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Client: **Mr and Mrs Selby**

Flood Risk Assessment for the Proposed Development at Home Farm, Kemnal Road, Chislehurst, Kent

August 2022

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2	1	Final report issued by email	28 July 2022
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Contents Page

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1 Background and Scope of Appraisal

Flooding is a major issue in the United Kingdom. The impacts can be devastating in terms of the cost of repairs, replacement of damaged property and loss of business. The objectives of the Flood Risk Assessment (FRA) are therefore to establish the following:

- whether a proposed development is likely to be affected by current or future flooding from any source.
- whether the development will increase flood risk elsewhere within the floodplain.
- whether the measures proposed to address these effects and risks are appropriate.
- whether the site will pass Part B of the Exception Test (where applicable).

Herrington Consulting has been commissioned by Mr and Mrs Selby to prepare a Flood Risk Assessment (FRA) for the proposed development at Home Farm, Kemnal Road, Chislehurst, BR7 6LY.

This appraisal has been undertaken in accordance with the requirements of the National Planning Policy Framework (2021) and the National Planning Practice Guidance Suite (August 2021) that has been published by the Department for Communities and Local Government. The Flood Risk and Coastal Change planning practice guidance included within the Suite represents the most contemporary technical guidance on preparing FRAs. In addition, reference has also been made to Local Planning Policy.

To ensure that due account is taken of industry best practice, this FRA has been carried out in line with the CIRIA Report C624 'Development and flood risk - guidance for the construction industry'.

2 Development Description and Planning Context

2.1 Site Location and Development

The site is located at OS coordinates 544888, 171356, off Kemnal Road in Chislehurst. The site covers an area of approximately 7.11 hectares and currently comprises a number of residential and farm buildings, access roads, and associated landscaping. The location of the site in relation to the surrounding area and the is shown in Figure 2.1.

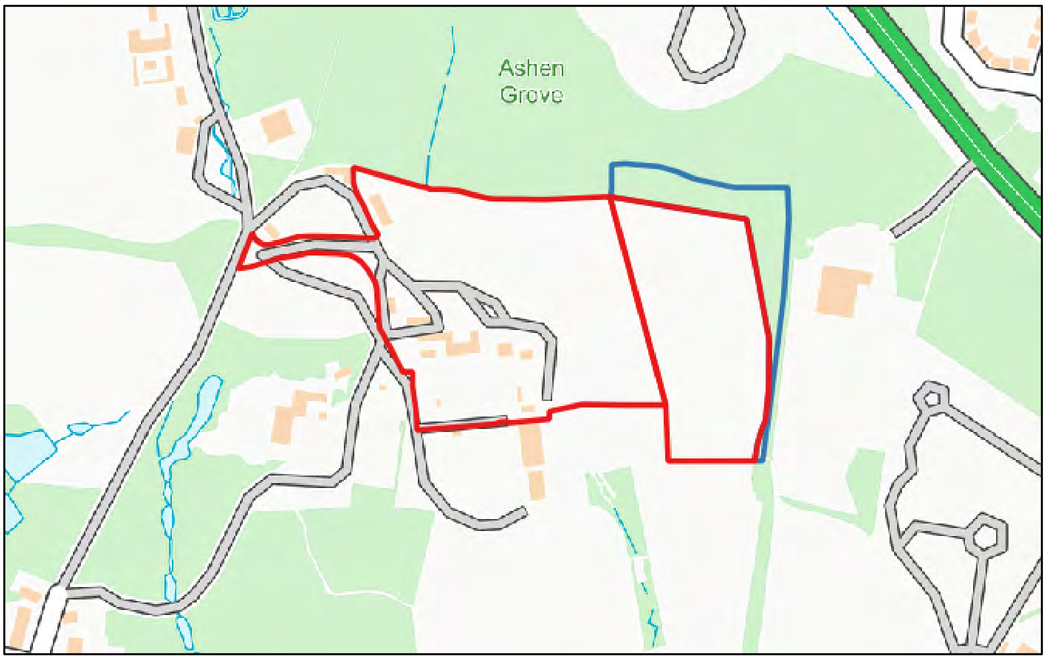


Figure 2.1 – Location map (contains Ordnance Survey data © Crown copyright and database right 2022).

The site plan included in Appendix A.1 of this report provides more detail in relation to the site location and layout.

2.2 Proposed Development

The proposals for development comprise the construction of a new residential dwelling, alterations to several of the existing buildings and dwellings that form part of the existing Bothy Cottage, Bothy House and Polo Mews. A significant area of hardstanding will be removed as part of the development and the proposals include the construction of a hydrogen plant building and the replacement of the existing driveway serving several of the existing buildings and the new house. The proposals are also to include the vineyard although, as the fields currently have a lawful agricultural use, this element does not, strictly speaking, require planning permission.

Drawings of the proposed scheme are included in Appendix A.1 of this report.

3 Definition of Flood Hazard

3.1 Site Specific Information

Information from a wide range of sources has been referenced to appraise the true risk of flooding at this location. This section summarises the additional information collected as part of this FRA.

Information contained within the SFRA – The London Borough of Bromley SFRA (2008) contains detailed mapping showing historic flood records for a wide range of sources. This document has been referenced as part of this site-specific FRA.

Information provided by Thames Water –Thames Water has provided the results of an asset location search for the site. The response is included in Appendix A.2.

Site specific topographic surveys – Numerous topographic surveys of the site have been undertaken over the years and a copy of the most contemporary survey data is included in Appendix A.1. From the survey, it can be seen that the level of the site varies between 59.88m and 73.88m Above Ordnance Datum Newlyn (AODN). Inspection of the survey reveals that the land levels are highest to the east of the site, with an area of lower land running through the centre of the site, following a northeast to the south orientation, surrounding the Longlands Stream.

Geology – Reference to the British Geological Survey (BGS) map shows that the underlying solid geology in the location of the subject site is Harwich Formation (sand and gravel). There are no overlying superficial deposits.

Historic flooding – The site was subject to a large surface water flood event in December 2013. A very heavy rainfall event resulted in a large amount of surface water travelling across the site following the natural valley contours of the land. Remedial works were subsequently installed to mitigate the risk of future flooding to the properties.

3.2 Potential Sources of Flooding

The main sources of flooding have been assessed as part of this appraisal. The specific issues relating to each one and its impact on this development are discussed below. Table 3.1 at the end of this section summarises the risks associated with each of the sources of flooding.

Flooding from Rivers, Ordinary or Man-Made Watercourses (Fluvial) – Inspection of OS mapping identifies that there are no main rivers in close proximity to the site therefore, the EA's 'Flood Map for Planning' (Figure 3.1) identifies the site to be located in Flood Zone 1.

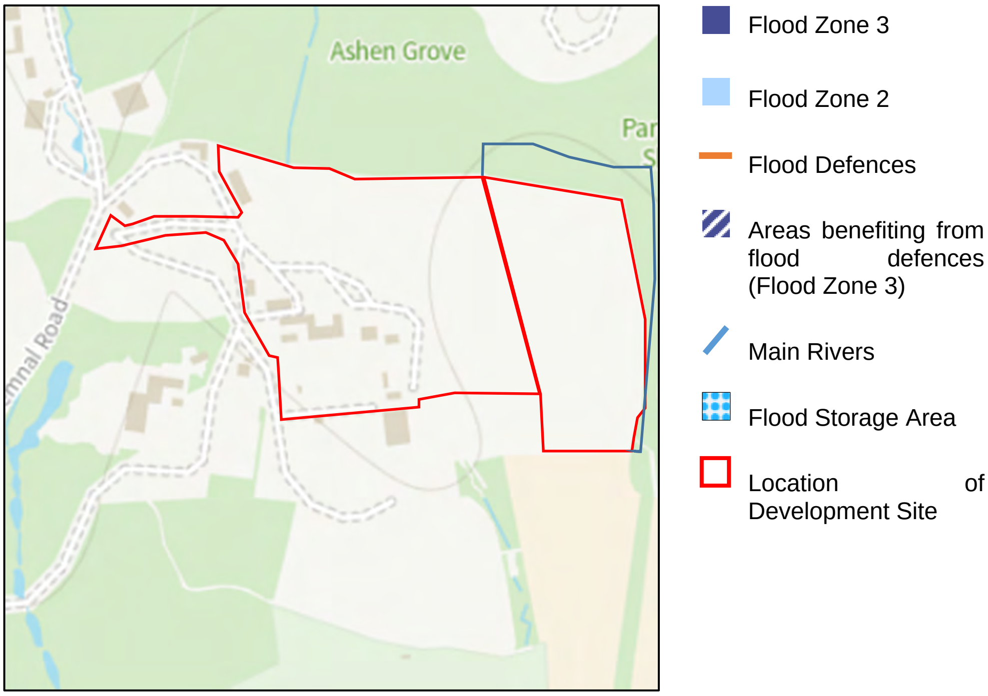


Figure 3.1 – EA's 'Flood Map for Planning' (© Environment Agency).

Further inspection of the OS mapping for the area reveals an ordinary watercourse (Longlands Stream) that flows through the site, with a culverted section that discharges into a basin located on the northern boundary of the site. From this point, water is discharged into the Ashen Grove woodland to the north through an existing outlet. In recent years a series of flood alleviation works have been undertaken to help to attenuate water within the stream, via a series of smaller ponds, controlled by a number of fixed weirs.

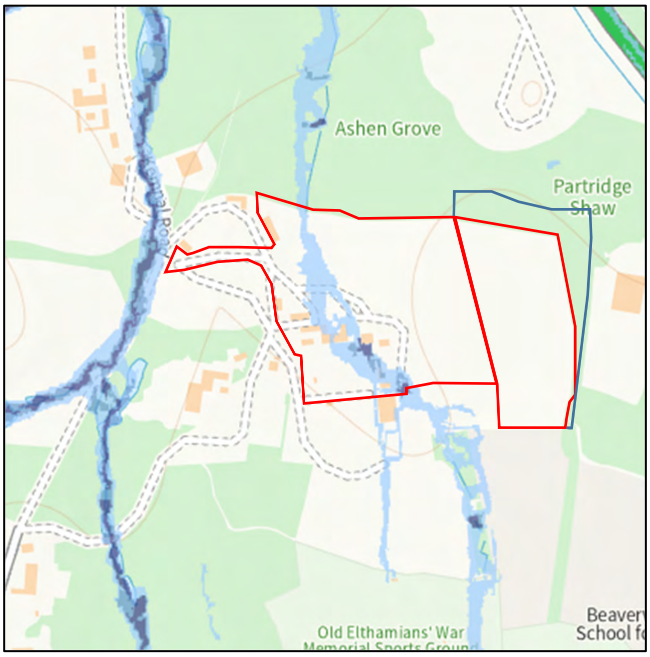
During an extreme rainfall event there is the potential for localised flooding around the artificial ponds, however, this water would flow over the weirs and would flow through the natural valley towards the lower pond, where a catchpit is located. This catchpit directs water through a 600mm diverter pipe, which outfalls into the basin located to the north of the site, away from the properties.

There is the potential for water to bypass the catch pit, e.g. during a blockage scenario, at which point water could collect in the lowest ornamental pond, before discharging into a 375mm culvert passing underneath Greenacres main house. As part of the flood alleviation works, the drainage system surrounding Greenacres was updated to include SuDS, including permeable surfacing around the main house, which was designed to prevent internal flooding. As a failsafe, the land levels were also reprofiled to allow water to pass between Greenacres and the existing ancillary building, enabling water to flow towards the northern basin, thereby directing any overland flows away from the habitable buildings.

Taking into consideration the flood alleviation works that have been implemented previously at this site, the risk of flooding to the habitable buildings from surface water is considered to be low.

Flooding from Surface Water – Surface Water, or overland, flooding typically occurs in natural valley bottoms as normally dry areas become covered in flowing water and in low spots where water may pond. This mechanism of flooding can occur almost anywhere but is likely to be of particular concern in any topographical low spot, or where the pathway for runoff is restricted by terrain or man-made obstructions.

Reference to the EA mapping shows that the development site is located in an area classified as having a 'very low' to 'high' risk of surface water flooding, in the form of a flow path crossing the site. As a result, the risk of flooding from this source has been investigated further in Section 5.



Probability of Flooding

High – Extent of flooding from surface water that has a 3.3% (1 in 30) or greater chance of happening each year.

Medium - Extent of flooding from surface water that has between a 3.3% (1 in 30) and 1% (1 in 100) chance of happening each year.

Low - Extent of flooding from surface water that has between a 1% (1 in 100) and 0.1% (1 in 1000) chance of happening each year.

Location of Development Site

Figure 3.2 – EA's 'Flood Risk from Surface Water' map (© Environment Agency).

Flooding from the Sea – The site is located a significant distance inland and is elevated well above predicted extreme tide levels. Consequently, the risk of flooding from this source is considered to be low.

Flooding from Groundwater – Water levels below the ground rise during wet winter months and fall again in the summer as water flows out into rivers. In very wet winters, rising water levels may lead to the flooding of normally dry land, as well as reactivating flow in 'bournes' (streams that only flow for part of the year).

The mapped underlying geology in this area is shown to be Harwich Formation (sand and gravel), which is a relatively permeable geology type. However, site photographs taken during the construction of the flood alleviation works shows the soils to comprise mainly of clay. Whilst groundwater could be present in some areas of the site, the risk of groundwater emergence is relatively low.

The new house will be constructed partially underground and as a result, has the potential to intersect the groundwater table. If this is the case, it will be necessary to tank the property to prevent groundwater ingress and install a secondary drainage system to remove groundwater from the property walls, should the primary tanking leak. At the detailed design stage it Is recommended that further ground investigations are undertaken to confirm the groundwater levels across the site in the winter period, to ensure that the development is suitably designed.

Flooding from Sewers – In urban areas, rainwater is typically drained into surface water sewers or sewers containing both surface and wastewater known as “combined sewers”. Flooding can result when the sewer is overwhelmed by heavy rainfall, becomes blocked, or has inadequate capacity; this will continue until the water drains away.

Currently surface water runoff from the Polo Mews area is discharged to a series of private combined sewers, which appear to discharge into the foul sewer network. The drainage proposals, discussed in section 8.6 below, include retrofitting SuDS and propose to incorporate a new dedicated surface water drainage network for the Polo Mews area. As a result, this will help to reduce the risk of flooding from sewers.

Flooding from Reservoirs, Canals and Other Artificial Sources – Non-natural or artificial sources of flooding can include reservoirs, canals, and lakes, where water is retained above natural ground level. In addition, operational and redundant industrial processes including mining, quarrying, sand and gravel extraction, may also increase the depth of floodwater in areas adjacent to these features.

The potential effects of flood risk management infrastructure and other structures also needs to be considered. For example, reservoir or canal flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure.

Inspection of the OS mapping for the area shows that there are no artificial sources of flooding within close proximity to the site. In addition, the EA’s ‘Flood Risk from Reservoirs’ map shows that the site is not located within an area considered to be at risk of flooding from reservoirs. Therefore, the risk of flooding from this source is considered to be low.

A summary of the overall risk of flooding from each source is provided in Table 3.1 below.

Source of Flooding	Initial Level of Risk	Appraisal method applied at the initial flood risk assessment stage
Flooding from Main Rivers Ordinary or Man-Made Watercourses (Fluvial)	Flooding attributed to surface water appraised in section 5	OS mapping and the EA 's 'Flood Map for Planning'
Surface Water	Appraised further in section 5	EA's 'Flood Risk from Surface Water' map
Sea	Low	OS mapping and the EA's 'Flood Map for Planning'
Groundwater	Low	BGS Geology of Britain Mapping and information detailing previous works onsite
Sewers	Low	Asset location data provided by Thames Water and information detailing previous works onsite
Artificial Sources	Low	OS mapping and EA's 'Flood Risk from Reservoirs' map

Table 3.1 – Summary of flood sources and risks.

4 Climate Change

The global climate is constantly changing, but it is widely recognised that we are now entering a period of accelerating change. Over the last few decades there have been numerous studies into the impact of potential changes in the future and there is now an increasing body of scientific evidence which supports the fact that the global climate is changing as a result of human activity. Past, present, and future emissions of greenhouse gases are expected to cause significant global climate change during this century.

The nature of climate change at a regional level will vary for the UK, projections of future climate change indicate that more frequent short-duration, high-intensity rainfall, and more frequent periods of long-duration rainfall could be expected.

These effects will tend to increase the size of Flood Zones associated with rivers, and the amount of flooding experienced from other inland sources. The rise in sea level will change the frequency of occurrence of high-water levels relative to today's sea levels. It will also increase the extent of the area at risk should sea defences fail. Changes in wave heights due to increased water depths, as well as possible changes in the frequency, duration and severity of storm events are also predicted.

4.1 Planning Horizon

To ensure that any recommended mitigation measures are sustainable and effective throughout the lifetime of the development, it is necessary to base the appraisal on the extreme flood level that is commensurate with the planning horizon for the proposed development. The NPPF and supporting Planning Practice Guidance Suite state that residential development should be considered for a minimum of 100 years. The development that is the subject of this FRA is classified as residential therefore a design life of 100 years has been assumed.

4.2 Potential Changes in Climate

Peak Rainfall Intensity

Recognising that the impact of climate change will vary across the UK, the allowances were updated in May 2022 to show the anticipated changes to peak rainfall by management catchment.

The proposed development site is located in the London Management Catchment, as defined by the EA 'Peak Rainfall Allowance' maps. Guidance provided by the EA states that this mapping should be used in small catchments (less than 5km^2) or urbanised drainage catchments. For large rural catchments, the peak river flow allowances should be used. In this case, the development site lies within an urbanised drainage catchment and therefore the Peak Rainfall Allowances for the London Management Catchment should be used.

For each Management Catchment, a range of climate change allowances are provided for two different time epochs. For each epoch there are two climate change allowances defined. These represent different levels of statistical confidence in the possible emissions scenarios on which they are calculated. The two levels of allowance are as follows:

- Central: based on the 50th percentile
- Upper End: based on the 90th percentile

The EA has provided guidance regarding the application of the climate change allowances and how they should be applied in the planning process. The range of allowances for the Management Catchment in which the development site is located are shown in Table 4.1 below.

Management Catchment Name	Annual exceedance probability	Allowance Category	2050s	2070s
London	3.3%	Central	20%	20%
		Upper End	35%	35%
	1%	Central	20%	25%
		Upper End	45%	40%

Table 4.1 – Recommended peak rainfall allowances for each epoch for the London Management Catchment.

For a development with a design life of 100 years the Upper End climate change allowance is recommended when assessing that:

- There is no increase in flood risk elsewhere, and.
- Your development will be safe from surface flooding.

From Table 4.1 above, it can be seen that the recommended climate change allowance for this site is a 45% increase for peak rainfall.

5 Probability and Consequence of Flooding

5.1 The Likelihood of Flooding

When appraising the risk of flooding to new development it is necessary to assess the impact of the 'design flood event'. Flood conditions can be predicted for a range of return periods, and these are expressed in either years or as a probability, i.e., the probability that the event will occur in any given year, or Annual Exceedance Probability (AEP). The pluvial 'design flood event' is taken as the 1 in 100 year return period event (1% AEP) including a 40% allowance for climate change (refer to Section 4.2).

It has been identified in section 3 that based on the EA's 'Flood Risk from Surface Water' mapping, the site could be affected by flooding from surface water flowing overland, across the centre of the site. To better understand the risk of flooding from this source, this mapping has been further interrogated and the results of an overland flow model constructed for the flood alleviation works has been referenced.

Whilst the EA's mapping does not include an event which is modelled with an appropriate allowance for climate change, the maps do include a modelled scenario whereby a rainfall event is applied which exceeds the design flood event, represented by the 'low' likelihood of occurrence event. This scenario represents the impacts of an extreme pluvial event with a 1 in 1000 year return period. Whilst it is recognised that the 'low' likelihood of occurrence event can be used to estimate the impacts of climate change, in some case these results are likely to significantly overestimate the risk of flooding at the site which are attributed to climate change.

It should also be recognised that the EA's mapping does not include the existing flood alleviation measures, as delineated in Figure 8.3, which have been designed to manage the flow of surface water across the site. The EA's mapping (Figure 5.1).has been overlain onto the proposed scheme drawings to show the impact during the 'low' likelihood of flooding event without taking into consideration the flood alleviation works, which divert most of the overland flooding underground towards the basin to the north of the site.

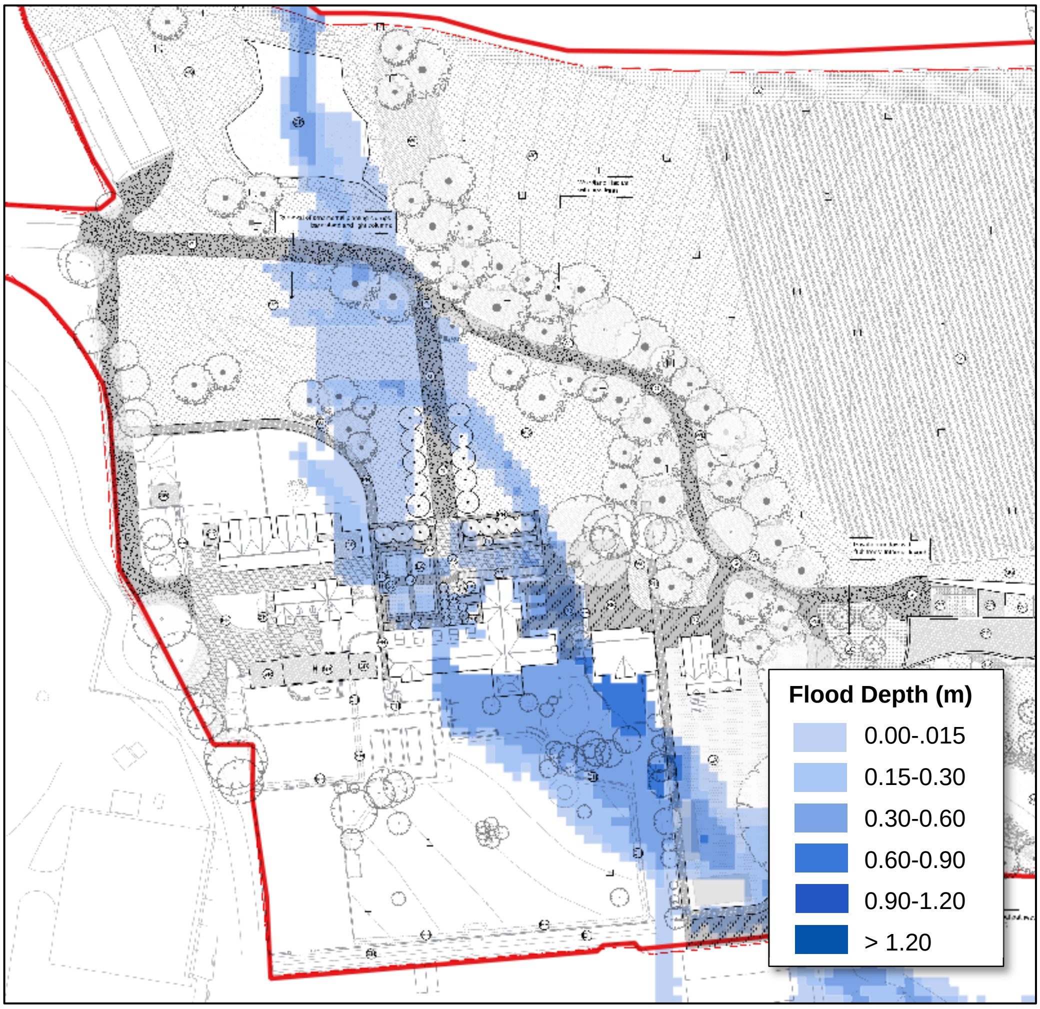


Figure 5.1 – Extent and depth of flooding during the EA's 'Risk of Flooding from Surface Water' 'low' likelihood of occurrence event, overlain onto the proposed site layout – <u>without</u> the flood alleviation scheme.

Even without taking the flood alleviation works into consideration, it is evident from Figure 5.1 that only a very small area of the Bothy House (primarily an area proposed to be a car port/garage) could be subject to shallow flooding of less than 0.15m during this extreme rainfall event. The remainder of the proposed development, including the proposed new house and hydrogen plant building are located outside the predicted extent of flooding.

In reality, whist detailed modelling of the flood alleviation works has not been undertaken, it is evident that a large percentage of the overland flow would be intercepted by the ditch running along the south of the site. The water captured will be diverted towards the series of ponds, which are designed to capture and slow the water reaching the lowest of the ponds. The catchpit located at the bottom of the valley directs water into a large diversion pipe, which carries water away from Greenacres. It is only under a scenario whereby the diversion pipe is blocked that water would follow the overland flow path shown in Figure 5.1. The additional permeable surfacing and improved drainage system surrounding Greenacres would capture the floodwater, diverting into the existing

375mm drainage pipe running beneath Greenacres and out-falling into the woodland to the north of the site. In the extreme unlikely event that both the diversion pipe and 375mm pipe were to block, water would be diverted safely between the buildings at Greenacres and into the holding basin to the north of the site.

In conclusion, the risk of surface water flooding is shown to be low as a direct result of the mitigation measures that have been constructed previously.

6 Offsite Impacts and Other Considerations

6.1 Displacement of Floodwater

The construction of a new building within the floodplain has the potential to displace water and to increase the risk elsewhere by raising flood levels. A compensatory flood storage scheme can be used to mitigate this impact, ensuring the volume of water displaced is minimised.

In this case, it has been identified that the proposed development is located outside the extent of flooding. As such compensatory floodplain storage is not considered necessary.

6.2 Public Safety and Access

The NPPF states that safe access and escape should be available to/from new developments located within areas at risk of flooding. The Practice Guide goes on to state that access routes should enable occupants to safely access and exit their dwellings during design flood conditions and that vehicular access should be available to allow the emergency services to safely reach the development.

It can be seen that the proposed development is located outside the extent of flooding and residents of the proposed development will be able to safely move around the building and complex. The main access road to the site, Kemnal Road, could be subject to flooding from a separate surface water flow path and as such, safe access to the wider area may not be available at the very peak of an extreme rainfall event. Notwithstanding this, the residents can sign up to a flood warning an evacuation plan which will help to minimise any disruption associated with such an event (refer to Section 7.3).

6.3 Proximity to Watercourse

Under the Land Drainage Act 1991, as amended by the Flood and Water Management Act 2010, Lead Local Flood Authorities (LLFA) are responsible for the regulation of ordinary watercourses. The LLFA responsible for the watercourse adjacent to the development site is the London Borough of Bromley. The Land Drainage Act requires that formal written consider is sought for any works adjacent to, or within a watercourse that could affect in-channel flows.

In this instance the proposed development does not encroach towards the Longlands Stream more than the existing site conditions.

7 Flood Mitigation Measures

The key objectives of flood risk mitigation are:

- to reduce the risk of the development being flooded.
- to ensure continued operation and safety during flood events.
- to ensure that the flood risk downstream of the site is not increased by increased runoff.
- to ensure that the development does not have an adverse impact on flood risk elsewhere.

The following section of this report examines ways in which the risk of flooding at the development site can be mitigated.

Mitigation Measure	Appropriate	Comment
Raising floor levels	x	These measures are not considered necessary to include.
Land raising	x	
Compensatory floodplain storage	x	
Alterations/ improvements to channels and hydraulic structures	x	
Flood Defences	x	
Careful location of development within site boundaries (i.e., Sequential Approach)	✓	Refer to section 7.1
Flood resistance & resilience	✓	Refer to Section 7.2
Flood warning	✓	Refer to Section 7.3
Surface water management	✓	Refer to Section 8

Table 7.1 – Appropriateness of mitigation measures.

7.1 Application of the Sequential Approach at a Local Scale

The sequential approach to flood risk management can also be adopted on a site based scale and this can often be the most effective form of mitigation. For example, on a large scheme this would mean locating the more vulnerable dwellings on the higher parts of the site and placing parking, recreational land or commercial buildings in the lower lying and higher risk areas.

For the development that is the subject of this FRA it can be seen that this approach has been adopted and the more vulnerable elements of the development have been located outside the extent of flooding.

7.2 Flood Resistance and Resilience

During a flood event, floodwater can find its way into properties through a variety of routes including:

- Ingress around closed doorways.
- Ingress through airbricks and up through the ground floor.
- Backflow through overloaded sewers discharging inside the property through ground floor toilets and sinks.
- Seepage through the external walls.
- Seepage through the ground and up through the ground floor.
- Ingress around cable services through external walls.

Since flood management measures only manage the risk of flooding rather than eliminate it completely, flood resilience and resistance measures may need to be incorporated into the design of the buildings. The two possible alternatives are:

Flood Resistance or ‘dry proofing’, where flood water is prevented from entering the building. For example, using flood barriers across doorways and airbricks, or raising floor levels. These measures are considered appropriate for ‘more vulnerable’ development where recovery from internal flooding is not considered to be practical.

Flood Resilience or ‘wet proofing’, accepts that flood water will enter the building and allows for this situation through careful internal design for example raising electrical sockets and fitting tiled floors. The finishes and services are such that the building can quickly be returned to use after the flood. Such measures are generally only considered appropriate for some ‘less vulnerable’ uses and where the use of an existing building is to be changed and it can be demonstrated that no other measure is practicable.

Details of flood resilience and flood resistance construction techniques can be found in the document 'Improving the Flood Performance of New Buildings; Flood Resilient Construction', which can be downloaded from www.gov.uk.

A Code of Practice (CoP) for Property Flood Resilience (PFR) has been put in place to provide a standardised approach for the delivery and management of PFR. Further information on the CoP and guidance on how to make a property more flood resilient can be accessed, and downloaded, from the Construction Industry Research and Information Association (CIRIA) Website:

https://www.ciria.org/Resources/Free_publications/CoP_for_PFR_resource.aspx

The use of flood resistance and resilience design is always favoured in location which are potentially at risk of flooding, however, they should be considered as a precautionary option only for this development.

7.3 Flood Warning

It has been identified that the site could experience surface water flooding following an extreme weather event. Occupants of the site are therefore recommended to monitor the Met Office's Weather Warnings to provide forewarning of weather conditions which could result in surface water flooding:

www.metoffice.gov.uk/weather/uk/uk_forecast_warnings.html

8 Surface Water Management Strategy

8.1 Background and Policy

The general requirement for all new development is to ensure that the runoff from the development is managed sustainably and that the drainage solution does not increase the risk of flooding at the site, or within the surrounding area. In the case of brownfield sites, drainage proposals are typically measured against the existing performance of the site, although it is preferable (where practicable) to provide runoff characteristics that are similar to greenfield behaviour.

The Non-statutory Technical Standards for SuDS (NTSS) specify criteria to ensure sustainable drainage is included within development classified as 'major development' as set out in Article 2(1) of the Town and Country Planning (Development Management Procedure) (England) Order 2015. It is, however, recognised that SuDS should be designed to ensure that the maintenance and operation requirements are economically proportionate.

In this instance, the proposed development is for various works across the ~7.11 ha site. As a result, the proposals are classified as 'major' development and therefore, the NTSS will apply. Reference to the NTSS has therefore been made throughout the following sections of this report to ensure the principles of sustainable drainage are considered.

In addition to the NTTS the proposals must take into consideration the requirements of local planning policy. In this case it is likely that the Lead Local Flood Authority (LLFA) will request above ground SuDS be used where possible.

8.2 Surface Water Management Overview

The main characteristics of the site that have the potential to influence surface water drainage are summarised in Table 8.1 below. For the purposes of this summary, the existing and proposed impermeable areas only consider the parts of the site which are subject to change as a result of the development proposals (brownfield). They exclude the vineyard, as discussed in section 2.2. (above).

Site Characteristic	Value
Total area of site	7.11 ha
Impermeable area (existing)	Polo mews – ~1610 m^2 Existing driveway – 3480 m^2 **Total = ~ 5090 m^2**
Impermeable area (proposed)	Hydrogen plant – 50m^2 Driveway – 2687 m^2 New house – 1025 m^2 Polo mews – 1269 m^2 **Total = 5028 m^2**
Current site condition	Brownfield Site
Infiltration coefficient	0.01 m/hr or less (assumed based on underlying geology and typical observed soil conditions)
Current surface water discharge method	Combination of discharging to sewer system and existing watercourse
Is there a watercourse within close proximity to site?	Yes (Longlands Stream)

Table 8.1 – Site characteristics affecting rainfall runoff.

Reference to the tables above show the proposed development will result in a decrease in the percentage of impermeable area within the boundaries of the site. Notwithstanding this, it will still be necessary to provide mitigation measures to ensure that the rate of runoff discharged from the site is managed appropriately, to best replicate the greenfield site conditions, in accordance with the NTSS.

As the proposals consist of a series of smaller developments within the existing predeveloped site, each element of the proposed scheme, is shown on the site plan, Figure 8.1 below.

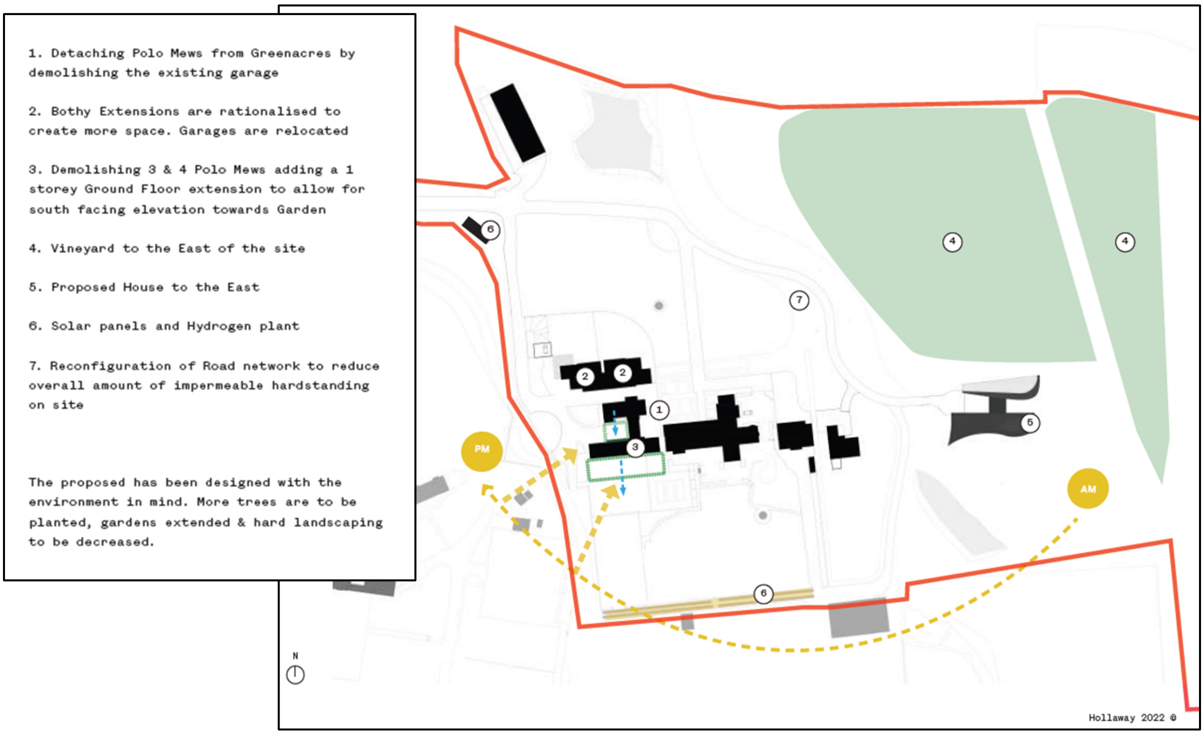


Figure 8.1 – Concept masterplan detailing the extent of proposed development at the site, extracted from the Design and Access Statement.

Furthermore, the potential use of SuDS within each element the proposed development will be considered to assess the practicality of better replicating greenfield behaviour, in accordance with Local Planning Policy, and S3 and S5 of the NTSS.

8.3 Existing Drainage

The majority of the existing site drains to the watercourse (Longlands Stream), through a combination of natural overland flow, partial infiltration into the ground, and through the underlying Harwich Formation bedrock. Water is transported via a network of drains, culverts, and channels, which ultimately drain into the watercourse crossing the site.

Figure 8.2 (below) is a plan showing the existing onsite drainage, in relation to the proposed development. The drainage surrounding the existing house, which is to remain unchanged, has been excluded from this figure. This includes some areas of permeable hardstanding, and numerous gullies and slot drains used to drain the area around the existing house into the culverted watercourse located beneath the building.

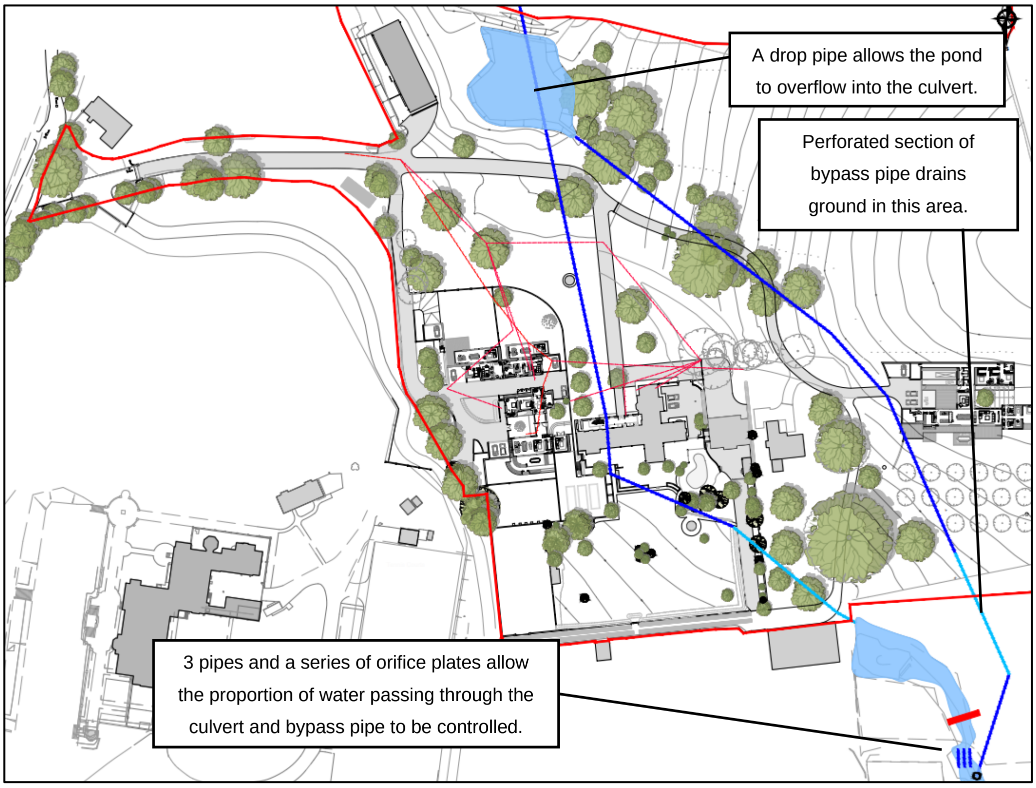


Figure 8.2 – Existing drainage layout for Home Farm, Chislehurst.

From Figure 8.2 (above) the following is evident:

1) The undeveloped greenfield area where the new house is proposed drains directly to the existing watercourse by overland flow. Some of the runoff from this area may become impounded by an existing embankment, where it is likely to infiltrate into the perforated pipe and bypass culvert which drains into the watercourse. Both of which were installed previously as part of the flood alleviation works.

2) The existing drainage for the Polo Mews discharges into the foul sewer network. Any water overflowing from the foul sewer, e.g. during a flood event, will most likely flow overland into the basin to the north of the site, or to the surrounding formal drainage, which discharges to the culvert beneath Greenacres. In both cases, any water which overflows from the sewer network could end up in the watercourse.

3) The existing driveway drains water informally to a filter strip, and subsequently to the adjacent land. Any runoff draining from the existing driveway is likely to be discharged into the northern basin and therefore, the watercourse.

Greenfield Runoff rates have been calculated for the area of the site being redeveloped and are summarised in Table 8.2 (below). These rates are based on the combined total area being developed (5028 m^2) from Table 8.1 (above) and uses the FEH statistical method and FEH 2019 point data.

Return Period (years)	Greenfield Runoff Rate (l/s)
2	0.6
QBar	0.6
10	1.0
30	1.5
100	1.7
100 + 45%	2.0

Table 8.2 – Summary of greenfield runoff rates for the area of the site being developed.

In accordance with the NTSS, the proposed drainage will aim to restrict runoff rates to the greenfield rates, as detailed in Table 8.2 above. It is, however, acknowledged that brownfield runoff rates from the existing driveway and Polo Mews are likely to vastly exceed the calculated greenfield runoff rates for the site, due to the large expanse of impermeable surfacing and the existing drainage in these areas. As a result, if greenfield runoff rates cannot be achieved, the proposed SuDS will need to be designed to ensure that runoff rates are not increased as a result of the proposed development. Calculations have therefore also been undertaken to estimate the existing brownfield runoff rates from the areas of the site which are proposed to be developed, and these are summarised in Table 8.3 (below).

Return Period (years)	Brownfield Runoff Rates (l/s)	
	Existing Polo Mews	Existing Driveway
2	32	70
10	70	152
30	95	205
100	123	267
100 + 45%	197	425

Table 8.3 – Summary of brownfield runoff rates for the area of the site proposed to be developed.

Further investigation may be required as part of the detailed design to confirm the exact layout of the existing underground drainage network, particularly in the area around the Polo Mews, as well as the potential to utilise any pre-existing connections to the culverted watercourse.

8.4 Opportunities to Discharge Surface Water Runoff

Part H of the Building Regulations summarises a hierarchy of options for discharging surface water runoff from developments. The preferred option is to infiltrate water into the ground, as this deals with the water at source and serves to replenish groundwater. If this option is not viable, the next option is for the runoff to be discharged into a watercourse. Water should only be discharged into the public sewer system if neither of these options are possible.

The following opportunities for managing the surface water runoff discharged from the development site are listed in order of preference:

Water Re-Use - Water re-use systems can rarely manage 100% of the surface water runoff discharged from a development, as this requires the yield from the building and hardstanding area to balance perfectly with the demand from the proposed development. Consequently, whilst rainwater recycling systems could be considered for inclusion within the scheme, an alternative solution for attenuating storm water would still be required.

Infiltration – Previous site investigations (trenches constructed across the site) have confirmed that the soils at this site comprise clay and thus, are likely to be relatively impermeable. Beneath this layer of clay are mapped deposits from the Harwich Formation, and deep below these are deposits are chalk.

The presence of the field which is drained via a perforated pipe, suggests that groundwater levels across the site could rise and combined with the clay soils, could restrict the potential for infiltration SuDS, even if the deposits at depth are confirmed to have higher infiltration rates.

From the previous investigations carried out it is considered unlikely that infiltration SuDS will be suitable for use at the development site and as a result, an alternative method for draining the proposed development will be required. Infiltration testing can be undertaken at the detailed design stage to confirm these assumptions if necessary.

Discharge to a watercourse – Figure 8.2 (above) shows the location of an existing watercourse which crosses the site. Due to the proximity of this watercourse, it is likely that a direct connection will be possible and will present the most sustainable solution for draining surface water runoff from the proposed development.

Discharge to public sewer system – As an alternative preferred solution is available, a new surface water connection to the public sewer system will not be required.

8.5 Constraints and Further Considerations

The key constraints that are relevant to this development are listed below:

- It is assumed that there will be no practicable opportunity to retrofit SuDS into the drainage system for the areas of the development site where works are not being carried out. This includes for the majority of the existing house (Greenacres), which will remain unchanged. Any hardstanding, such as the retained sections of the driveways, will also not be included with the new drainage proposals.

- Some of the existing structures will be retained and as such, there may be limited opportunity to incorporate SuDS within these existing buildings. Retrofitting SuDS into the retained parts of the development may present an unsustainable or unattainable situation if a large part of the existing drainage onsite remains unchanged.

- If connections to the watercourse crossing the site are to be constructed, it will be necessary to obtain ordinary watercourse consent from the LLFA before construction can commence.

- To avoid the need for a dedicated management company, or complex covenants, it is envisaged that each property will have a separate drainage system and the responsibility for the continued maintenance will fall to the individual property owners.

- Ideally post development runoff rates should be restricted to greenfield runoff rates. However, on sites where discharge rates are exceptionally low (less than 2.0l/s) higher rates are generally considered acceptable, due to the technical limitations of flow control devices. In this case a limiting discharge rate of 2.0l/s is likely to be acceptable by the LPA and LLFA.

8.6 Proposed Surface Water Management Strategy (SWMS)

The drainage strategy set out below discusses each of the different elements of the proposed scheme, along with the results of a hydraulic drainage model that has been constructed to demonstrate how the overall objectives can be achieved. This does not represent a detailed surface water drainage design; it is simply an assessment to demonstrate that the objectives and requirements of the NPPF and NTSS can be met at the planning stage.

Areas 1, 2 and 3 – Detaching the Polo Mews and constructing new hardstanding within the adjacent courtyard.

Drainage for the Polo Mews can include disconnecting the rainwater downpipes from the existing foul sewer network and diverting them into a new dedicated surface water drainage network. These surface water drains will discharge runoff from the existing and redeveloped buildings to a large geocellular storage tank. Runoff from the courtyard and area of hardstanding adjacent to the Polo Mews buildings can also be drained into this storage tank, via a series of new linear channel drains and gullies within the courtyard. The outfall from the storage tank can be connected into the basin located to the north of the site, or directly to the existing culverted watercourse.

Flows from the geo-cellular storage tank can be attenuated using a flow control device (Hydro-Brake or similar). Details of the proposed geocellular storage tank have been provided in Table 8.4 and an indicative drainage layout plan showing the proposed Polo Mews area has been provided in Figure 8.3 (below)

Parameter	**Value**
SuDS	Geocellular Storage
Area draining to SuDS	1270 m^2
Dimensions of SuDS	225m^2 x 1m (deep)
Porosity of Crates	95%
Infiltration Rate	Negligible
Flow control device	Hydro-Brake
Limiting discharge rate	2.0l/s
Critical storm duration	480 minutes
Volume stored during design rainfall event	136 m^3

Table 8.4 – Summary of the proposed Geo-cellular storage tank.

Figure 8.3 – Indicative drainage layout for the Polo Mews showing the geocellular storage tank.

Demolition of existing buildings

Whilst the demolition of the buildings and areas of hardstanding do not present any new opportunities for incorporating SuDS, nonetheless, these areas do reduce the impermeable surfacing. By default, this will reduce the total volume and rate of runoff discharged offsite from these areas.

Area 4 – Vineyard

The vineyard does not require planning permission and as such, has been excluded from the analysis.

Area 5 – New residential dwelling (New House)

Runoff draining from the new house can be discharged to the watercourse via a large basin, located within the garden area of the property. The outflow from this basin can be restricted to 2.0l/s using a flow control device (e.g. Hydro-Brake or similar). The basin may need to be lined to prevent water discharging directly to the ground and it is envisaged that the outfall from the new basin will either drain into the existing pond downstream of the inlet to the bypass pipe, or connected to the bypass pipe directly. Details of the proposed basin are provided in Table 8.5 and the indicative drainage layout plan delineates the drainage for proposed new house, refer to Figure 8.4.

Parameter	Value
SuDS	Basin / Pond
Area draining to SuDS	1020 m^2
Dimensions of SuDS	300m^2 x 0.75m (deep)
Porosity	100%
Infiltration Rate	Negligible (lined to prevent groundwater ingress, and direct outflows to underlying perforated pipe)
Flow control device	Hydro-Brake
Limiting discharge rate	2.0l/s
Critical storm duration	240 Minutes
Volume stored during design rainfall event	112 m^3

Table 8.5 – Summary of the proposed basin / pond.

Figure 8.4 – Indicative drainage layout plan for the proposed new house, showing the basin.

Area 6 – Construction of a Hydrogen Plant

The surface water drainage for the hydrogen plant can discharge into a small rain garden located adjacent to the proposed building. This rain garden can be designed with an overflow that allows excess water to drain into the sub-base located beneath the adjacent permeable access road. Details of the proposed rain garden are provided in Table 8.6 (below).

As the rain garden will only include an outfall via the overflow system, it may be full prior to the onset of the design rainfall event and has therefore been excluded from the drainage calculations.

Parameter	Value
SuDS	Rain Garden
Area draining to SuDS	~50m^2
Dimensions of SuDS	13 m^2 x 300mm (deep)
Porosity	~ 90%
Infiltration Rate	Negligible
Flow control device	None
Outfall	Overflow draining directly to the adjacent permeable surfacing system
Volume / capacity when full	~ 3.5m^3 (max)
Included within drainage model	No

Table 8.6 – Summary of the proposed rain garden.

Area 7 – Driveway

The proposed main driveway / access road can be made permeable and laid atop a sufficient thickness of open graded granular sub-base, to ensure that the road has sufficient storage capacity for stormwater draining from the surface of the roads and the adjacent inflows from the hydrogen plant. For the purpose of the calculations, an area of ~1550m^2 (out of the 2670m^2 of road) has also been assumed to be impermeable, as this will allow for the steeper sections of the access road to drain into the flatter areas lower down the hill, where the gradient is shallower.

The outfall from the permeable surfacing system can drain into to the existing basin, which overflows via a pipe into the culverted watercourse. Flows from the permeable surfacing system can be restricted to no greater than 2.0l/s using a flow control device (e.g. Hydro-Brake or similar). The sub-base depth used within the drainage model has been based solely on the attenuation and storage capacity requirements for the permeable surfacing. Additional analysis should be undertaken at the detailed design stage to ensure that the structural design of the paving system is suitable.

To allow floodwater to pass through the permeable surfacing and into the sub-base in areas where the driveway is slightly raised, a series of pipes can be included within the design. These pipes can pass through the sub-base and drain into a small swale located to the north of the access road.

Details of the proposed permeable surfacing system are provided in Table 8.7 and an indicative drainage layout plan showing the proposed new house has been provided in Figure 8.5 (below).

Parameter	Value
SuDS	Permeable Surfacing
Area draining to SuDS	~2690 m^2
Dimensions of SuDS	1130 m^2 x 1m (deep)
Porosity	30%
Infiltration Rate	Negligible
Flow control device	Hydro-Brake
Limiting discharge rate	2.0l/s
Critical storm duration	720 Minutes
Volume stored during design rainfall event	321 m^3

Table 8.7 – Summary of the proposed permeable driveway.

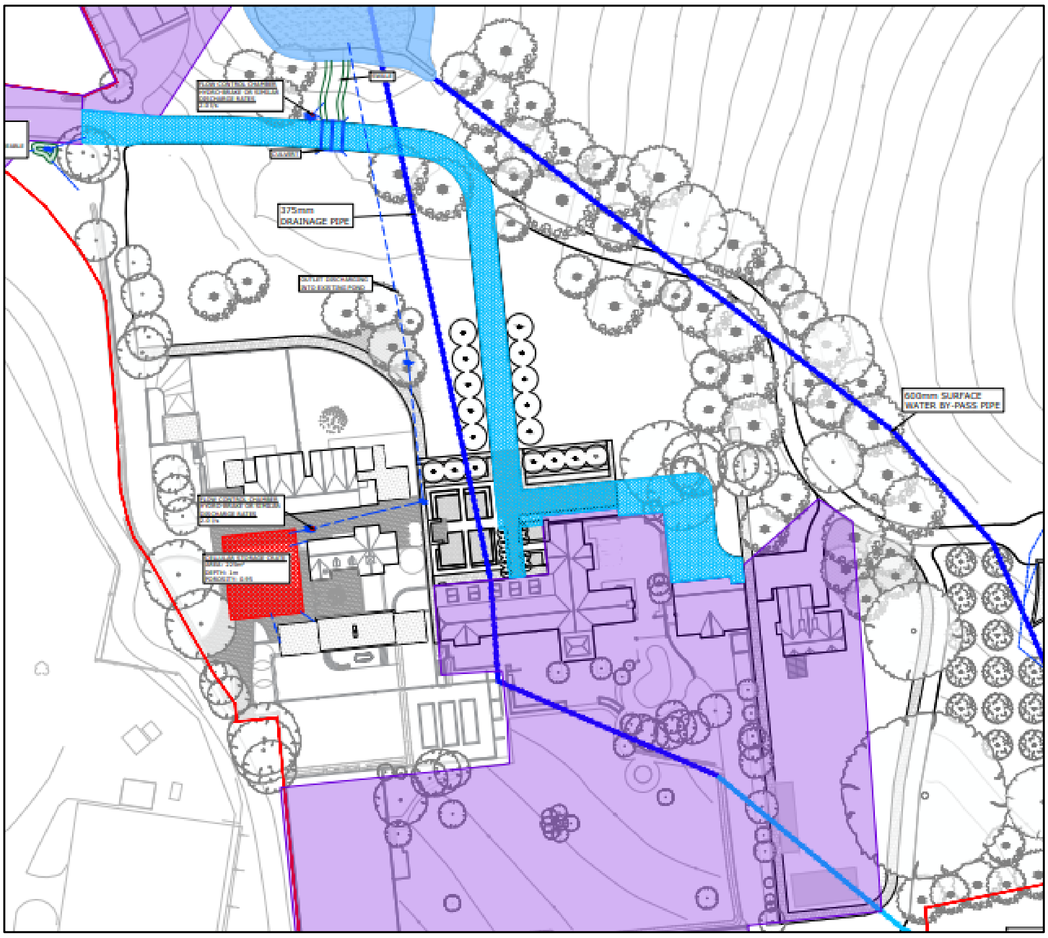


Figure 8.5 – Indicative drainage layout plan for the proposed driveway (permeable), shown in blue.

8.7 Hydraulic Drainage Model

A hydraulic drainage model for the proposed drainage system and SuDS has been constructed in Causeway Flow + and used to confirm that the proposed drainage system will provide sufficient storage and attenuation for runoff draining into Longlands Stream (watercourse). Table 8.8 below provides a summary of the pre- and post-development discharge rates, based on the results of this drainage model.

Return period (years)	Courtyard and Polo Mews (storage tank) (l/s)	New House (pond / basin) (l/s)	Driveway and hydrogen plant (raingarden and permeable surfacing system) (l/s)	*Combined discharge offsite. (l/s)
2	1.2	1.5	1.8	4.0
10	1.7	1.6	2.0	5.2
30	1.7	1.7	2.0	5.2
100	1.7	1.7	2.0	5.2
100 + 45%	1.7	1.7	2.0	5.2

Table 8.8 – Summary of peak runoff rates from the proposed development (including SuDS).

** Combined discharge offsite may differ from the sum of the outfall from each of the SuDS, due to each of the SuDS being subject to a slightly different critical storm durations.*

From Table 8.8 (above) it is evident that by including SuDS, as outlined above, the proposed development can restrict the rates to a maximum of 2 l/s, per outfall. In addition to attenuating flows from across the development, the combination of proposed rain gardens, permeable surfacing and basins, should also provide an improvement to the quality of the water draining from the site.

8.8 Management and Maintenance

For any surface water drainage system to operate as originally designed, it is necessary to ensure that it is adequately maintained throughout its lifetime.

The key requirements of any management regime are routine inspection and maintenance. When the development is taken forward to the detailed design stage, an 'owner's manual' will need to be prepared. This should include:

- A description of the drainage scheme.
- A location plan showing all of the SuDS features and equipment, such as flow control devices etc.
- Maintenance requirements for each element, including any manufacturer specific requirements.

- An explanation of the consequences of not carrying out the specified maintenance.
- Details of who will be responsible for the ongoing maintenance of the drainage system.

For the SuDS recommended by this assessment, the most obvious maintenance tasks will be cleaning the permeable surfacing and de-silting the basins, rain gardens and any underground storage areas. For the latter, it is important to ensure that the design must recognise the need for this operation and thus incorporate silt traps and easy access for emptying.

The maintenance requirements for the various SuDS measures incorporated into the proposed scheme are outlined in the following section.

For developments such as this that rely to some extent on the ongoing inspection and maintenance of SuDS, it will be necessary to ensure that measures are in place to maintain the system for the lifetime of the development. One option could be to task the property owners with the maintenance responsibilities for each individual property and the associated drainage features. However, measures will need to be put in place to ensure occupants are made aware of maintenance schedules and maintenance for any communal elements of the scheme should be shared evenly between all of the owners / occupiers.

8.9 Sensitivity Testing and Residual Risk

It is necessary to ensure that the drainage proposals will not increase the risk of flooding if the drainage system becomes blocked, or if a rainfall event exceeds the design rainfall event.

Inspection of the topography across the site suggests that if the permeable surfacing system was to block, or become overwhelmed following an extreme rainfall event, water would exit the system and would flow overland. Figure 8.6 shows the most likely path water would take as it flows across the site.

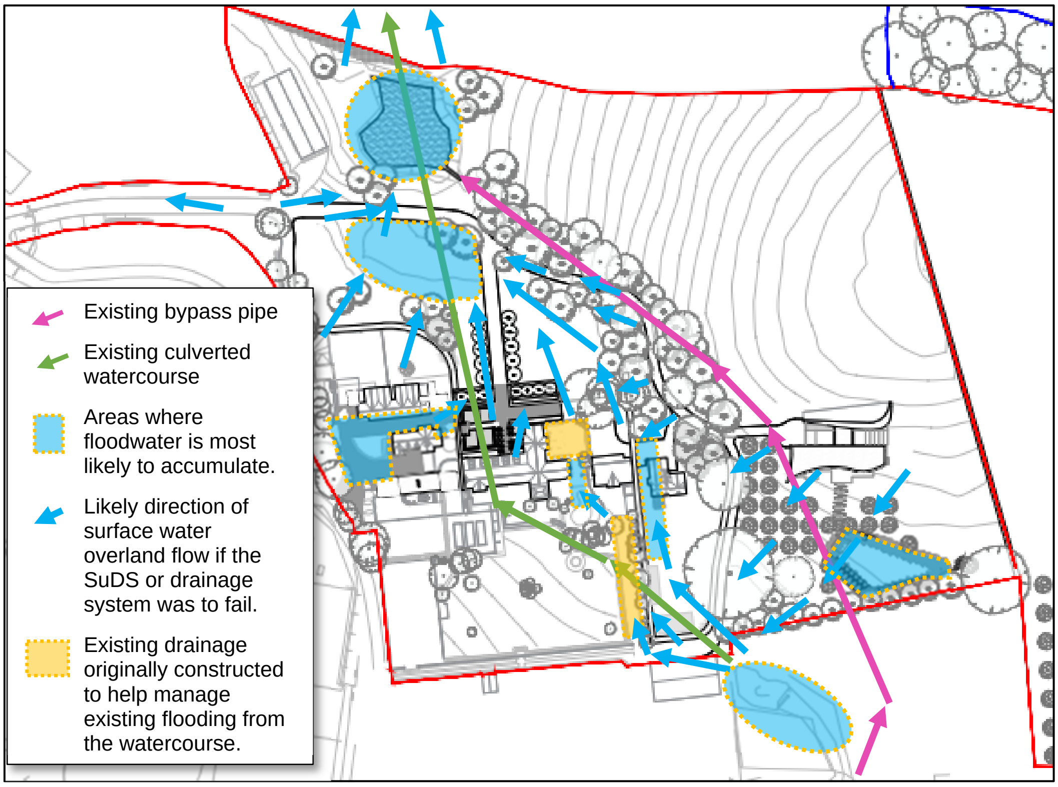


Figure 8.6 – Anticipated flow routes during an exceedance or blockage event.

From Figure 8.6, above it is evident that there are several areas where flooding may occur if the drainage system was to fail from a blockage, or during an exceedance event. If the new basin or the drains surrounding the existing house were to overflow, water would flow downhill towards the existing basin to the north of the site. If the culverted watercourse beneath Greenacres is at capacity, then water will be directed between the gap between the existing house and adjacent building (currently in use as an office). This artificially managed overland flow path formed part of the previous flood alleviation works and is designed to allow water to be directed towards the main basin, located to the north of the site.

If the cellular storage or drainage for the Polo Mews was to become blocked, or become surcharged, a similar situation may occur. A small amount of localised flooding could occur around the existing buildings, however, the risk of flooding in this area will generally be lower, when compared to the pre-existing situation. This is due to the additional storage proposed as part of the development (i.e. provided by the geocellular storage tank), and by decoupling the surface water drainage from the foul sewers in this area.

For the proposed raingarden, hydrogen plant and driveway, it is likely that any failure will result in runoff flowing overland into the existing basin located to the north of the site. This water is unlikely to present a significant risk to the occupants of the site. Furthermore, the additional storage provided within the permeable surfacing system should improve the situation when compared to the current impermeable driveway.

Based on the analysis above it is therefore concluded that with the inclusion of the proposed SuDS discussed within this strategy, the development will not increase the risk of flooding on or off-site.

9 The Sequential Test and Exception Test

Local Planning Authorities (LPA) are encouraged to take a risk-based approach to proposals for development in or affecting flood risk areas through the application of the **Sequential Test**. The objectives of this test are to steer new development away from high-risk areas towards those areas at lower risk of flooding. However, in some locations where developable land is in short supply there can be an overriding need to build in areas that are at risk of flooding. In such circumstances, the application of the Sequential Test is used to ensure that the lower risk sites are developed before the higher risk ones.

In this circumstance, it is recognised that the site is located within Flood Zone 1 (Figure 3.1), and therefore, is located in the lowest possible flood risk zone. The previous flood alleviation works have significantly reduced the risk of surface water flooding in this area and the new areas of proposed development are predominately located away from the areas of high risk. Considering the above, it is concluded that there is evidence that the development cannot be located elsewhere and therefore that the Sequential Test can be passed.

As the site is located within Flood Zone 1, the **Exception Test** is not required to be applied, however, as the NPPF requires a flood risk assessment to be prepared to accompany all planning applications for sites greater than 1 hectare, the primary focus of the FRA has been to appraise the risk of flooding from all sources.

10 Conclusions

The overarching objective of this report is to appraise the risk of flooding at Home Farm, Kemnal Road, Chislehurst, to ensure that the proposals for development are acceptable and that any risk of flooding to the occupants of the proposed residential dwellings is appropriately mitigated. In addition, the NPPF also requires the risk of flooding offsite to be managed, to prevent any increase in flood risk as a result of the development proposals. This report has therefore been prepared to appraise the risk of flooding from all sources and to provide a sustainable solution for managing the surface water runoff discharged from the development site.

From the evidence presented the Sequential Test is assumed to be passed, and given the location of the site within Flood Zone 1, the Exception Test is not necessary to be applied. Nevertheless, as the subject site is larger than 1 hectare in size, it is still necessary to examine the impact of all sources of flooding to the development, which has been the focus of this site-specific FRA.

The risk of flooding has therefore been considered across a wide range of sources and it is only during an extreme rainfall event that the proposals could be at risk of flooding. However, a series of flood mitigation measures have previously been installed, which formed part of a site-specific flood alleviation scheme. The alleviation scheme was designed to direct surface water away from the existing buildings and to retain water in the existing watercourse, before divert flows towards a new storage basin located to the north of the site.

Furthermore, the surface water drainage strategy included within this report demonstrates that the development will not increase flood risk elsewhere by incorporating appropriate mitigation measures and SuDS within the scheme. This includes realigning the driveway using permeable materials, a geocellular storage tank with a flow control device, and above ground SuDS in the form of rain gardens and ponds. The proposed drainage system has been tested for the design rainfall event and is shown to significantly reduce the discharge rate when compared to the existing site.

In conclusion, following the recommendations of this report, the occupants of the overall development will be safe, and the development will not increase the risk of flooding elsewhere. Consequently, it has been demonstrated that the development will therefore meet the requirements of the NPPF and NTSS.

11 Appendices

Appendix A.1 – Drawings

Appendix A.2 – Surface Water Management Calculations

Appendix A.3 – Indicative Drainage Layout

Appendix A.4 – Maintenance Schedules