There is no information available for Manhole 5902 in Manor Road, but access to it for a connection is blocked by surrounding properties.

Sewer Records

4.2 Anglian Water has confirmed in a pre-development enquiry report Ref 1002/SP190 (001) dated 13th February 2012 that the foul drainage from this development is in the catchment of Whitlingham Sewage Treatment Works, which has capacity available for these flows. The sewerage system, at present, also has available capacity for gravity flows from the proposed development site. The obvious connection point would be into manhole 7704 which is located within the small triangular area of land at the end of Wyngates. This manhole has an Invert Level of 23.49m AOD and a depth of 1.55 metres. Apparently, there have been no instances of flooding in the vicinity of the development site that can be attributed to the public sewerage system. Appendix G.

4.3 To facilitate a foul gravity connection from the development, and to obviate the need for a pumping station, it is necessary to relay the existing public foul sewer within the main Wyngates access road, down to its connection with the sewer in Yarmouth Road. This will be carried out with approval and supervision from Anglian Water.
5 PROPOSED SURFACE WATER MANAGEMENT

5.1 There does not appear to be any natural watercourses in the immediate vicinity of the site to which surface water could be taken. Currently all rainwater falling on the site appears to soak into the ground which is slightly contradictory to the permeability results obtained.

Historical Background

5.2 Correspondence dating back to 1997 suggests that at the time Wyngates was developed by Harvey & Leech Ltd the surface water drainage was adopted by Norfolk County Council as part of a S38 Agreement dated 10th February 1988. In a letter dated 25th February 1997, Ref.P.9/5/86/274 RGA/KF, Mr R G Alexander of Norfolk County Council confirmed that calculations submitted by Chaplin & Farrant on behalf of Harvey & Leech, indicate that spare capacity amounting to 102.34 l/sec has been provided in the existing surface water drain for future development. Appendix H

5.3 It is understood that the surface water drain was constructed along Yarmouth Road and then southwards through what is now the residential development of Nursery Gardens. It then connected with the highway drain on Danesbower Lane and thence into Church Road before discharging southwards into the watercourse known as Witton Run. There is therefore a positive drainage route available for surface water down to a receiving watercourse.

5.4 Highway drainage records from NCC also confirm the location of these surface water drains, and associated gullies, within Fox Lane, Danesbower Lane and Church Road that eventually outfall to the watercourse to the south of Blofield.
5.5 Bryan Dye of Norfolk County Council has confirmed in an email dated 22\textsuperscript{nd} January 2013 that a connection into the existing highway surface water system would be acceptable. Obviously with today’s emphasis on the use of SuDS, the Council would expect the new system to be in compliance with SuDS principles and water from the site to be attenuated to the Greenfield run-off rate. There is therefore the possibility of a positive outfall which could drain by gravity towards the existing 300mm pipe that has an Invert Level of 21.73m AOD (depth 2.39m) at the nearest manhole in Wyngates.

5.6 If it is proposed to connect houses to any new surface water system, then the Highway Authority would expect the pipes to be adopted by either Anglian Water or the new SuDS Approving Body, which again would be Norfolk County Council. In either case, the discharge would need to be limited to the Greenfield Runoff Rate, and storage provided within oversized pipes together with additional off-line storage for extreme storm events.

5.7 Under Section 115 of the Water Industry Act 1991, a Highway Authority cannot unreasonably refuse a Water Authority connection into their drainage network, provided it can be demonstrated that sufficient capacity exists to accommodate the additional flows. It is understood that CCTV survey work and hydraulic modelling has recently been carried out on the highway drainage network downstream of the site which confirms that it is able to accommodate additional flows, without increasing the risk of flooding downstream.

5.8 It is now a requirement, wherever possible, to use soakaways and/or other forms of infiltration drainage (SuDS) to deal with the surface water; although in this particular location the permeability at the surface appears to preclude this, except for permeable paving.

**Use of Sustainable Urban Drainage Systems (SuDS)**

5.9 Current legislation advocates that surface water run-off should be controlled as near to its source as possible through a sustainable approach to surface water management. Sustainable Drainage Systems (SuDS) are an approach to managing surface water run-off by mimicking natural drainage systems and managing surface water at the source, rather than allowing it to freely discharge through traditional piped systems.

5.10 The surface water system will be designed in accordance with the Environment Agency's document ‘Preliminary Rainfall Runoff Management for Developments - R&D Technical Report W5-074/D/TR/1 Rev D’. The criteria in this document appear in most current guidance, and form the backbone of the current proposed national SuDS standard. This results in the following criteria having to be met:

5.10.1 Peak discharge rates post-development should replicate the pre-development flow regime.

5.10.2 Where possible, minimal discharge should be attained for rainfall up to 5mm.

5.10.3 The difference in runoff volume, pre and post development for a 1 % annual probability (1 in 100 year storm), even of 6 hours duration, should be discharged at rates no greater than 2l/sec/ha.
5.11 NPPF recommends that a precautionary principal should be applied to flood risk assessments. In accordance with this principal the hydraulic design has incorporated an allowance of 30% increase on peak rainfall intensity to account for the period to 2115.

**Surface Water Management – Minor Storm Event System**

5.12 The permeability of the soil at the surface is less than $10^{-8}$ m/s, which makes the use of infiltration techniques with soakage into the ground virtually impossible. At greater depths where the sand layer is encountered, the infiltration rate is much better and soakage would be possible.

5.13 An outline strategy has been produced to demonstrate that a sustainable drainage system can be provided on this site. The proposals are shown on drawing 1174/DRA/001. The principles by which it is proposed the drainage system will operate are as follows:
5.14 Roof water from the houses will be directed to Rainwater Harvesting Units, with overflows taking any excess water to the positive piped drainage system in the highway. Suitable landscaping of the gardens will ensure that water can also be stored on the surface under extreme conditions and not pose a flood risk to nearby properties.

**Permeable Paving**

5.15 Permeable paving will be used for all unadoptable roads, shared parking areas and residential driveways. It will be designed in accordance with the ‘Interpave’ (The Precast Concrete Paving and Kerb Association) ‘Guide to the Design, Construction and Maintenance of Concrete Block Permeable Pavements’, the recognised Industry standard.

5.16 With Infiltration Rates for the sub grade at the surface being in the region of $10^{-8}$ m/s the guide confirms that the system of permeable paving should be limited to only System C (no infiltration) with under-drains to collect water that cannot infiltrate into the ground.

<table>
<thead>
<tr>
<th>permeability of subgrade defined by coefficient of permeability k (m/s)</th>
<th>System A total infiltration</th>
<th>System B partial infiltration</th>
<th>System C no infiltration</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{-6}$ to $10^{-3}$</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>$10^{-4}$ to $10^{-1}$</td>
<td>X</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>$10^{-10}$ to $10^{-6}$</td>
<td>X</td>
<td>X</td>
<td>✔️</td>
</tr>
</tbody>
</table>

Table 1: Guidance on selection of a pavement system.

<table>
<thead>
<tr>
<th>Soil classification</th>
<th>Typical range for coefficient of permeability K (ms)</th>
<th>Typical range of CBR values</th>
</tr>
</thead>
<tbody>
<tr>
<td>heavy clay</td>
<td>$10^{-10}$ to $10^{-6}$</td>
<td>2 to 5</td>
</tr>
<tr>
<td>silty clay</td>
<td>$10^{-5}$ to $10^{-4}$</td>
<td>3 to 6</td>
</tr>
<tr>
<td>sandy clay</td>
<td>$10^{-4}$ to $10^{-6}$</td>
<td>5 to 20</td>
</tr>
<tr>
<td>poorly graded sand</td>
<td>$5 \times 10^{-7}$ to $5 \times 10^{-5}$</td>
<td>10 to 40</td>
</tr>
<tr>
<td>well graded sand</td>
<td>$5 \times 10^{-4}$ to $10^{-4}$</td>
<td>10 to 40</td>
</tr>
<tr>
<td>well graded sandy gravel</td>
<td>$10^{-4}$ to $10^{-3}$</td>
<td>30 to 80</td>
</tr>
</tbody>
</table>

Table 2: Soil classification guide.

5.17 The loading category of the permeable paving has been determined using the following table which then also suggests the appropriate construction method.
Table 7: Loading categories.

<table>
<thead>
<tr>
<th>Loading Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Domestic Parking</td>
<td>No Large Goods Vehicles</td>
</tr>
<tr>
<td>2 Car</td>
<td>100 standard axles</td>
</tr>
<tr>
<td>3 Pedestrian</td>
<td>0.01 tensa</td>
</tr>
<tr>
<td>4 Shopping</td>
<td>0.1 tensa</td>
</tr>
<tr>
<td>5 Commercial</td>
<td>1.0 tensa</td>
</tr>
<tr>
<td>6 Heavy Traffic</td>
<td>10 tensa</td>
</tr>
</tbody>
</table>

**Note:** tensa = millions of standard 8,000 kg axles.

**DESIGN CHART**

**SYSTEM C**

**LOAD CATEGORY 1**

- Coarse graded aggregate
- Capping

**LOAD CATEGORY 2**

- Coarse graded aggregate
- Capping

**LOAD CATEGORY 3**

- Hydraulically bound coarse graded aggregate
- Dacrie graded aggregate
- Capping

**LOAD CATEGORY 4**

- Hydraulically bound coarse graded aggregate
- Coarse graded aggregate
- Dacrie graded aggregate
- Capping

**LOAD CATEGORY 5**

- Hydraulically bound coarse graded aggregate
- Dacrie graded aggregate
- Capping

**LOAD CATEGORY 6**

- Hydraulically bound coarse graded aggregate
- Coarse graded aggregate
- Dacrie graded aggregate
- Capping

**Figure 24:** Design chart for System C (detention) permeable pavements (on subgrade > 5% equilibrium moisture content CBR).

**Key:**

- Impermeable membrane
- Geotextile (upper geotextile optional)
5.18 Although the design for the permeable paving has not been finalised at this stage it is possible to ensure that the surface water falling onto the private drives and parking areas is collected and stored until it is able to drain away.

5.19 A conventional storage-piped system will be used to collect surface water from the highway and connections from the overflows from the house harvesting units and from the permeable paving under-drains, and route it to the outfall sewer. A Hydro-brake flow control device will limit the discharge to the existing Greenfield run-off rate of 6.1 l/sec.

5.20 Micro Drainage calculations confirm that 900mm diameter pipes are adequate to store 1 in 30 year storms, whilst additional storage within the Public Open Space to the north of the development will accommodate the 1 in 100 year storm event, with an additional allowance of 30% in rainfall intensity to deal with possible future climate change. This will take the form of an attenuation lagoon or an underground concrete tank depending upon the requirements of the eventual adopting authority.

5.21 It is proposed that this whole system will be adopted and maintained by Norfolk County Council, the SuDS Approval Body (SAB), and will be designed and constructed to National Standards as encouraged by the Flood and Water Management Act 2010. It is envisaged that the pipe system will be designed to fully surcharge in a 1 in 30 year event and may, very rarely, flood during 1 in 100 year events.

5.22 In extreme storm events a small amount of water may escape from the surface water sewers, but this will be directed onto the two Public Open Spaces in the centre of the development site or the large POS to the north. The construction of shallow depressions or swales within the POS will ensure that this water is retained on site and not affect properties downstream. These areas will be landscaped to soften the appearance and to provide natural habitats for wildlife.

**Surface Water Management – Major Storm Event System**

5.23 Drawing 1174/DRA/001 also shows how the site will be designed to route and store surface water during events greater than 1:30 year (3·3% annual probability) which cannot be accommodated within the adoptable system. Since the site is relatively flat and the roads can be made to fall towards the positions of the Public Open Spaces, it is practical to use routing of flows to these areas as the primary method of dealing with flows resulting from failure of the adoptable system during events between 1:30 year and 1:100 year return periods.

5.24 Water unable to enter, or escaping from, the on-site piped system during a 100 year event will be managed using a variety of techniques. These will include temporary storage on the highway and parking areas, but more importantly with overflows into shallow depressions constructed within the public open spaces. The depressions will be landscaped to soften their appearance such that they enhance the Public Open Spaces and provide additional natural habitats for wildlife. It is proposed that these features be a maximum of 600mm deep and will be dry for the majority of the time.
5.25 The Environment Agency also require consideration of the potential for the major system to experience flows generated by rainfall intensity greater than 50mm/hr, for any annual probability event. These flows are generated due to restricted capacity of receiving devices (gullies, gutters, channels etc) and are assumed to equate to 5mm rainfall not entering the system. The major system will ensure that any such flows are routed through the site to the public open spaces.

**Soil types and SuDS suitability**

5.26 As already stated, soakage testing has confirmed that infiltration cannot be used as a primary method of surface water disposal. This does not, however, prevent the implementation of a sustainable drainage system. The table below contains proposed design features that contribute to the sustainable surface water system.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Control</td>
<td>Ensures peak runoff rates do not exceed pre-development peak rates mitigating flooding in downstream watercourses.</td>
</tr>
<tr>
<td>Water Butts</td>
<td>Provide limited collection of surface water and also reduce use of potable water. Can reduce the typical volume of discharge by approximately 18m$^3$/year/plot.</td>
</tr>
<tr>
<td>Swales/Depressions</td>
<td>The proposed depressions on the Public Open Spaces will enable limited infiltration and provide storage during large events. Enable effective interception and routing of surface water flows.</td>
</tr>
<tr>
<td>Permeable Surfaces</td>
<td>Provide limited infiltration but effective storage and increased time of concentration.</td>
</tr>
</tbody>
</table>

5.27 With the inclusion of some or all of the above features, the development will offer a suitable level of sustainability with respect to surface water management.

6 RESIDUAL FLOOD RISK

**Risks to the Site**

6.1 There is currently no flood risk to the site from the sea. The site is located within Flood Zone 1 (Low Risk) and residential development is appropriate for this zone.

6.2 Sheet flows may be generated by the adjacent catchment which may currently flow across the site. Should these occur, the major system designed into the site will ensure that there is no significant risk to the dwellings
Risks from the Site

6.3 This report has demonstrated how the site will be designed to restrict flow rates to replicate the pre-development regime in accordance with NPPF. Some reduction in volume of surface water run-off will be achieved by the variety of Infiltration techniques being proposed. Other sustainable drainage features such as water butts and rainwater harvesting can also be assumed to reduce the volume of runoff for any individual event even further.

6.4 With these measures in place the development will not result in a significant increase in flood risk and will comply with both NPPF and the Code for Sustainable Homes (SUR1 and SUR2).

6.5 There is an area of the site, along the southern boundary, which, because of the local topography, occasionally allows rainwater to run off the surface of the field into the rear gardens of properties along the northern side of Yarmouth Road. The owners have raised this as an issue with the farmer, who now ploughs this area parallel to the boundary slowing down the run-off.

6.6 The construction of new properties and highways means that all surface water falling on the site will be intercepted and removed in a positive piped system. It is proposed to remodel levels in this area to reduce the fall towards the rear gardens of the existing properties, thus preventing water from affecting their gardens. As a precautionary measure, it is also proposed to install a French Drain along the boundary to intercept any residual water and connect this into the positive system and removed from site.

7 FLOOD RESISTANCE AND RESILIENCE

7.1 Protection to buildings is usually provided to a 1% annual probability (1:100 year), however, the Environment Agency assesses flood risk from fluvial and coastal sources of up to a 0.1% annual probability (1:1000 year). It is not always practicable to provide flood protection to an entire site for such events but measures can be provided to protect buildings from the ingress of water, even if the site is flooded, at a lesser cost than protecting the entire site.

7.2 In considering protection there are four concepts that can be applied:

- **Avoidance:** Removing the building footprint from the flooded area.
- **Resistance:** Preventing water entering the building.
- **Resilience:** Reducing the impact water will have if it enters the building.
- **Repairability:** Managing damage so as to make it easily repaired.

In this case a strategy of avoidance can easily be achieved and hence resistance, resilience and repairability measures will not be required.

7.3 The safe routing of potential surface water flows across the site has already been identified and forms part of the flood avoidance strategy.
8 CONCLUSIONS AND RECOMMENDATIONS

8.1 The site is within Flood Zone 1, and there is currently only a very limited flood risk at the development site.

8.2 A positive piped system for surface water drainage, utilising infiltration where possible, will be implemented which complies with the NPPF. This will achieve the following:

8.2.1 Replication of, or indeed a reduction of, pre-development runoff rates.

8.2.2 Less than 2 l/s/ha discharges for the increased volume created by the development, based on the 100 yr 6hr event.

8.2.3 Minimal discharge for rainfall events up to 5mm.

8.2.4 Safe routing of flows unable to enter the adoptable system, such as those generated by rainfall greater than 50mm/hr.

There will therefore be no significant increase in flood risk due to the construction of the proposed development.

8.3 The findings, analysis and conclusions of this Flood Risk Assessment Report prove that a detailed design is achievable, as part of a Reserved Matters application, to provide foul and surface water disposal solutions that are fit for purpose in terms of use, and fully in accordance with the latest policies on Sustainable Drainage.
9 REFERENCES


## GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual exceedance probability</td>
<td>The estimated probability of a flood of given magnitude occurring or being exceeded in any year. Expressed as, for example, 1 in 100 chance or 1 per cent.</td>
</tr>
<tr>
<td>Adoption of sewers</td>
<td>The transfer of responsibility for the maintenance of a system of sewers to a sewerage undertaker.</td>
</tr>
<tr>
<td>Attenuation</td>
<td>Reduction of peak flow and increased duration of a flow event.</td>
</tr>
<tr>
<td>Climate change</td>
<td>Long-term variations in global temperatures and weather patterns, both natural and as a result of human activity.</td>
</tr>
<tr>
<td>Design event</td>
<td>A historic or notional flood event of a given annual flood probability, against which the suitability of a proposed development is assessed and mitigation measures, if any, are designed.</td>
</tr>
<tr>
<td>Design event exceedance</td>
<td>Flooding resulting from an event which exceeds the magnitude for which the defences protecting a development were designed – see residual risk.</td>
</tr>
<tr>
<td>Design flood level</td>
<td>The maximum estimated water level during the design event.</td>
</tr>
<tr>
<td>Exceedance flood risk assessment</td>
<td>A study to assess the risk of a site or area being affected by exceedance flow, and to assess the impact that any changes made to a site or area will have on the exceedance flood risk.</td>
</tr>
<tr>
<td>Exceedance flow</td>
<td>Excess flow that emerges on the surface once the conveyance capacity of a drainage system is exceeded.</td>
</tr>
<tr>
<td>Flood defence</td>
<td>Flood defence infrastructure, such as flood walls and embankments, intended to protect an area against flooding to a specified standard of protection.</td>
</tr>
<tr>
<td>Operating Authorities</td>
<td>The Environment Agency, local authorities and Internal Drainage Boards with legislative powers to undertake flood and coastal defence works.</td>
</tr>
<tr>
<td>Flood effect mitigation</td>
<td>All measures to reduce the effect of flooding on a building and its occupants including flood avoidance, flood resistance and flood resilience.</td>
</tr>
<tr>
<td>Flood Map</td>
<td>A map produced by the Environment Agency providing an indication of the likelihood of flooding within all areas of England and Wales, assuming there are no flood defences. Only covers river and sea flooding.</td>
</tr>
<tr>
<td>Floodplain</td>
<td>Area of land that borders a watercourse, an estuary or the sea, over which water flows in time of flood, or would flow but for the presence of flood defences where they exist.</td>
</tr>
<tr>
<td>Functional floodplain</td>
<td>Land where water has to flow or be stored in times of flood.</td>
</tr>
<tr>
<td>Flood risk management strategy</td>
<td>A long-term approach setting out the objectives and options for managing flood risk, taking into account a broad range of technical, social, environmental and economic issues.</td>
</tr>
<tr>
<td>Flood risk assessment</td>
<td>A study to assess the risk to an area or site from flooding, now and in the future, and to assess the impact that any changes or development on the site or area will have on flood risk to the site and elsewhere. It may also identify, particularly at more local levels, how to manage those changes to ensure that flood risk is not increased.</td>
</tr>
<tr>
<td>Flood risk management measure</td>
<td>Any measure which reduces flood risk such as flood defences.</td>
</tr>
<tr>
<td>Flood Zone</td>
<td>A geographic area within which the flood risk is in a particular range, as previously defined within PPS25.</td>
</tr>
</tbody>
</table>
Fluvial  Flooding caused by rivers.
Freeboard  The difference between the flood defence level and the design flood level.
Greenfield land  Land that has not been previously developed.
Main River  A watercourse designated on a statutory map of Main Rivers, maintained by Defra, on which the Environment Agency has permissive powers to construct and maintain flood defences.
Major development  A major development is a) where the number of dwellings to be provided is ten or more, or the site area is 0.5 hectares or more or b) non-residential development, where the floorspace to be provided is 1,000m$^2$ or more, or the site area is 1 ha or more.
Ordinary watercourse  All rivers, streams, ditches, drains, cuts, dykes, sluices, sewers (other than public sewer) and passages through which water flows which do not form part of a Main River. Local authorities and, where relevant, Internal Drainage Boards have similar permissive powers on ordinary watercourses, as the Environment Agency has on Main Rivers.
Pluvial  Surface flooding caused by rain.
Precautionary principle  Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.
Previously-developed land  Land which is or was occupied by a permanent structure, including the (often referred to as brownfield land) curtilage of the developed land and any associated fixed surface infrastructure (PPS3 annex B)
Reservoir (large raised)  A reservoir that holds at least 25,000 cubic metres of water above natural ground level, as defined by the Reservoirs Act, 1975.
Resilience  Constructing the building in such a way that although flood water may enter the building, its impact is minimised, structural integrity is maintained and repair, drying & cleaning are facilitated.
Resistance  Constructing a building in such a way as to prevent flood water entering the building or damaging its fabric. This has the same meaning as flood proof.
Return period  The long-term average period between events of a given magnitude which have the same annual exceedance probability of occurring.
Residual risk  The risk which remains after all risk avoidance, reduction and mitigation measures have been implemented.
Run-off  The flow of water from an area caused by rainfall.
Section 106 Agreement  Section 106 of the Town and Country Planning Act 1990 (as amended) allowing local planning authorities to negotiate arrangements whereby the developer makes some undertaking if he/she obtains planning permission. These are known interchangeably as planning agreements, planning obligations or planning gain.
Section 106  (Water Industry A key section of the Water Industry Act 1991, relating to the right of Act 1991) connection to a public sewer.
Standard of protection  The design event or standard to which a building, asset or area is protected against flooding, generally expressed as an annual exceedance probability.
Sustainable Drainage Systems  A sequence of management practices and control structures, often referred to as SUDS, designed to drain water in a more sustainable manner than some conventional techniques. Typically these are used to attenuate run-off from development sites.
Sustainability Appraisal  An integral part of the plan-making process which seeks to appraise the economic, social and environmental effects of a plan in order to inform decision-making that aligns with sustainable development principles.

Washland  An area of the floodplain that is allowed to flood or is deliberately flooded by a river or stream for flood management purposes.

Water Framework Directive  A European Community Directive (2000/60/EC) of the European Parliament and Council designed to integrate the way water bodies are managed across Europe. It requires all inland and coastal waters to reach “good status” by 2015 through a catchment-based system of River Basin Management Plans, incorporating a programme of measures to improve the status of all natural water bodies.
APPENDICES