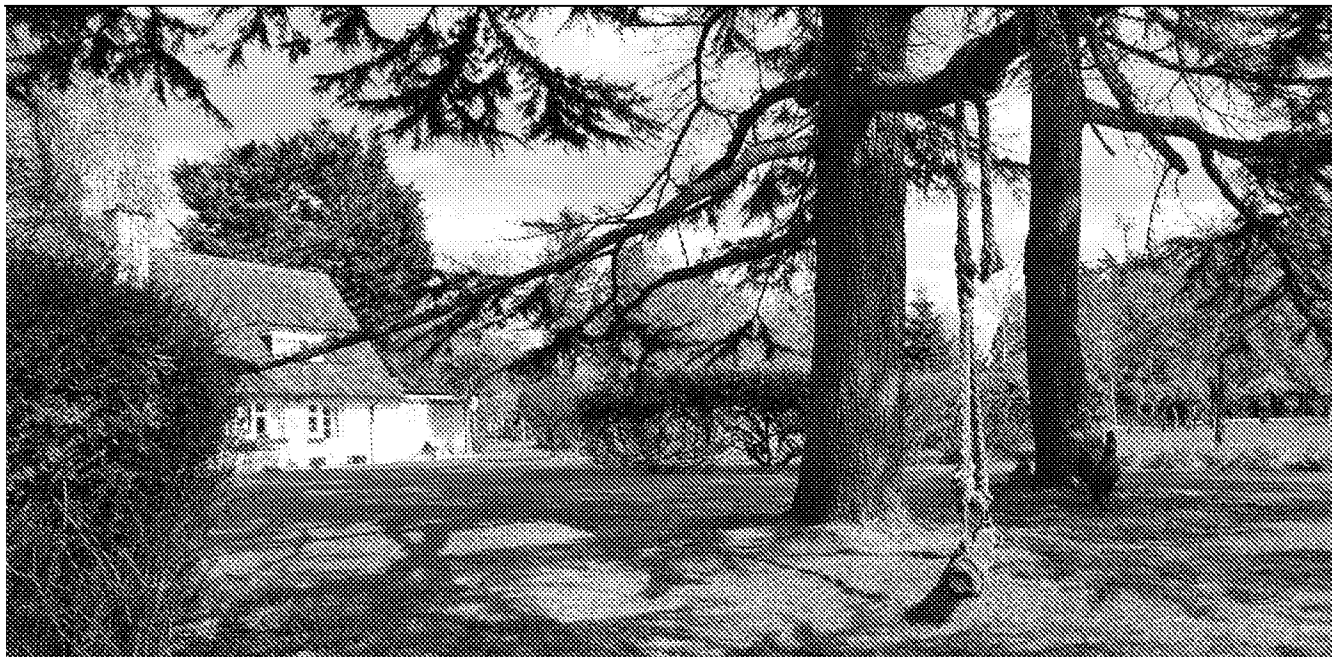




Flood Risk Assessment

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PROJECT:

**THE COTTAGE, SHRIPNEY
THE COTTAGE, SHRIPNEY ROAD
BOGNOR REGIS
WEST SUSSEX, PO22 9PA**

CLIENT:

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Executive Summary

Castle Property Developments Ltd has commissioned Hilson Moran Partnership Ltd (Hilson Moran) to prepare a National Planning Policy Framework (NPPF) compliant Flood Risk Assessment (FRA) for its residential development located on land at The Cottage, Shripney Road, Bognor Regis, PO22 9PA, National Grid Reference SU 93828 02318.

This document constitutes a formal FRA to NPPF guidelines, appropriate to the scale and nature of the development and risks involved.

The proposed development site comprises a total area of 0.72 ha, currently occupied by one dwelling, agricultural land, including greenhouses, trees and hedgerows. The Outline Planning Application for the site seeks to construct 31 new houses and flats following the demolition of the existing dwelling and outbuildings. According to NPPF Technical Guidance, such residential use is considered “**More Vulnerable**” to flood risk.

The Arun District Council (ADC) Strategic Flood Risk Assessment (SFRA) provides a detailed account of the risk of flooding across the borough and, as such, supplements the Environment Agency (EA) Flood Map. These indicate that the proposed development is currently wholly located in the EA’s Flood Zone 1. Referring to NPPF Technical Guidance, the location of the proposed development would be categorised as “Low Flood Probability” - *i.e.* the annual probability of flooding from riverine sources is less than 0.1 %. Consequently, there is no requirement to provide compensatory fluvial flood storage and the residual risk of fluvial/coastal flooding is deemed to be of **neutral/negligible significance**. However, part of the site is modelled to be at risk of undefended risk of flooding by 2070 and the whole site by 2115, although the site is currently protected by tidal flood defences and the EA is committed to maintain the current Standard of Protection (SoP) throughout the lifetime of the proposed development. Nevertheless, flood resilience measures are recommended to reduce the residual risk of flooding. This will be achieved by ensuring that the ground floor levels are raised above the 2070 flood level and by employing a flood exclusion strategy to protect the dwellings by 2115. The residual risk with climate change taken into account would therefore be considered of **negligible/neutral significance**.

A review of EA, ADC information demonstrates that the site does not lie within an area susceptible to groundwater flooding. The risk of groundwater flooding to the proposed development is therefore considered of **negligible/neutral significance**.

EA and ADC resources demonstrate that the site has low susceptibility to surface water flooding. The risk of flooding of the proposed development from surface water flooding is therefore considered **negligible/neutral significance**.

There are no records of surface water sewer problems or flooding incidents from highway drainage within the vicinity of the site. Consequently, the risk of flooding of the site from sewers is therefore considered **negligible/neutral significance**.

Neither the ADC SFRA nor the EA identify any potential flooding from reservoirs, canals and/or other artificial sources specifically within the application site. The risk of flooding of the site from artificial drainage bodies is therefore considered **negligible/neutral significance**.

Within the bounds of the proposed development site, infiltrating subsurface storage will be incorporated into the design to sustainably manage runoff from rainfall events up to and including the 1 in 100 year event.



As a consequence of the proposal, the rate of runoff generated from the site will be maintained at the current greenfield rate. The effect of the proposed redevelopment on the volume and rate of surface runoff generated is, therefore, deemed to be of **neutral/negligible significance**.

The Sustainable Drainage System (SuDS) for the proposed redevelopment will be designed to accommodate all additional runoff from the site for rainfall events up to and including the 1 in 100-year event and infiltrate it to ground. Consequently, there will be no requirement for additional discharges to the surface water sewer system, and thus no mitigation is deemed necessary. The residual risk from surface water sewer flooding is therefore deemed to be of **neutral/negligible significance**.

It is anticipated that the proposed redevelopment will lead to an increase in foul water discharges from the site. The developer will augment the existing sewer infrastructure accordingly. In accordance with Building Regulations Part G, it is also anticipated that low water consumption appliances (low-flow taps and white goods) will be introduced throughout the proposed redevelopment, which will minimise foul water discharges. Following the introduction of these measures, the residual impact of the proposed redevelopment on the local sewerage infrastructure is deemed to be of **neutral/negligible significance**.

In light of the above, the principle of the proposed redevelopment is deemed acceptable on flood risk grounds and will provide a positive contribution to the sustainable management of surface water runoff.

A summary of the flood risks associated with the redevelopment is presented as Table 0-1.

Table 0-1 - Summary of Flood Risks associated with the Proposed Development

Effect	Impact	Mitigation	Residual Impact
Displacement of floodwater	Negligible/neutral (Flood Zone 1)	None required.	Negligible/neutral
Groundwater emergence	Negligible/neutral	None required.	Negligible/neutral
Flooding from artificial drainage bodies	Negligible/neutral	None required.	Negligible/neutral
Surface water flooding	Negligible/neutral	None required.	Negligible/neutral
Increased surface runoff generation	Minor adverse (through increased impermeable surfaces)	Incorporation of SuDS.	Negligible/neutral
Performance of existing surface water sewage system	Negligible/neutral (none in the vicinity of the site)	Incorporation of SuDS.	Negligible/neutral
Performance of existing foul water sewage systems	Minor adverse	Augment sewer infrastructure & introduce low flow appliances.	Negligible/neutral



1. Introduction

1.1. Background

Hilson Moran Partnership Ltd (Hilson Moran) was appointed by Castle Property Developments Ltd to undertake a FRA and prepare recommendations for the proposed residential development on the 0.72 ha plot of land at The Cottage, Shripney Road, Bognor Regis, PO22 9PA

1.2. Purpose

This FRA accords with the NPPFⁱ, the Flood and Water Management Act (2010) and Building Regulations, Part H (Drainage and Waste Disposal). This report will accompany the planning application and is produced in accordance with guidance contained within the NPPF relating to the necessary requirements of FRAs for the evaluation of risks associated with development.

1.3. Structure

The following sections of the report appraise the pre-existing baseline conditions on the application site, describe the proposed development, flood issues relating to the development, flood risk posed by the development on the surrounding area, scope for mitigation and conclusions of the assessment.

Relevant appendices are included at the end of the report with document control information included at the front.

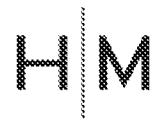
1.4. Scope of the Assessment

This document comprises a FRA with respect to the proposed development of 31 new houses and flats following the demolition of the existing dwelling and outbuildings, on a 0.72 ha site currently occupied by one dwelling and large garden, including greenhouses, trees and hedgerows. The site is centred approximately on National Grid Reference SU 93828 02318.

1.5. Limitation and Copyright

This report has been prepared on behalf of and for the exclusive use of Castle Property Developments Ltd, and is subject to and issued in connection with the provisions of the agreement set out by Hilson Moran. Hilson Moran accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

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2. Policy Framework and Legislative Regulation

2.1. Planning Policy

2.1.1. National

The NPPF sets out policies which apply to the preparation of local plans, and to development management decisions. This framework sets out the Government's economic, environmental and social planning policies for England. Taken together, these policies articulate the Government's vision of sustainable development, which should be interpreted and applied locally to meet local aspirations. The NPPF states that flood risk and surface water disposal are material considerations for Local Planning Authorities (LPAs) when determining individual land-use planning proposals. The NPPF supersedes the previous Planning Policy Statement 25 on the consideration of flood risk in the planning process.

The NPPF reinforces the importance that the Government attaches to the management and reduction of flood risk in the land-use planning process, whilst also adopting a precautionary approach and fully accounting for the effects of climate change. The NPPF states how flood risk should be considered at all stages of planning and development, in an attempt to reduce future loss of life and damage to property.

NPPF states that *"A site-specific flood risk assessment is required for proposals of 1 hectare or greater in Flood Zone 1; all proposals for new development (including minor development and change of use) in Flood Zones 2 and 3, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency); and where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding."*

The site lies wholly within Flood Zone 3 (high risk), however benefiting from flood defences. Consequently, this document constitutes a formal FRA to NPPF guidelines, appropriate to the scale and nature of the development and risks involved.

The NPPF also states that surface water disposal is a material consideration for LPAs when determining individual land-use planning proposals and that SuDS should be incorporated into a development wherever practical.

In particular, Paragraph 103 of the NPPF states that:

'When determining planning applications, local planning authorities should ensure flood risk is not increased elsewhere and only consider development appropriate in areas at risk of flooding where, informed by a site-specific flood risk assessment following the Sequential Test, and if required the Exception Test, it can be demonstrated that:

- 1) *within the site, the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location; and,*
- 2) *development is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed, including by emergency planning, and it gives priority to the use of sustainable drainage systems'.*

The NPPF is supported by Planning Practice Guidanceⁱⁱ, which provides further information on key issues in the implementation of policies identified in the NPPF. The overall aim of the NPPF guidance is to steer development into areas of low flood risk (Flood Zone 1). The NPPF requires LPAs to demonstrate application of the Sequential Test, which aims to steer development into



areas of low flood risk where all development types are considered to be appropriate. Sites in Flood Zone 3 should only be considered where opportunities in Flood Zones 1 or 2 are not reasonably available with the flood risk vulnerability of land uses taken into account and the application of the Exception Test if required.

2.1.2. Local

Local planning policy is provided through the Arun District Council (ADC) Local Plan 2011-2031ⁱⁱⁱ. This sets out the strategy and the detail for the way in which the area will develop over the coming years, identifying policies and principles to be applied in decision making.

The Local Plan states that *“the potential impacts of climate change need to be taken into account in planning for all new development, both in terms of location and design. This will include locating major development away from areas of high flood risk, unless the development will help to remove the flood risk to benefit existing residents, businesses and for economic growth. Energy and water efficiency will have to be taken on board along with water storage measures, sustainable drainage systems, and the provision of renewable energy generation in major development schemes.”*

With relation to flood risk the following policies are of note for this development:

Policy ECC SP1 – Adapting to Climate Change states that:

“The Council will support development which is located and appropriately designed to adapt to impacts arising from climate change such as the increased probability of tidal and fluvial flooding; water stress; health impacts as a result of extreme temperatures and a decline in the quality of habitats and richness of biodiversity.

In order to achieve this, development must be designed to take account of the following issues:

- a. Location (in relation to flood risk and vulnerability to coastal erosion);*
- b. Water efficiency;*
- c. Shade, cooling, ventilation, solar gain;*
- d. Connectivity to the green infrastructure network;*
- e. Layout and massing;*
- f. Resilience of buildings and building materials to extreme weather events; and*
- g. Capacity of drainage systems and incorporation of Sustainable urban Drainage Systems (SuDS)”*

Policy W SP1 – Water states that:

“District's water resources and enhance the quality of the water environment which supports a range of habitats and ecosystems. Development will be encouraged to make active use of surface water as a design feature and permitted where it identifies measures to improve and enhance waterbodies, coastal habitats or provides additional flood relief.

The Council will also support development that:

- a. is appropriately located, taking account of flood risk and promotes the incorporation of appropriate mitigation measures into new development, particularly Sustainable Drainage Systems that reduces the creation and flow of surface water;*
- b. reduces the risk to homes and places of work from flooding whilst increasing biodiversity;*



- c. *delivers a range of community benefits including enhancing the quality of life and providing greater resistance to the impact of climate change.*

Developments with respect to all of the above shall also be consistent with all other Local Plan policies."

Policy W DM2 – Flood Risk states that:

"Development in areas at risk from flooding, identified on the latest Environment Agency flood risk maps and the Council's Strategic Flood Risk Assessment (SFRA), will only be permitted where all of the following criteria have been satisfied:

- a. *The sequential test in accordance with the National Planning Policy Framework Technical Guidance has been met.*
- b. *A site specific Flood Risk Assessment demonstrates that the development will be safe, including access and egress, without increasing flood risk elsewhere and reduce flood risk overall.*
- c. *The scheme identifies adaptation and mitigation measures.*
- d. *Appropriate flood warning and evacuation plans are in place; and*
- e. *New site drainage systems are designed to take account of events which exceed the normal design standard i.e. consideration of flood flow routing and utilising temporary storage areas.*

The reports prepared as part of the criteria above must take into account contingency allowances, taking climate change into account as set out in the NPPF Technical Guidance.

In locations where strategic flood defence or resilient and resistant construction measures are necessary within the site itself, proposals will be required to demonstrate how measures have been incorporated as an intrinsic part of the scheme in a manner which is compatible with the Strategic Flood Risk Assessment.

All development proposals must take account of relevant Surface Water Management Plans, Catchment Flood Management Plans and related Flood Defence Plans and strategies such as the Lower Tidal River Arun Strategy. The council may require financial contributions from development on sites where measures to address flood risk or to improve the environmental quality of watercourses have been identified by these Plans and Strategies.

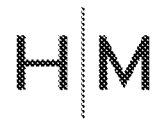
Developments shall also be consistent with all other Local Plan policies."

Additionally Policy W DM3 – Sustainable Urban Drainage Systems states that:

"To increase the levels of water capture and storage and improve water quality, all development must identify opportunities to incorporate a range of Sustainable Urban Drainage Systems (SUDS), appropriate to the size of development, at an early stage of the design process.

Proposals for both major and minor development proposals must incorporate SUDS within the private areas of the development in order to provide source control features to the overall SUDS design. These features include:

- *Green roofs*
- *Permeable driveways and parking*
- *Soakaways*



- *Water harvesting and storage features including water butts.*

Proposals for major development must also integrate SUDS within public open spaces and roads, in liaison with West Sussex County Council, (the SUDS Approval Body) or its agent. SUDS must therefore be integrated into the overall design of a development and must:

- Contribute positively to the appearance of the area*
- Effectively manage water (including its quality)*
- Accommodate and enhance biodiversity by making connections to existing Green Infrastructure assets and*
- Provide amenity for local residents (ensuring a safe environment) and*
- Retain existing open drainage ditches in their current form.*
- Be maintained in perpetuity, supported through a Maintenance and Management Plan/Regime, including its financing, agreed with the Local Planning Authority.*

In order to ensure that SUDS discharge water from the development at the same or lesser rate, as prior to construction, developers must:

- Follow the hierarchy of preference for different types of surface water drainage disposal systems as set out in Approved Document H of the Building Regulations and the SUDS manual produced by CIRIA.*
- Undertake up to six months groundwater monitoring within the winter period.*
- Undertake winter percolation testing in accordance with BRE365.*
- The proposed drainage system must be designed to ensure that there is no flooding on a 1 in 30 year storm event.*
- The design must also take account of the 1 in 100 year storm event plus 30% allowance for climate change, on stored volumes, to ensure that there is no flooding of properties or the public highway or inundation of the foul sewerage system. Any excess flows must be contained within the site boundary, and within designated storage areas."*

2.2. Legislative Regulation

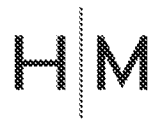
2.2.1. Building Regulations Part H: Drainage and Disposal (2010)

Building Regulations Approved Document Part H^{iv} states that, where feasible, the first choice for surface water removal should be to discharge such waters to an adequate soakaway or infiltration system. If this is not reasonably practicable then discharge should be to a watercourse, the least favoured option being to an existing sewer.

2.2.2. Environmental Protection Act (1990)

The Environmental Protection Act (1990)^v states that 'Contaminated land is any land which appears to be in such a condition, by reason of substances in, on or under the land, that:

- *Significant harm is being caused or there is a significant possibility of such harm being caused, or*
- *Pollution of controlled waters is being or is likely to be caused'.*



2.2.3. Flood and Water Management Act (2010)

The Flood and Water Management Act (FWMA 2010)^{vi} makes specific provision for the management of risks associated with flooding and coastal erosion.

The Act states that construction work which has drainage implications may not be commenced unless a drainage system for the work has been approved by an approving body (unitary authority/county council).

In determining an application for approval the approving body must:

- *'grant it, if satisfied that the drainage system, if constructed as proposed, will comply with national standards for sustainable drainage'; or,*
- *'refuse it, if not satisfied'.*

The Act therefore removes the automatic right to connect to the public sewer if the proposed drainage strategy does not fully consider the feasibility of sustainable drainage techniques.

2.3. Designation of the Development for Flood Risk Assessment Purposes

With regard to the proposed development, the application site has a footprint of approximately 0.72 ha. For FRA purposes, and with reference to the Environment Agency (EA) and Department for Environment, Food & Rural Affairs (DEFRA)'s guidance for flood risk assessment for planning applications, the proposed development does not constitute a *'development of more than 1 ha'*. According to the ADC SFRA and EA Flood Map, the entire application site is located within Flood Zone 1, however it is modelled to be located within Flood Zone 3 by 2115 and therefore it is recommended that the developer provides a FRA for the proposed development to demonstrate that any residual future flood risk is appropriately managed.

3. Proposed Development

3.1. Location

The application site is located in the eastern side of the small village of Shripney, to the north of Bognor Regis. The site is located at the edge of the village alongside the A29 (Shripney Road), with residential houses to the west, and south of the site, agricultural land further to the south and immediately east of the site, whilst the Premier Inn (Bognor Regis) bounds the site to the north. The village of Shripney is generally surrounded by agricultural land.

The site is currently occupied by one dwelling, agricultural land, including greenhouses, trees and hedgerows with a public footpath along the southern boundary of the site. The site is centred approximately on National Grid Reference SU 93828 02318 (refer to Figure 3-1) and occupies an area of approximately 7166 m² (0.7166 ha).

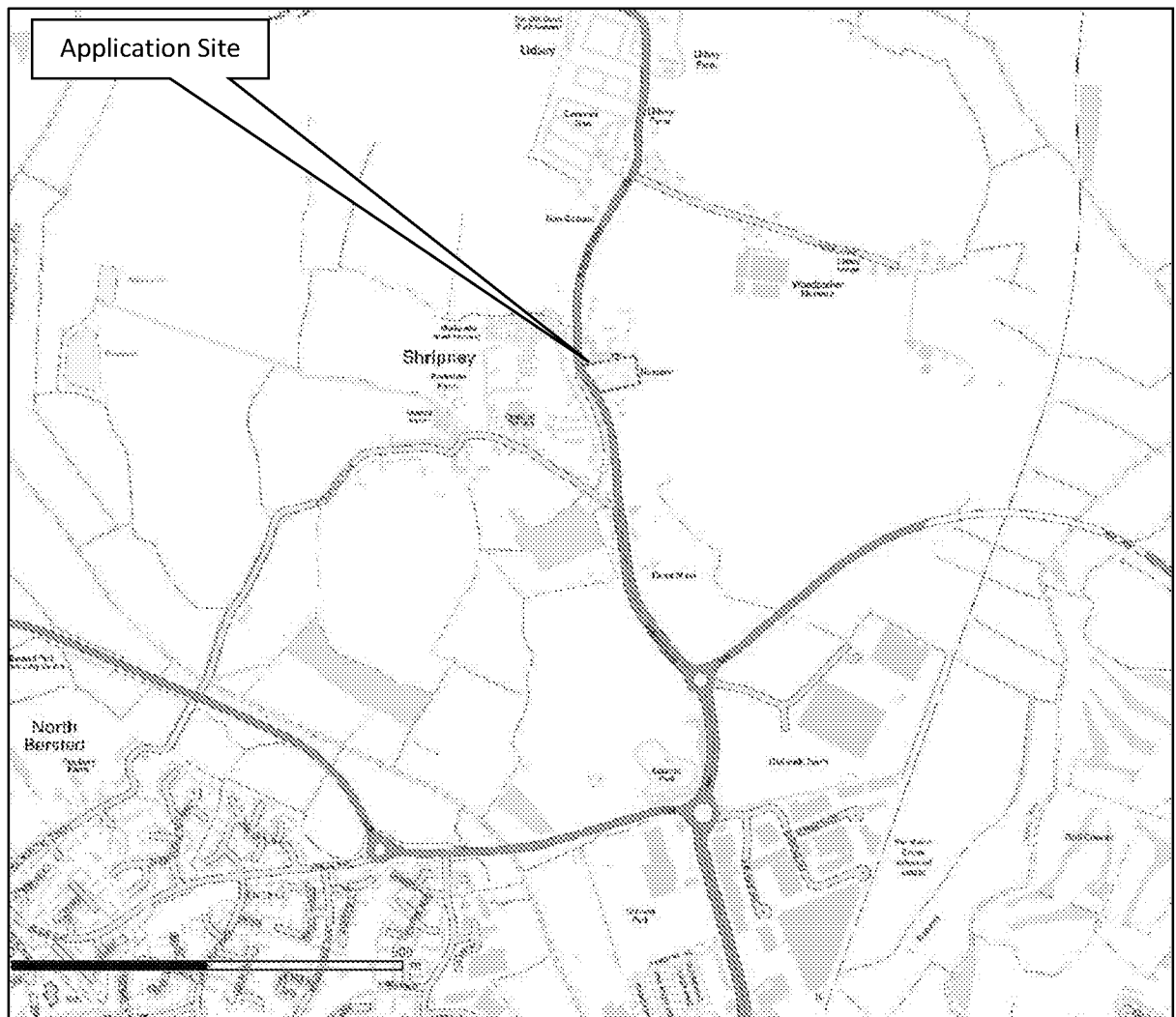


Figure 3-1 - Approximate location of the proposed development

3.2. Proposal

The proposed development comprises 31 residential dwellings of varying sizes and access road with some shared open spaces. Access to the development will be a new access road, which will extend from Shripney Road through the centre of the development. The proposed layout of the site is provided in **Error! Reference source not found..**

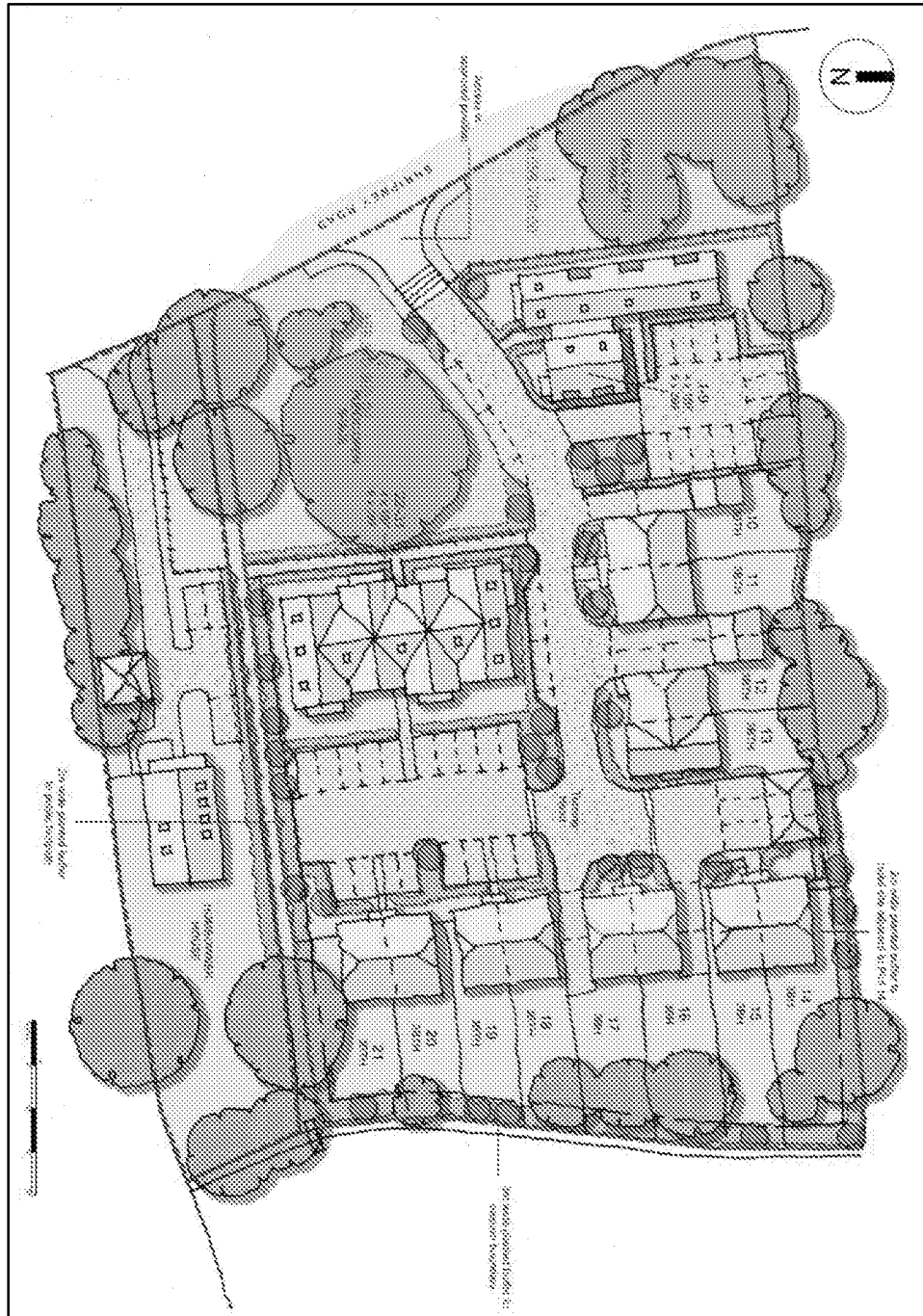


Figure 3-2 - Proposed development layout (red line boundary is the application site)

4. Baseline Conditions

4.1. Existing Site

The application site is currently occupied by one dwelling, agricultural land, including greenhouses, trees and hedgerows with a public footpath running along the southern boundary of the site. The site boundaries are generally vegetated with trees and hedges. To the north of the site is the Premier Inn hotel and grounds, to the east lies farmland, whilst the southern boundary is an area of rough grazing. Immediately west of the site Shripney Road (A29) runs north-south, beyond which lies residential houses making up the majority of Shripney Village. The village of Shripney is set in a rural location, mostly surrounded by agricultural fields. The existing site can be seen in Figure 4-1.



Figure 4-1 - Existing site aerial photo

A site visit was undertaken on 12th April 2017 by Pippa Messenger from Hilson Moran; photographs are shown in Appendix 3. At this time, the site was occupied by a private dwelling with a large, mature landscaped garden with the majority of the site given over to grass and scattered trees. The site was bounded by trees, and bushes to the west and east and a mixture of wooden fences and brick walls to the north and south. Four disused greenhouse structures, along with small brick and concrete built outbuildings and sheds were also present on site, in addition to the main brick built house in the north western corner of the site. The site was generally flat, with a marked raise between Shripney Road and the main part of the site, and between the site and the ditch along the eastern boundary. There was also a raised area of grass in the centre-east of the



site. In addition, the public footpath to the south was set below the level of the site. The ground conditions at the time of the site visit were generally very dry. There was evidence of drainage ditches along both the eastern and western boundaries of the site, with the eastern ditch completely dry and the western boundary ditch exhibiting some standing water at the time of visit. Also on site, to the south of the main house, was a circular hedge/tree which encircled a disused cess pit and metal pump. Anecdotal evidence was supplied by the occupier of the site that this has been disused for many years, but that the roof drainage from the house had been connected to the pit to drain away. Anecdotal evidence from the occupier also indicated that overland surface water drains generally through infiltration, however the drainage ditch to the west of the site takes some surface water during very heavy storms, whilst the drainage ditch to the east of the site is occasional filled with water but has never been known to get very high or overflow onto the property.

4.2. Topography

The site slopes generally to the south and to the west, however, with several stepped areas. The overall gradient of the site is approximately 1.8%. The highest point on the site is located in the north east corner of the site, at approximately 4.87 mAOD. The northern boundary acts as a step break in the slope, with the main part of the site gently sloping south westwards at a gradient of approximately 0.5 %, although with isolated spots of slightly lower ground in the centre-east of the site and an isolated high point in the centre of the eastern boundary. Shripney Road has step down in the gradient, with the edge of this step in the west of the site providing the lowest point on site at 1.71 mAOD, approximately at the current site access point. The site topography is shown in Figure 4-2.

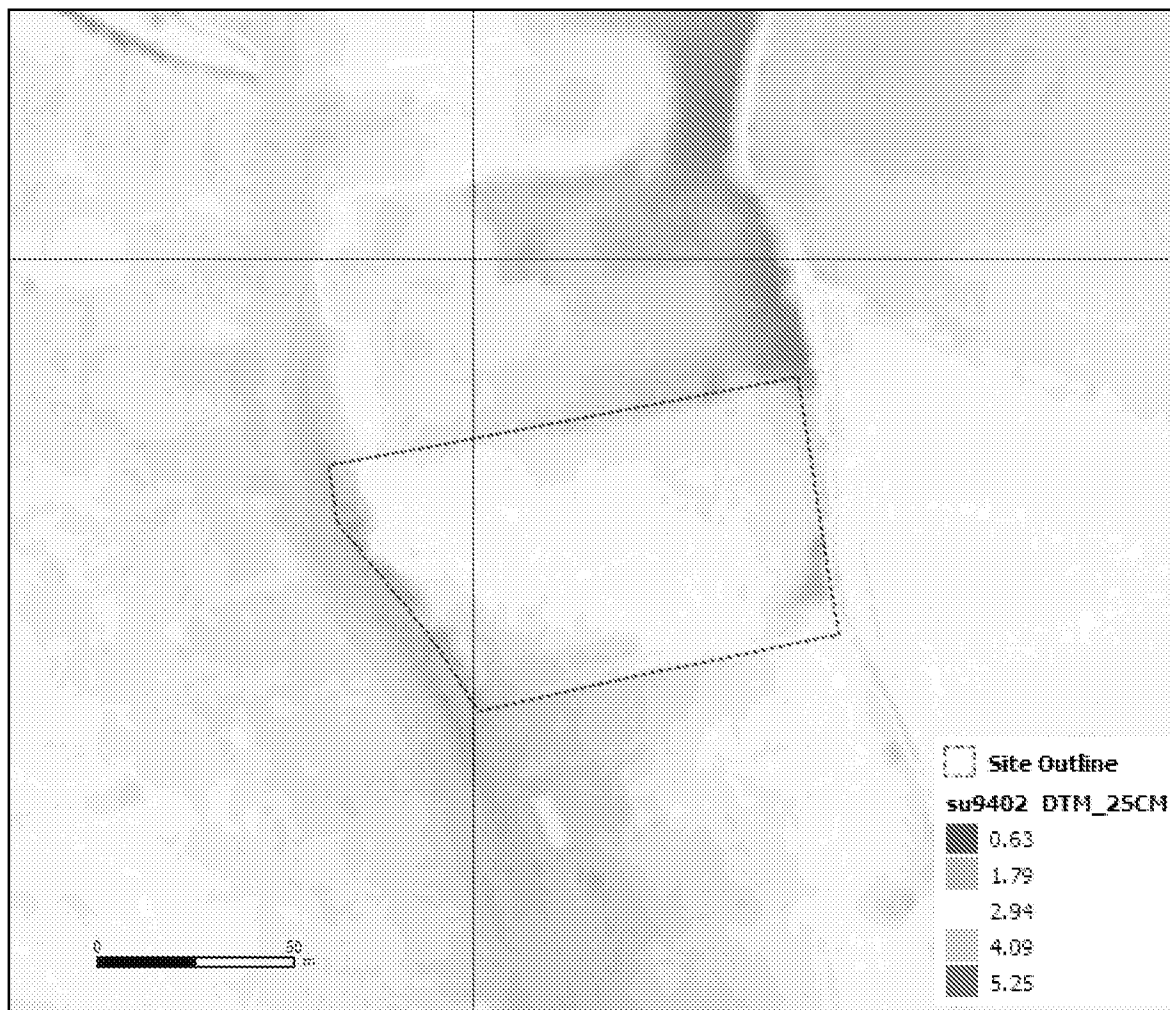


Figure 4-2 - Topographic Plan of the site

4.3. Geology and Soils

The British Geological Survey's (BGS) Geology of Britain viewer^{vii} provides an understanding of the geological formations throughout Great Britain. Review of the information at the 1:50,000 scale mapping identifies that the application site is underlain by Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation and Portsdown Chalk Formation (Undifferentiated) - chalk, with overlying superficial deposits of River Terrace Deposits (Undifferentiated) - sand, silt and clay.

There are no known boreholes on site; the closest boreholes to site lie approximately 220 m to the north west and 270 m to the west of the site. These are both characterised by a thin layer of silty, gravelly clay overlying gravelly silt with chalk and flint pebbles (typical of River Terrace deposits in this area), which further overlie chalk bedrock.

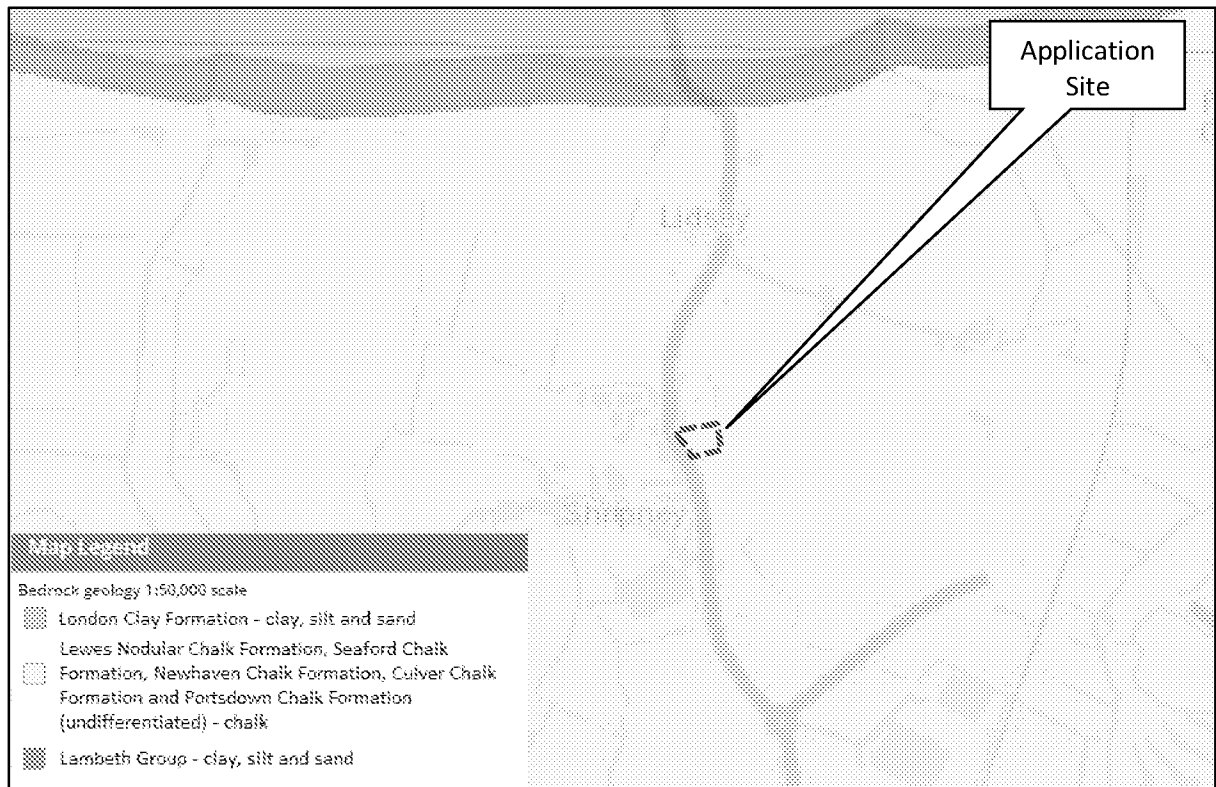


Figure 4-3 - Bedrock geology in and around the site (BGS, 2017)

The National Soil Resources Institute (NSRI) Soilscape^{viii} database identifies the soil types across England and Wales. The database identifies that the land on which the development site stands is split between “*Slightly acid loamy soils*” and “*Loamy soils with naturally high groundwater*”. The drainage aspect of the soils is identified as “*freely draining*” and “*naturally wet*”. On the site visit, undertaken by Hilson Moran on 12th April 2017, the soils appeared to be generally quite loamy, and the soils were very dry on site. There was evidence of water in the ditch to the west of the site alongside Shripney Road, however, the ditch to the east of the site was completely dry.

4.4. Hydrology

4.4.1. Information Sources

In determining hydrological conditions across the proposed site, reference has been made to a number of sources. In particular, information has been brought together from:

- The EA’s Flood Map internet resource;
- The EA’s Product 4 information (included in Appendix 4)
- The ADC Strategic Flood Risk Assessment Level 1 (SFRA)^{ix};
- Arun Strategic Surface Water Management Study (SSWMS)^x
- West Sussex Local Flood Risk Management Strategy (LFRMS)^{xi}
- The Arun and Western Streams Abstraction Licensing Strategy^{xii} (CAMS) and Catchment Flood Management Plans (CFMPs)^{xiii}; and
- Lidsey Surface Water Management Plan (SWMP)^{xiv}.

4.4.2. Surface Waters

The main catchment in the ADC area is for the River Arun. According to the ADC Local Plan, “*the River Arun is one of the fastest flowing rivers in the country.*” In addition to the River Arun, the District has large streams and smaller watercourses, grouped together they are known as the West Sussex Rifes. The Rifes are considered to be “*of strategic drainage importance, as classified by the Environment Agency, because they are critical to the surface water drainage of the area.*” The site sits within the catchment of the Aldingbourne Rife. The Aldingbourne Rife is predominantly rural in character, with the exception of Bognor Regis, through which it flows into the English Channel. According to the SFRA, the Aldingbourne Rife is “*known to flood frequently, and when it does, the river is very slow to drain due to the low topography of the area.*”

There are a number of ordinary watercourses and drainage ditches in the vicinity of the site. These are all ultimately tributaries of the Aldingbourne Rife. According the Ordnance Survey mapping, there are drainage ditches 75m to the north, 140 m to the north west and 206 m to the south of the site which are drain directly to the Aldingbourne Rife, which at its closest point is 1.54 km to the south west of the site. There is also a drainage ditch which lies 350 m to the south of the site which drains to the Lidsey Rife, which at its closest point is 1.6 km to the south east of the site. These drainage ditches generally follow field boundaries to drain southwards. The Aldingbourne Rife and Lidsey Rife both flow southwards to a confluence approximately 2.9 km to the south of the site. The Aldingbourne Rife then continues southwards through Bognor Regis to discharge into the English Channel approximately 5.2 km to the south of the site.

These drainage paths are indicated on the ADC SFRA “*Surface Water Flood Risk*” Map (refer to Figure 4-4) and the ADC SFRA “*Watercourses*” Map (refer to **Figure 4-5**).

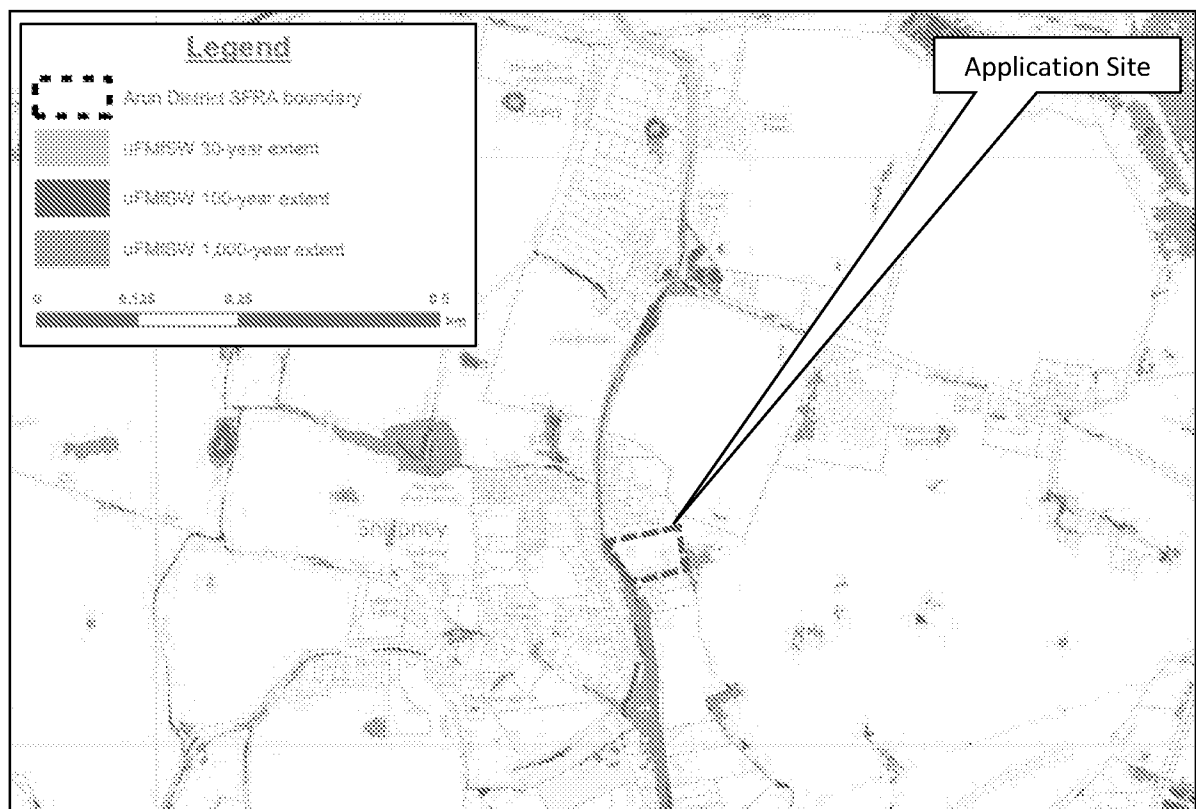


Figure 4-4 – ADC SFRA Surface Water Flood Risk Map

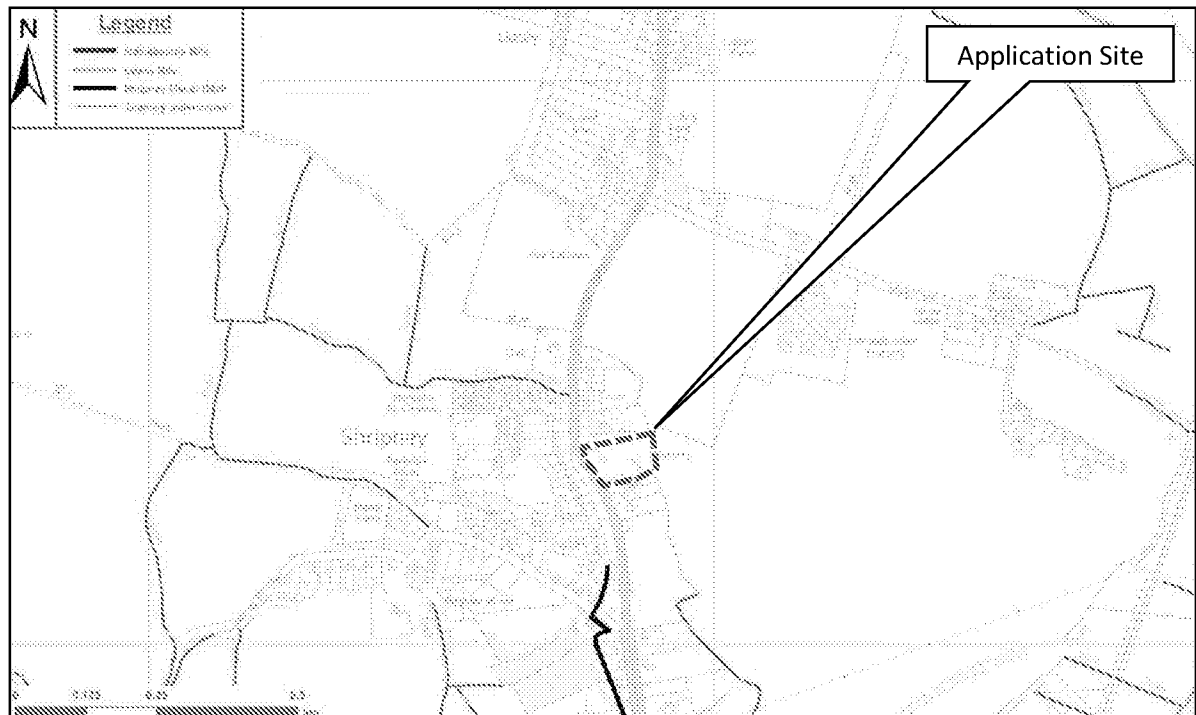


Figure 4-5 - ADC SFRA watercourses

4.4.3. Flood Mapping

4.4.3.1. EA Flood Map

The EA Flood Zone Mapping, provided in Figure 4-6, identifies that the application site is located entirely within Flood Zone 1 (Low Risk, *i.e.* less than 1 in 1,000 annual probability of river or sea flooding, <0.1%). The closest areas of Flood Zone 2 and 3 are associated with the drainage ditches approximately 75 m to the north, 140 m to the north west and 206 m to the south of the site.

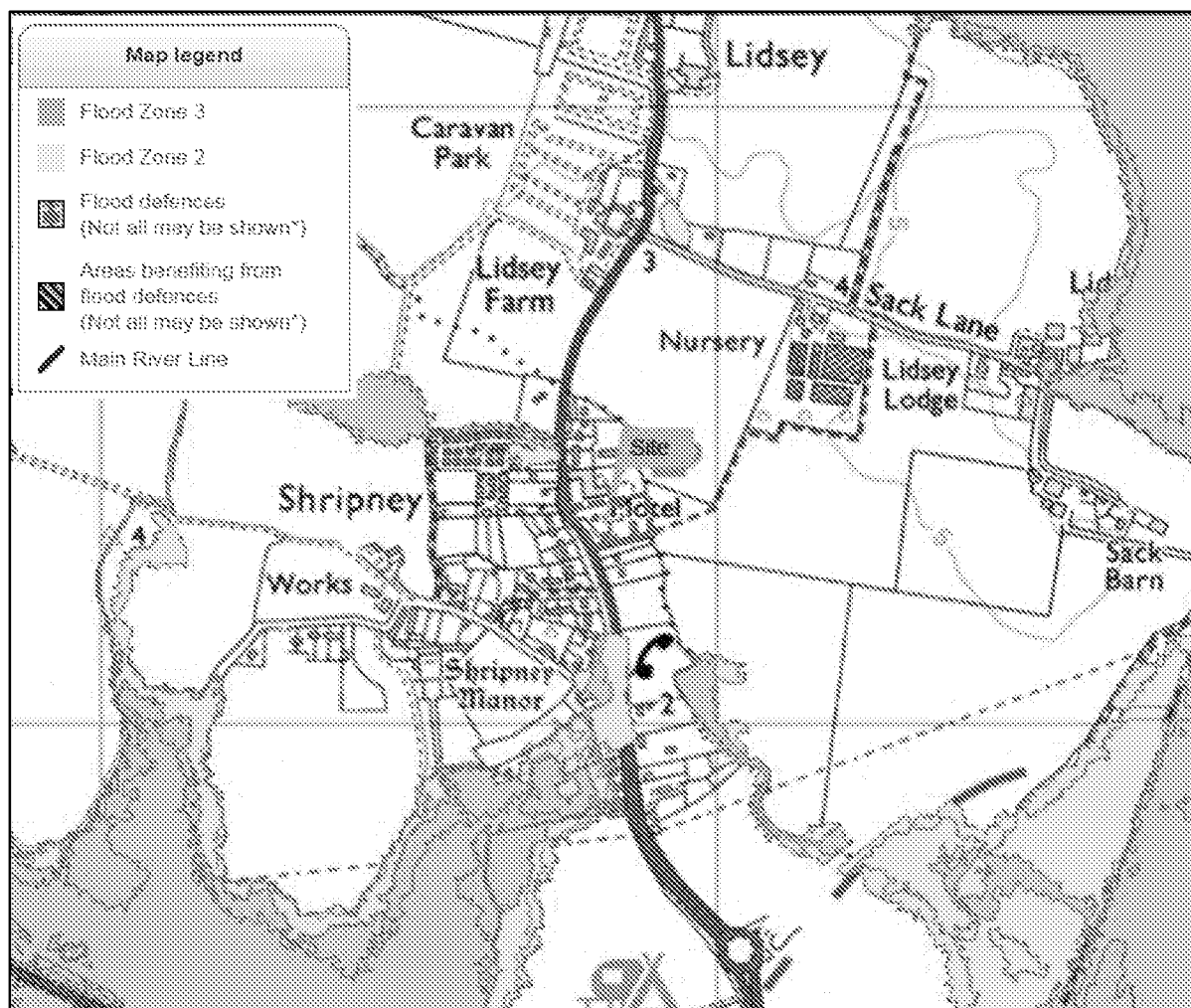


Figure 4-6 - EA Flood Map (not to scale)

To put the flood zone mapping into context, Flood Zone 3 comprises areas categorised as subject to 1% annual probability of flooding from rivers or sea (*i.e.* the 1 in 100-year event) and Flood Zone 2 comprises areas categorised as subject to 0.1% annual probability of flooding from rivers or sea (*i.e.* the 1 in 1000-year event). Cumulatively, these areas provide the best estimate of the indicative floodplain of the identified watercourses if there were no flood defences or other man-made structures and channel modifications in place.

4.4.3.1. ADC SFRA Flood Map and EA Product 4 Flood Map – Riverine and Tidal Flooding

The extent of the flood zones depicted in the ADC SFRA have been used to define the EA's Flood Mapping and therefore are coincident with Figure 4-6. The flood modelling for the ADC SFRA also included scenarios for climate change, of which detailed flood maps for the Undefended Tidal and Defended Tidal scenarios were provided through Product 4. The EA officer indicated, that although there are no flood defences close the site, the Defended model scenario takes into account the tidal defences located in Bognor Regis.

The undefended scenario, as shown in Figure 4-7, indicates that the site will be partially at risk of flooding from the 1 in 200 year tidal flood event by 2070 and entirely at risk of flooding from the 1 in 200 year tidal flood event by 2115. The flood levels on site are predicted to reach 2.62 mAOD in

2070 and 3.60 mAOD in 2115. This will result in a maximum flood depth of 0.22 m on site in 2070 and 1.19 m in 2115. This area is currently planned to be the access road and front garden for one of the properties. The maximum flood depth elsewhere on site predicted to reach 0.58m.

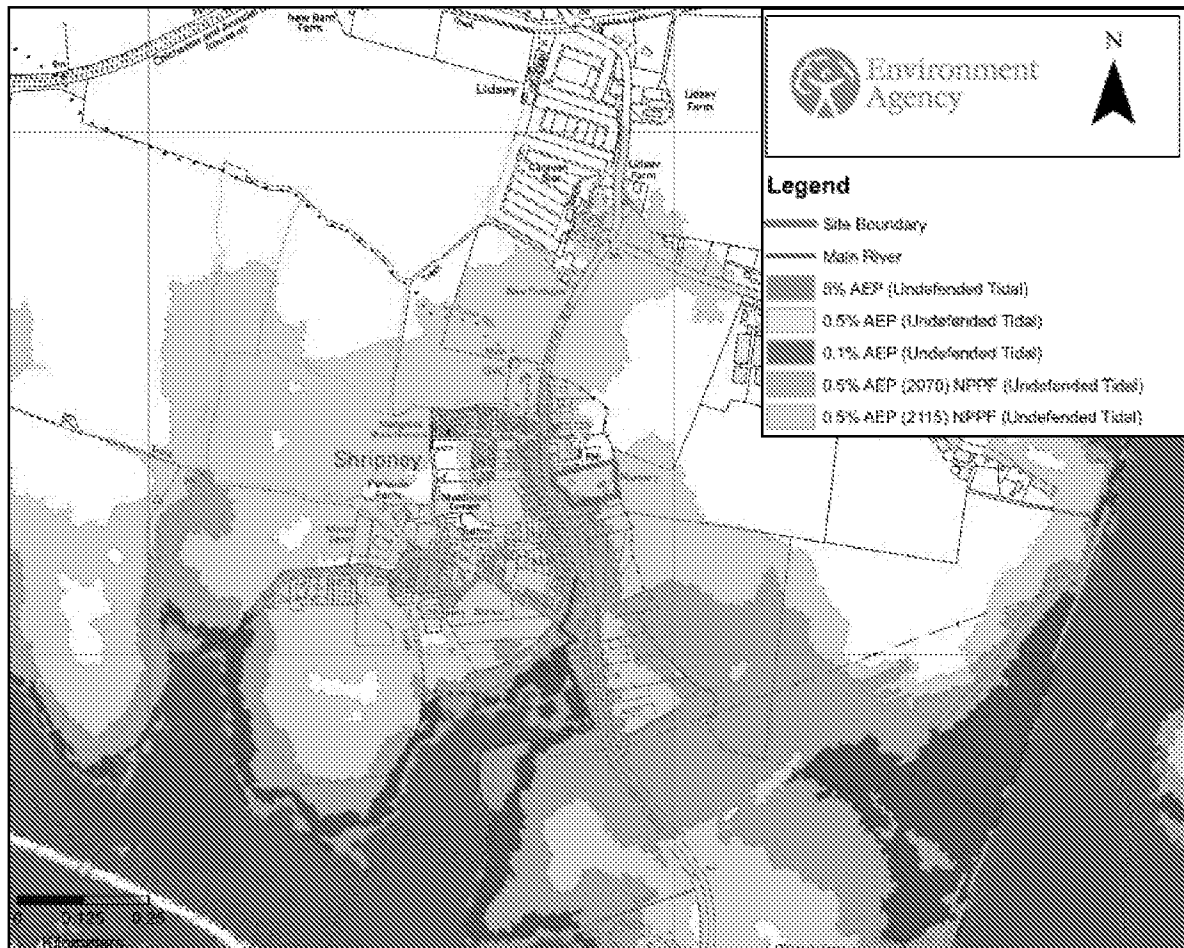


Figure 4-7 - EA Product 4 Modelled Flood Outlines (Un defended Tidal)

The Defended scenario, as shown in Appendix 4, removes the site entirely from risk of flooding in 2115.

The EA are committed to maintaining the level of flood protection currently provided. It is therefore expected that the site should be considered at low residual risk of fluvial and tidal flooding with climate change impacts taken into account.

4.4.4. Groundwater

Relative to other sources of flooding, there are very few records of flooding events recorded as attributable to groundwater flooding, with most records not providing detailed information on groundwater flooding events.

According to the Local Plan "A large proportion of developable land in Arun also suffers from potential ground water flooding"... "Two major aquifers, the Chalk and the Lower Greens, underlie much of the area and are the area's most important water resources accounting for more than 50% of licensed abstraction. The aquifers are the source of numerous springs and streams that help to support surface water flows and water dependent habitats." The LFRMS adds to this with: "The

characteristics of the district mean that surface water ponding and water logging due to high groundwater or extreme rainfall events can cause flooding. Groundwater flooding can also occur along a spring line across the coastal plain."

Groundwater levels are also identified as a major constraint in the area by the SSWMS: "Where the ground is already saturated, water is unable to infiltrate the ground."... "Some infiltration may be possible however, at a shallow depth below ground level, e.g. through the base of swales. There is a risk that due to high groundwater levels across the catchment, this could increase groundwater emergence, potentially reducing the capacity of the system for surface water."

As part of the SFRA, susceptibility to groundwater flooding has been assessed for the district on a 1 km square grid. This shows "the proportion of each grid square where geological and hydrogeological conditions indicate that groundwater might emerge. It does not show the likelihood of groundwater flooding occurring"... "This dataset covers a large area of land, and only isolated locations within the overall susceptible area are actually likely to suffer the consequences of groundwater flooding." The site is shown to not be in a grid square susceptible to groundwater flooding, as shown in Figure 4-8.



Figure 4-8 – Excerpt from ADC SFRA Areas Susceptible to Groundwater Emergence Map



The EA's groundwater protection map identifies that the entire application site falls outside of any Groundwater Source Protection Zones (SPZ) (refer to Appendix 2 for definitions of SPZs), the closest SPZ is Zone 3 (total catchment), approximately 3.5 km to the north of the site.

Given that the site is not located within a SPZ/potable water abstraction points, the potential risk of contaminant mobilisation and migration to groundwater resources is considered to be of low significance and therefore special measures or restrictions are not anticipated to be required when designing the drainage systems for the scheme.

4.4.5. Surface Water Flooding

Surface water flooding occurs when intense, often short duration, precipitation events are unable to enter a drainage system due to blockages, breakages in water pipes or where the drainage capacity has been exceeded. This type of flooding is usually short-lived, associated with heavy precipitation events and highly localised. Surface run-off will tend to flow towards low spots where it collects. Flooding can occur both to land or property which lies in the flow path of the water or to property situated in the low spot where the water finally collects. The effects of climate change are predicted to increase the frequency of heavy downpours, therefore increasing the number of events that exceed the capacity of the sewer system.

The combination of surface water flooding and urban drainage issues can cause some localised areas of combined fluvial and urban flooding. The risk of surface water flooding associated with the application site is identified in the EAs Risk of Flooding from Surface Waters Map (see Figure 4-4).

Figure 4-4 and the ADC SFRA demonstrate that the majority of the site is considered to have a very low risk of surface water flooding below 0.1 % probability of occurrence in any given year, with the western boundary of the site and the southern part of the eastern boundary both demonstrating a low risk (0.1% - 1% probability) of surface water flooding and isolated areas of high risk of flooding in the highway and outside the south eastern corner of the site.

The EA and the ADC LFRMS have not identified any critical drainage areas (CDA) in the vicinity or immediately downstream of the site. CDAs are areas in which new development is likely to overload the capacity of the existing drainage system, with areas upstream having potential to put further pressure on the capacity of the downstream drainage system.

4.4.6. Sewer Flooding

During heavy rainfall, flooding from the sewer system may occur if: the rainfall event exceeds the capacity of the sewer system/drainage system; the system becomes blocked (by debris or sediment); or the system surcharges due to high water levels in receiving watercourses.

The SFRA and LFRMS have not identified any surface water sewer and highway gulley flooding events within the vicinity of the site, however two incidents of sewer flooding were recorded along Shripney Lane to the west of the site. Additionally, according to the Lidsey SWMP, public foul manholes have been widely reported to surcharge and flood the Lidsey SWMP study area, and in particular in Barnham.

According to Southern Water the closest adopted sewer and sewer manhole (7301) is a foul sewer which runs along Shripney Road to the west of the site from north to south, this is then pumped westward along Barn Lane from the Robin Hood Pumping Station to the south of the site. There is also a decommissioned foul rising sewer which runs along Shripney Road. There are no surface water drainage facilities, recorded by Southern Water, in the vicinity of the site. All the sewers described are indicated on Figure 4-9.

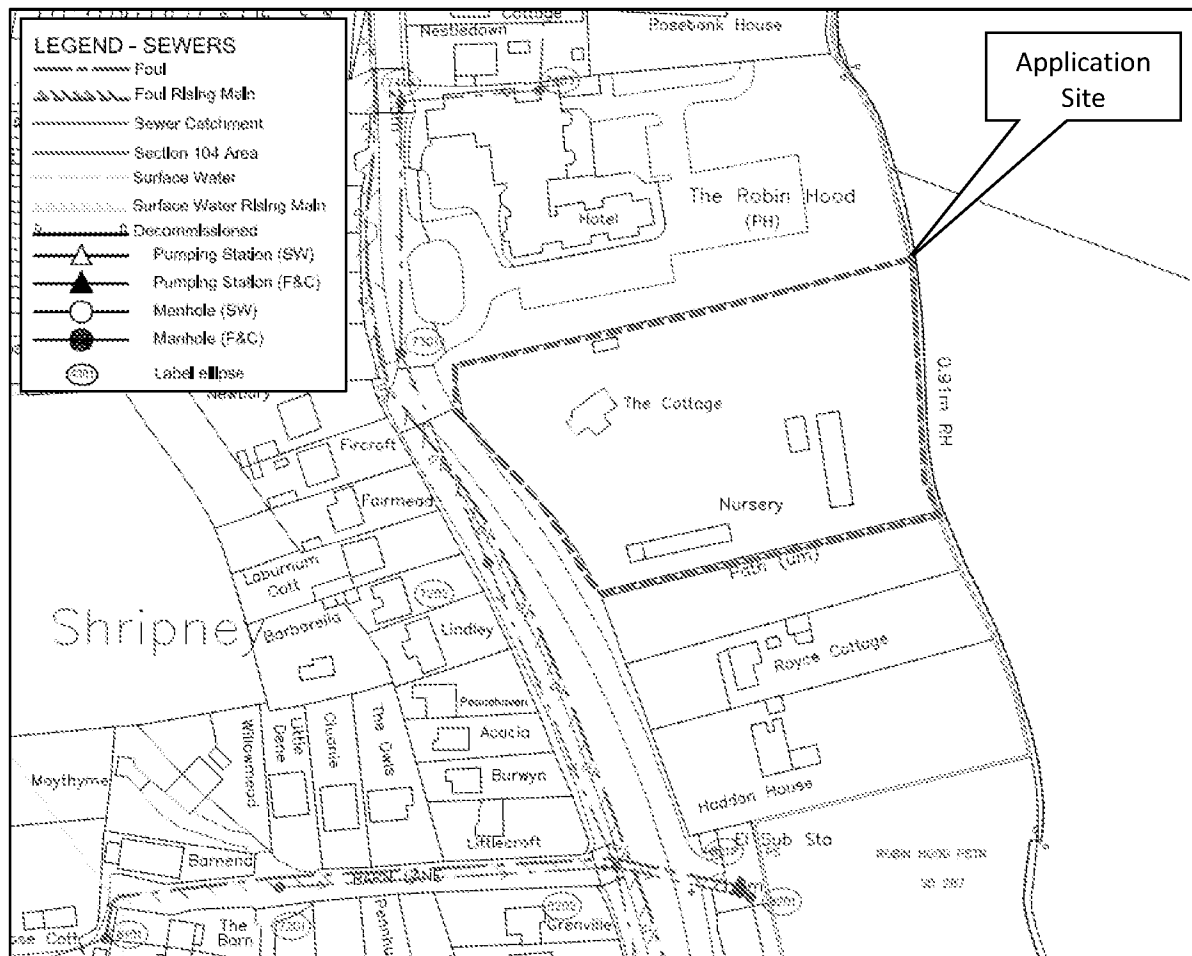


Figure 4-9- Sewer Records (Southern Water, 2017)

In the event of a sewer flooding, it is expected that any potential sewer flooding would follow the path of the highways towards low ground, which in the case of the closest sewer would be along Shripney Road and southwards away from the site.

4.4.7. Artificial Waterbodies

Neither the SFRA nor EA identify any potential flooding of the application site or the nearby area from reservoirs, canals and/or other artificial sources.

4.4.8. Records of Historical Flooding

The SFRA shows that there have been no known events of flooding of any cause affecting the site.

According to the SFRA, *“the main flood events to have directly impacted the Aldingbourne catchment are November 1960, December 1993 and June 2012. Across these events surface water issues are reported to be main drivers behind the flooding experiences, although these often corresponded with elevated river levels which influence drainage of surface water. In the case of the 1993 event inadequate culvert capacity at Barnham also contributed to flooding experienced. The Aldingbourne catchment was particularly affected during the 2012 flood event, with over 400 properties being affected in areas of Bognor Regis, Barnham, Elmer, Middleton and Felpham. The flood mechanism was thought to be primarily surface water but this was exacerbated by fluvial*

flooding from the Rife network. There were also some isolated areas impacted by flooding such as Shripney, Westergate and Yapton”

Additionally the SFRA indicates that the district has had significant events of groundwater flooding recorded in: 1974, winter 1993-1994, winter 2000-2001, winter 2002-2003, 2012 and 2013-14 in the Westergate/Barnham Area, and 2014 in the Northfields Lanes/Nyton Road/Level Mere Lane in Aldingbourne areas.

The Lidsey SWMP also identified that groundwater flooding was reported in Elm Grove in Barnham, Northfields Lane/Nyton Road in Westergate, and Wandleys Lane in Eastergate in the winter of 2000-2001.

Figure 4-10 below is an excerpt of the SWMP which shows the recorded locations and causes of flooding in the vicinity of the site.

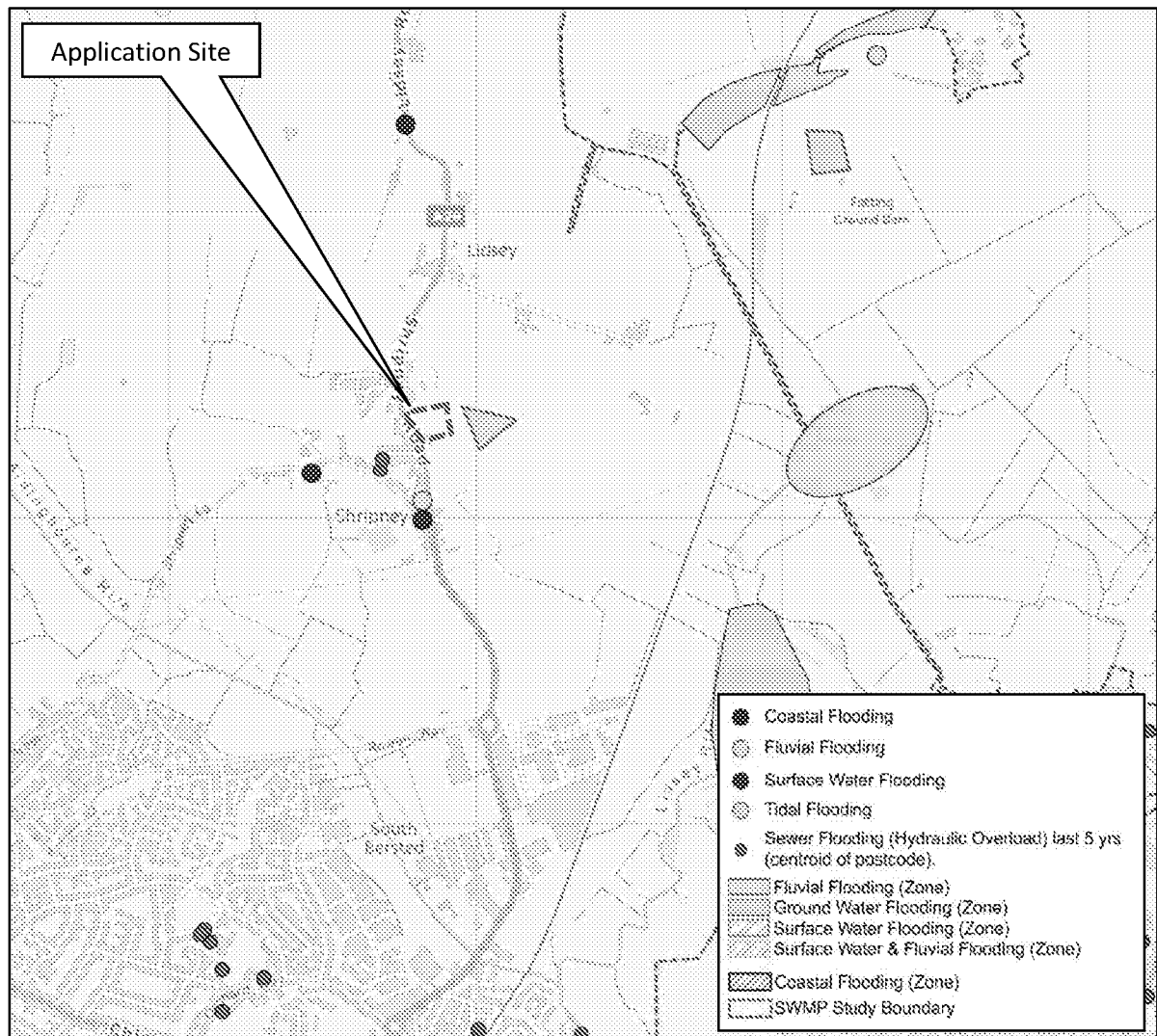


Figure 4-10 - Excerpt from Lidsey Surface Water Management Plan Historic Flooding Plan 3- south



5. Flood Risk Effects of the Proposed Development

5.1. Assessment of On-Site Flood Risk

The ADC SFRA and EA Flood Map indicate that the proposed development is wholly located in the EA's Flood Zone 1. Referring to NPPF Technical Guidance, the location of the proposed development would be categorised as "*Low Flood Probability*" - i.e. the annual probability of flooding from riverine sources is less than 0.1 %. Consequently, there is no requirement to provide compensatory fluvial flood storage and the residual risk of fluvial/coastal flooding is deemed to be of **neutral/negligible significance**. However, the tidal flood risk has also been modelled taking into account the effects of climate change and puts part of the site into risk of flooding by 2070 and the whole site by 2115, it is therefore recommended that appropriate *practical* measures be considered to make the site flood resilient for the future, this should include ensuring that the ground floor levels lie above the flood level for 2070 of 2.62 mAOD.

A review of EA, ADC SFRA information demonstrates that the site does not lie within an area susceptible to groundwater flooding. The risk of groundwater flooding to the proposed development is therefore considered of **negligible/neutral significance**.

The EA and ADC resources demonstrate that the site has a low risk of localised surface water flooding. Consequently the risk of surface water flooding to the proposed development is therefore considered of **negligible/neutral significance**.

There are no records of surface water sewer problems or flooding incidents from highway drainage within the vicinity of the site, however there are 2 records of incidents relating to foul sewer flooding in the vicinity of the site, however these were both down gradient of the site, the risk of flooding of the site from sewers is therefore considered **negligible/neutral significance**.

Neither the ADC SFRA nor the EA identify any potential flooding from reservoirs, canals and/or other artificial sources specifically within the application site. The risk of flooding of the site from artificial drainage bodies is therefore considered **negligible/neutral significance**.

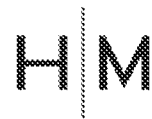
5.1.1. Flood Risk Mitigation Consideration

5.1.1.1. Climate Change Resilience

The tidal flood risk has been modelled taking into account the effects of climate change and places part of the site at risk of flooding (the private drive and front garden of the southernmost proposed dwelling) during the undefended scenario by 2070 and the whole site during the undefended scenario by 2115. However, the site is currently protected by tidal flood defences, and there is a commitment by the EA to maintain them at their current SoP throughout the lifetime of the proposed development. Nevertheless, as a precautionary measure, the dwellings will be made resilient to this residual future flood risk.

It is proposed that the finished ground floor levels are raised above the 2070 undefended flood level of 2.62 mAOD, which will mitigate the risk from the 2070 undefended scenario.

For the 2115 undefended risk, the flood level is predicted to reach a maximum of 0.58 m on site within the vicinity of the proposed dwellings. Consequently the use of a flood exclusion strategy, as described in the UK Government's guidance document "*Improving the Flood Performance of New Buildings*"^{xv} is appropriate (which provides effective flood resilience to a flood depth of 600 mm). It is therefore intended that the proposed dwellings will be protected through flood



proof external doors (PAS 1188-1:2009^{xvi} compliant), to provide passive protection, along with flood resilient design such as self-closing air bricks (alternatively the construction may include solid ground floor slabs without the need for air bricks or the use of air bricks only above the flood level), non-return valves for all utilities affected and electrical sockets placed above the flood level, etc. It is also recommended that flood resilient materials are used in the construction of all of the properties, such as (but not limited to) those documented in BS 85500:2015: Flood resistant and resilient construction. Guide to improving the flood performance of buildings.^{xvii}

5.2. Assessment of Effects on Surrounding Area

5.2.1. Surface Water Management and SuDS Philosophy

The NPPF states that the Government's policy is to reduce flood risk. Therefore, re-development of the site should be seen as an opportunity for environmental enhancement and a net reduction in flood risk. As such, the development should aim to reduce run-off below the existing condition. If this is deemed impractical due to various constraints, the proposed development should at least maintain run-off rates and volumes at existing conditions.

SuDS can be a combination of both physical structures and techniques used to control surface water run-off as close to its origin as possible, before surface water discharges to a watercourse or to ground. There are a wide variety of sustainable drainage options available that can be applied in different ways to help manage both surface and ground waters in a sustainable manner. Specific solutions need to be developed for each site, the choice of which will depend on factors such as the nature of the site, the type of pollutants potentially present, the hydrology of the area and the presence of Groundwater Source Protection Zones (SPZs).

The implementation of SuDS as an alternative to conventional drainage systems can provide significant direct and indirect long-term environmental benefits. Depending on the choice of the system these can include:

- Reduction in overall flood risk on-site and downstream from the proposed development by reducing surface water run-off to watercourses, either permanently or after peak flow periods in the system;
- Providing opportunity for infiltration of surface water into soil, where feasible, to replenish groundwater, and help maintain base flows in rivers;
- Promoting a healthier waterway flow regime to receiving watercourses and reducing the impact of bank erosion and habitat damage caused by the increase in flow rate of additional surface water run-off;
- Reducing the amount of pollutants reaching waterways and infiltrating the ground;
- Habitat creation and enhancement of the amenity of an areas. This applies predominantly to open drainage options, especially where wet ponds or wetlands are implemented;
- Potential reduction in development costs, by reducing costs for the provision of surface water drainage on-site;
- Refund of the annual surface water drainage fee that is usually charged for the provision of surface water drainage services on the property. If a SuDS device manages all of a sites' surface water and there is an agreement ensuring no surface water connection will be made to foul sewers, the service provider (e.g. Southern Water) will annually refund this portion of the service rate;



- If adopted as a philosophy rather than simply an engineering solution and integrated at the outset of a design layout, SuDS can offer significant infrastructure savings and add amenity value to a project.

5.2.2. Site Characteristics

The proposed development will be wholly located within Flood Zone 1 (Low Flood Probability) *i.e.* the annual probability of flooding from Main Rivers, tidal and coastal sources is less than 0.1 %. Therefore, the post development risk of displacement of fluvial floodwater is considered ***not significant***.

The site currently comprises 90.2 % soft landscaping. Without mitigation, the proposed development would reduce the existing area of soft landscaping to approximately 57.6 %. In the absence of any mitigating measures, it is anticipated that there would be an increase in rate and quantity of surface water runoff discharging to the adjacent field drains and the adjacent unnamed stream. The impact of the proposed scheme, without mitigation would, therefore, be of ***moderate significance and negative***.

The hydraulic capacity and control of locally installed surface water sewer infrastructure and SuDS infrastructure will be constructed so as to accommodate and retard surface water runoff discharges from the site to the pre-existing rate. With the proposed mitigation measures in place (Section 5.2.5) the impact of the proposed development on the rate and volume of surface water runoff generated is, however, considered to be considered ***negligible/neutral significance***.

There are no records of historical groundwater flooding in the immediate vicinity of the site. As such, the impact of the proposed scheme on groundwater flooding is considered ***of low significance***.

Although the proposed development will undoubtedly lead to an overall increase in foul water discharges to existing foul sewer infrastructure, in accordance with Building Regulations Approved Document Part G, the proposed development will manage water demand by incorporating efficient sanitary ware and water saving devices to reduce water consumption. In addition to augmenting the existing sewer infrastructure, such measures will reduce the burden on the local sewer infrastructure. The impact of the proposed development on the hydraulic performance and efficiency of any existing local foul sewer drainage infrastructure is therefore considered to be of ***negligible/neutral significance***.

5.2.3. General Design Considerations

For new developments there is a general expectation that a drainage system should be adequate, subject to compliance with Building Regulations. Adequate performance will usually be achieved if the drainage system:

- Conveys the flow via a suitable network of treatment systems to a suitable outfall (a soakaway, a watercourse, a surface water or combined sewer);
- Minimises the risk of blockage or leakage with good access for clearing blockages and any necessary maintenance;
- Has sufficient capacity to carry or retain the expected flow at any point in the system and so does not increase the vulnerability of the development to flooding;
- Provides drainage from roofs or paved areas to an adequately and suitably designed drainage system; and,
- Where necessary is adequately ventilated such that foul air does not enter buildings.



It should be noted that:

- The priority for discharge of rainwater is firstly to an adequate soakaway or infiltration system, if that is not reasonably practicable then to a watercourse, the last option is to a sewer; and
- Discharges into the ground (where permitted) should be distributed sufficiently so that foundations of buildings or structures are not damaged.

In considering the most appropriate SuDS for the proposed development, reference has been made to the CIRIA 'Sustainable Drainage System Manual'^{xviii} and the Office of the Deputy Prime Minister's (ODPM's) 'Interim Code of Practice for Sustainable Drainage Systems'^{xix}.

The difference in run-off volume pre- and post-development for the 100-year 6-hour event (the additional run-off generated) should be disposed of by way of infiltration, or if this is not feasible due to soil type, discharged from the site at a rate that does not adversely affect flood risk. In addition, any surface water discharges to watercourses should not exceed a velocity of 1 m s^{-1} .

Infiltration Rate

The effectiveness of infiltration-based SuDS depends on the 'infiltration potential' of the soil, protection of such systems from siltation and avoidance of compaction of the ground during construction. Infiltration techniques may not be effective if the infiltration rate is below $2.8 \times 10^{-6} \text{ m/s}$ (10mm/hr) for the upper sub-surface soils and strata.

The Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation and Portsdown Chalk Formation (Undifferentiated) - chalk, with overlying superficial deposits of River Terrace Deposits (Undifferentiated) which lie beneath the site are classified as major aquifers, it is therefore assumed that the site has high permeability. The soils were reported above as mixed between "freely draining" and "naturally high groundwater" (refer to Section 4.3), whilst the SFRA and the Lidsey SWMP indicated that the site lies in a 1km square grid which is not susceptible to groundwater emergence (refer to section 4.4.4). The site visit also indicated that the soils were very well drained at the time of visit and there was anecdotal evidence of infiltration being used for surface water discharge through the cess pit on site. Subsequently, the approach has been taken in the design of the SuDS strategy, assuming that infiltrating SuDS will be effective on this site. Nevertheless, it is recommended that site-specific infiltration tests are conducted early on as part of the detailed design stage of the development, to confirm the infiltration capacity of the site.

Location

Building Regulation H3 states: 'The requirements of H3 will be met if rainwater soaking into the ground is distributed sufficiently so that it does not damage foundations of the proposed building or adjacent structures'. Typically, therefore, soakaways or other infiltrating structures should be located a minimum of 5 m from any building (including buildings located over the boundary). Sub-surface conditions should be assessed by a geotechnical expert to ensure that the operation of the soakaway will not saturate the foundations of any structure. Thus, direction of groundwater flows, depth of existing groundwater and the presence of shallow impermeable strata should all be considered when selecting a suitable location.

It is not anticipated that spatial constraints will preclude the use of infiltrating SuDS across the application site. Where subsurface storage is included in the scheme, it will be ensured that it will be "tanked" by means of impermeable geotextile within 5 m of building foundations and infiltration will only be permitted from these structures beyond the 5 m threshold.



Soil Contamination

Building Regulation H3 stipulates that ‘...[Infiltration devices should not be built] *where the presence of any contamination in the run-off could result in the pollution of a groundwater source or resource*’. This is re-affirmed in the SuDS manual, which states that ‘*in areas containing contaminated soils or contaminated groundwater, soakaways are not acceptable*’.

Furthermore, The Environmental Protection Act (1990) states that ‘*Contaminated land is any land which appears to be in such a condition, by reason of substances in, on or under the land, that:*

- a) *Significant harm is being caused or there is a significant possibility of such harm being caused;*
or,
- b) *Pollution of controlled waters is being or is likely to be caused*’.

Historic land use maps are limited in extent for the Site, however the Site is currently a mixture of residential dwelling and extensive garden and greenhouses, therefore it is unlikely that the soils are contaminated. However, confirmation of the quality of the land and soil should be confirmed prior to any infiltration devices being installed.

5.2.4. Preliminary Run-off Calculations

The following section provides an empirical demonstration of the potential reduction in surface water run-off volumes and rates, anticipated from the use of the various SuDS throughout the scheme.

Methodology

Firstly, the greenfield peak run-off rates for a range of return periods have been estimated using the HR Wallingford online Greenfield Runoff Estimation Tool (refer to http://geoservergisweb2.hrwallingford.co.uk/uksd/greenfieldrunoff_js.htm). For sites under 50 ha, the tool advocates a pro-rata methodology based on IH Report 124^{xx} with growth curves from the Flood Studies Report^{xxi} and CIRIA Book 14^{xxii}. The tool also generates the standard average annual rainfall (SAAR) for the site which is 734 mm).

Run-off rates and volumes for the proposed development have then been calculated and any impact on run-off has been addressed through the installation of compensatory surface water storage (see Section 5.2.5).

In addition, FEH/FSR methods have been employed to facilitate determination of the surface water run-off from the developed site for a range of return periods. The FEH CD-ROM^{xxiii} generates the design rainfall depth for a range of specified return periods and storm durations.

Results were obtained using:

- The FEH method to establish rainfall depths for a range of return periods;
- The Wallingford Procedure^{xxiv} to determine values for soil index (SOIL) and winter ‘Urban Catchment Wetness Index’ (UCWI). The values are 0.37 and 131 respectively;
- The Modified Rational Method to calculate peak discharges for each return period;
- Derivation of run-off volume from RUNVOL (volume of run-off expressed as mm over total area) using the Wallingford Procedure.

A range of storm return periods have been modelled, using the modified Wallingford Procedure, to simulate a range of worst case scenario surface water run-off rates and volumes from the site.



There are inherent difficulties in estimating greenfield run-off volumes for specific storm durations using the Wallingford Procedure. Consequently, the existing greenfield run-off volumes were approximated using the simple method presented on HR Wallingford's "UK Sustainable Drainage Guidance & Tools website (refer to <http://www.uksuds.com/surfacewaterstorage.js.htm>) whereby it is assumed that the greenfield runoff volume is equal to the Standard Percentage Runoff (SPR) value of the soil. With reference to the same website, a value of 0.37 has been determined for the application site.

Thus, the greenfield runoff volume for the rainfall event can be calculated as:

$$\text{Greenfield Vol} = \text{RD} \times \text{AREA} \times 10 \times \text{SPR}, \text{ m}^3$$

Where RD = Rainfall Depth for the return period storm of interest.

Similarly, for those areas of impermeable surfaces the following equation has been used:

$$\text{Runoff volume} = \text{RD} \times \text{AREA} \times \text{Runoff Coefficient}, \text{ m}^3$$

Appropriate runoff coefficients have been sourced from the 2015 CIRIA SUDS Manual and comprise 0.90 for pitched roofs with tiles and 0.75 for all other hardstanding.

With reference to the size and topography of the site and the lack of existing surface water drainage infrastructure, the time to concentration (t_c) of peak overland run-off from the site was determined using the Kinematic Wave Equation. The average time to concentration for a 50.4 mm/hr storm (Building Regs recommended design rainfall intensity for surface water drainage design for normal situations – equating roughly to a 1 hour 1 in 100 year return storm) was estimated to be approximately 60.5 minutes (on the basis that the existing site has an average gradient of around 2 % from a high point close to the north eastern corner through the site to a low point at the western boundary of the site).

Furthermore, the 100-year 6-hour event was also modelled for each scenario, permitting the difference in run-off volume and pre- and post-development for this event to be calculated, as per EA guidance.

Greenfield Run-off Rates

Greenfield run-off rates were calculated using the methodology described in Section 5.2.4. The results of this procedure are presented in Table 5.1, which identifies an estimated greenfield run-off rate for the 100-year storm of 6.9 l/s or 9.7l/s/ha.

Table 5.1- ICP SuDS greenfield run-off rates

Return Period (Years)	Peak Greenfield Run-off Rate (l/s)	Peak Greenfield Run-off Rate (l/s/ha)
QBAR _{rural}	2.2	3.0
1	1.9	2.6
30	4.9	6.9
100	6.9	9.7

Existing (Pre-Developed) Run-off Rates and Volumes

Existing run-off rates and volumes have been calculated using the methodology described in Section 5.2.4. As the existing site comprises 90.2 % soft landscaping it has been considered to be greenfield for the purposes of calculating runoff rates and volumes for the pre-existing condition.

The results presented in Table 5.2 indicate a run-off rate of approximately 6.9 l/s (9.7 l/s/ha) and volume of 127.2 m³ for the 100-year critical storm.

The existing 100-year 6-hour storm (68.7 mm rain) was also modelled and returned a run-off volume of 209.4 m³.

Table 5.2 - Existing (pre-developed) peak run-off rates and volumes

Return Period (Years)	Critical FEH Storm Depth (mm)	Run-off Volume (m ³)	Peak Flow Q	
			(l/s)	(l/s/ha)
1 ¹	5.3	16.3	1.9	2.6
30	28.7	87.4	4.9	6.9
100	41.7	127.2	6.9	9.7

Proposed Development Run-off Rates and Volumes

Run-off rates and volumes have been calculated in the absence of any mitigation. The percentage impermeable surface area will increase to 42.4 %, and as a result the run-off rates and volumes post-development will increase. The run-off rates and volumes have been modelled using the 42.4 % impermeable surface area, which, using the Wallingford Procedure, equates to a percentage run-off (PR) value of 33.9 %.

The results are presented in Table 5.3 and demonstrate an estimated run-off rate for the 100-year critical storm of 35.7 l/s or 49.8 l/s/ha and a volume of 167.1 m³.

The brownfield 100-year 6-hour storm (68.7 mm rain) was also modelled and returned a run-off rate of 10.1 l/s or 14.0 l/s/ha and a volume of 275.0 m³.

Table 5.3 - Proposed development peak run-off rates and volumes (without mitigation)

Return Period (Years)	Critical FEH Storm Depth (mm)	Run-off Volume (m ³)	Peak Flow Q	
			(l/s)	(l/s/ha)
1 [*]	5.3	21.4	4.6	6.4
30	28.7	114.8	24.5	34.2
100	41.7	167.1	35.7	49.8

Consequently, when comparing the pre- and post-development run-off rates and volumes in the absence of mitigation, the development of the site will result in an increase in the run-off rate of 27.0 l/s or 31.4 l/s/ha for the critical storm and an increase in volume of 102.5 m³ for the 6-hour storm.

The UK Government climate change allowances were published on 19th February 2016^{xxv}. Both central and upper end predictions for peak rainfall intensity are provided in Table 2 of the guidance (*“peak rainfall intensity allowance in small and urban catchments”*) and the guidance goes on to advise that *“For flood risk assessments and strategic flood risk assessments, assess both the central and upper end allowances to understand the range of impact.”* Assuming a 100 year lifetime for the residential development, the guidance suggests that the central total potential change anticipated for 2060 to 2115 is +20 % and the upper end total potential change anticipated for the same period is 40 %.

¹ 1 in 1 year depths derived from 1 in 1.0004 year, due to inability of FEH method to provide depths for 1 year and less return periods.



Within the design of drainage networks for new developments, the incorporation of an appropriate allowance for future climate change impacts on peak rainfall intensities is recommended to ensure that all future developments gives rise to a net reduction in runoff rates and volumes throughout their operational lifetime.

Making a precautionary 40 % allowance for increased rainfall intensity over the anticipated lifetime of the proposed development, the post-development 100-year critical storm duration (58.4 mm rain) was also modelled and returned a run-off rate of 49.9 l/s or 69.7 l/s/ha and a volume of 233.9 m³. The post-development 100-year 6-hour storm (96.1 mm rain) was also modelled and returned a run-off rate of 14.1 l/s or 19.6 l/s/ha and a volume of 385.0 m³.

Therefore, the post-development 100-year critical storm event modelled above, inclusive of a 40 % allowance for increased rainfall intensity due to climate change, indicates that the application site, with the impacts of climate change over the lifetime of the development, would lead to an increase of approximately 43.0 l/s or 60.0 l/s/ha in runoff rate and the 6-hour storm rainfall run-off would increase by 203.0 m³ when compared against the existing situation.

Without mitigation the proposed development would not, therefore, facilitate the sustainable management of surface water run-off, or take account of the potential increase in rainfall run-off, due to climate change, expected over the operational lifetime of the development.

5.2.5. Runoff Mitigation Consideration

5.2.5.1. Climate Change Resilience

It is intended that the proposed development will aim to meet the 2015 Non-statutory Technical Standards for Sustainable Drainage Systems and EA best practice^{xxvi}, by reducing runoff rates from the proposed development during the 1 in 1 year and the 1 in 100 year events to respective green field rates, accounting for the effects of climate change on rainfall runoff over the lifetime of the proposed redevelopment.

5.2.5.2. Sustainable Urban Drainage

It is intended that the proposed development will aim to meet the 2015 Non-statutory Technical Standards for Sustainable Drainage Systems and EA best practice^{xxvii}, by reducing runoff rates from the proposed development during the 1 in 1 year and the 1 in 100 year events to respective green field rates, accounting for the effects of climate change on rainfall runoff over the lifetime of the proposed redevelopment.

With reference to the Non-statutory Technical Standards, ideally:

“For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event should never exceed the peak greenfield runoff rate for the same event.”

and

“Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event.”

Consequently, it has been calculated that:

- The peak greenfield runoff rate for the 1 in 1 year critical storm is 1.9 l s⁻¹, requiring 15.8 m³ storage during the critical storm taking into account climate change;

- The peak greenfield runoff rate for the 1 in 100 year storm is 6.9 l s^{-1} , requiring 123.3 m^3 storage during the critical storm taking into account climate change; and
- The greenfield runoff volume from the site for the 1 in 100 year, 6 hour rainfall event requires 203.0 m^3 storage taking into account climate change.

Following the SuDS hierarchy, natural SuDS solutions such as infiltration basins and swales have been considered. However, due to the established nature of the trees to be retained on the site, the open spaces, which would otherwise lend themselves to be SuDS devices, cannot be used for attenuation and infiltration devices. As such, the main choice for attenuation on site will be using permeable paving with subsurface storage alongside the local use of water butts.

Water Butts

Water butts are the most common means of harvesting rainwater for garden use. They are small, off-line storage devices that are designed to capture and store roof run-off.

A water butt collects rainwater run-off from roofs via an inlet that is connected to the roof down-pipe. The device is normally constructed from polyethylene, which is often sourced from recycled material. Water butts are manufactured in a wide variety of sizes and some models consist of inter-connectable units.

During wet periods, water butts are often full, resulting in little or no attenuation or reduction in outflow rates or volumes. However, water butts can be designed to attenuate run-off by using a throttled overflow system, as identified in Figure 5-1. It is, therefore, proposed to provide water butts for all dwellings, where practical, as per the design in Figure 5-1, resulting in both water conservation and storm water attenuation benefits.

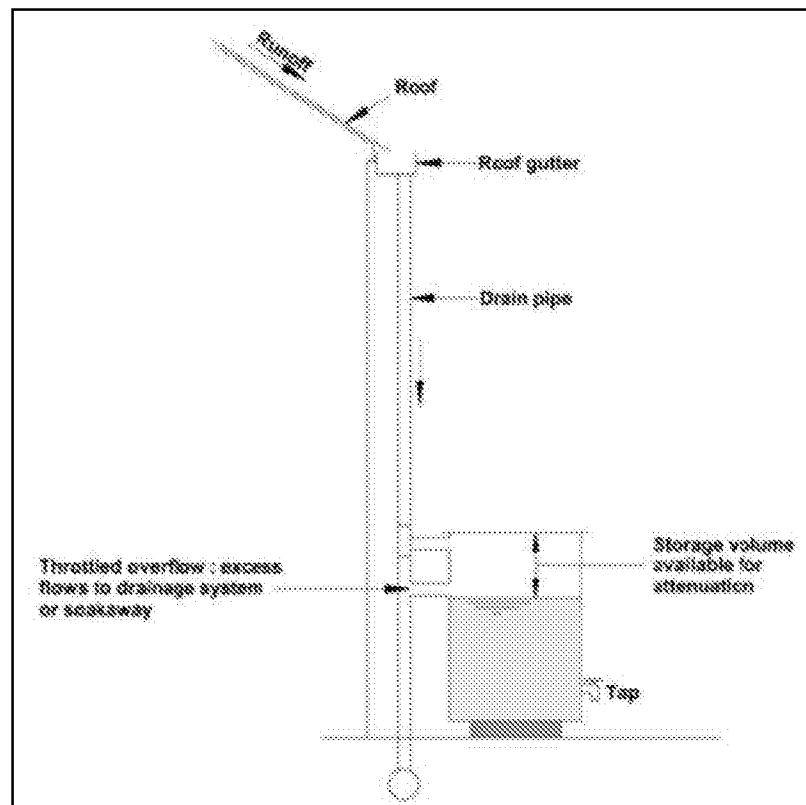


Figure 5-1 - Two-stage water butt schematic (designed for stormwater attenuation)

Permeable Pavements

A permeable pavement is an effective SuDS method of providing a structural hardstanding suitable for pedestrians and vehicular traffic, whilst allowing water to pass through the surface into the pavement construction for temporary storage and re-use, if required. It is a combined paving and drainage system which allows rain to infiltrate through permeable concrete block paving into a special sub-base, such as geocellular storage tanks, before being released in a controlled manner into sewers or watercourses, into the underlying sub-grade if it is suitable, or retained for re-use. The water is cleaned by filtration and microbial action and can be used for secondary (non-drinking) purposes.

Geocellular storage tanks are used to create below ground void space for the temporary storage of surface water before discharge. Geocellular systems are modular plastic units with high porosity, typically around 95% wrapped in a geomembrane or geotextile. They can be used in conjunction with a special sub-base to clean the water before being released in a controlled manner into sewers or watercourses, into the underlying sub-grade if it is suitable, or retained for re-use. Discharge rates of around 2 l/s/ha can be achieved from such systems.

Within the proposed development, the parking areas can be permeable paving underlain by geocellular storage tanks, the areas which have been identified as suitable are shown in Figure 5-3. This could cover a total area of approximately 871.1 m² and would equate to **248 m³** of storage, assuming a modular system with a depth of 0.3 m and with a nominal void ratio of 95 %. This would provide more than 100% of the required storage to attenuate runoff rates to greenfield.

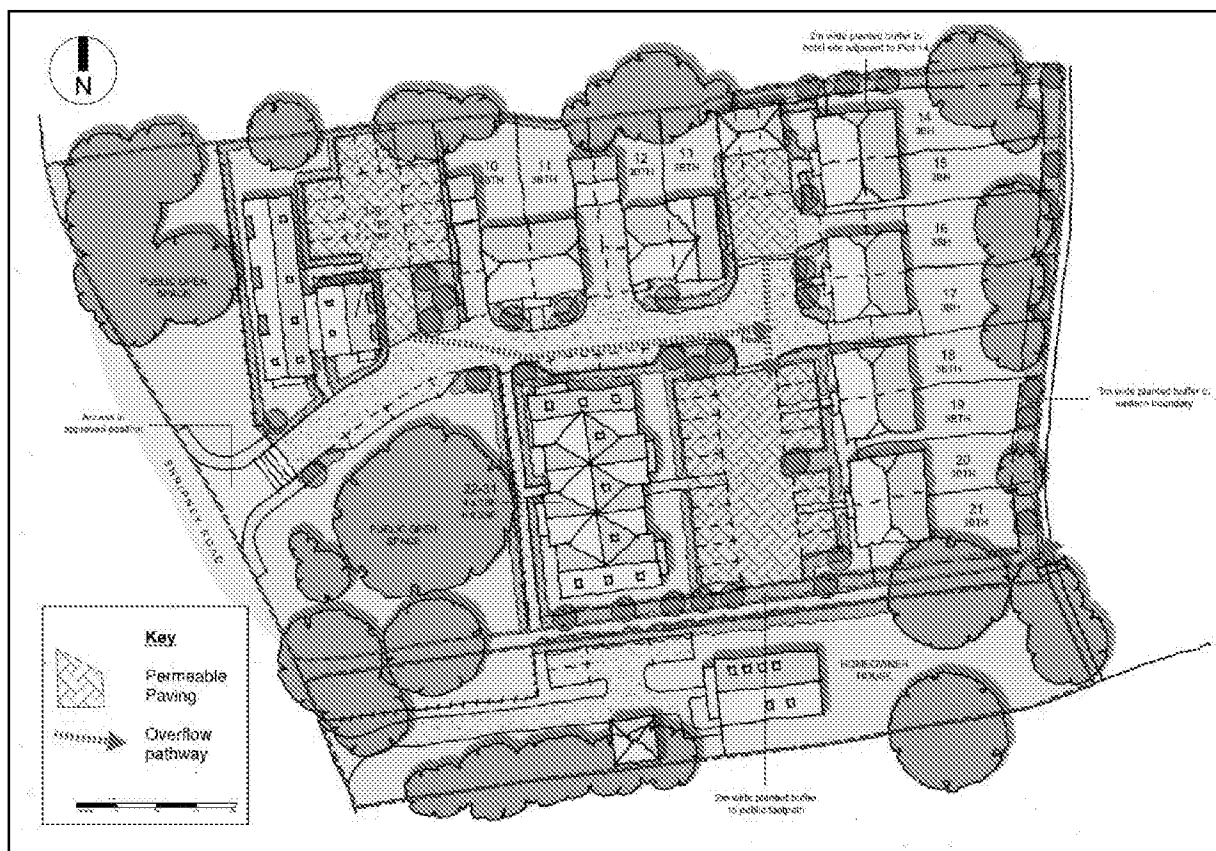


Figure 5-2 – Potential locations of permeable paving (not to scale)

Roof drainage, from residential areas will be directed to the subsurface storage system through traditional surface water drainage infrastructure, wherever possible. All such structures will be designed to attenuate run-off from at least the 1 in 100-year annual rainfall event, with runoff discharging ultimately via infiltration. However, levels on the site are sufficient to allow the structures to discharge to the drainage ditch to the east of the site if required, as shown by the overflow pathways on Figure 5-2.

Where there is the potential for oil contaminated run-off (*e.g.* from trafficked areas), a granular sub-base material or other suitable treatment system can be used to negate the need for oil interceptors (as accepted by the EA, due to the inherent oil absorbing/biodegrading properties of the permeable pavement system). Appropriate systems include the Formpave or Charcon Infiltra with granular sub-base.

Where depths of excavation are constrained by ground conditions, existing utilities, high groundwater levels or cost, then a modular sub-surface storage system is typically more suitable. The Althon SUDS SEL Source Control System is a modular storage system with sub-surface treatment that can also be used as an alternative to petrol interceptors (Figure 5-3).

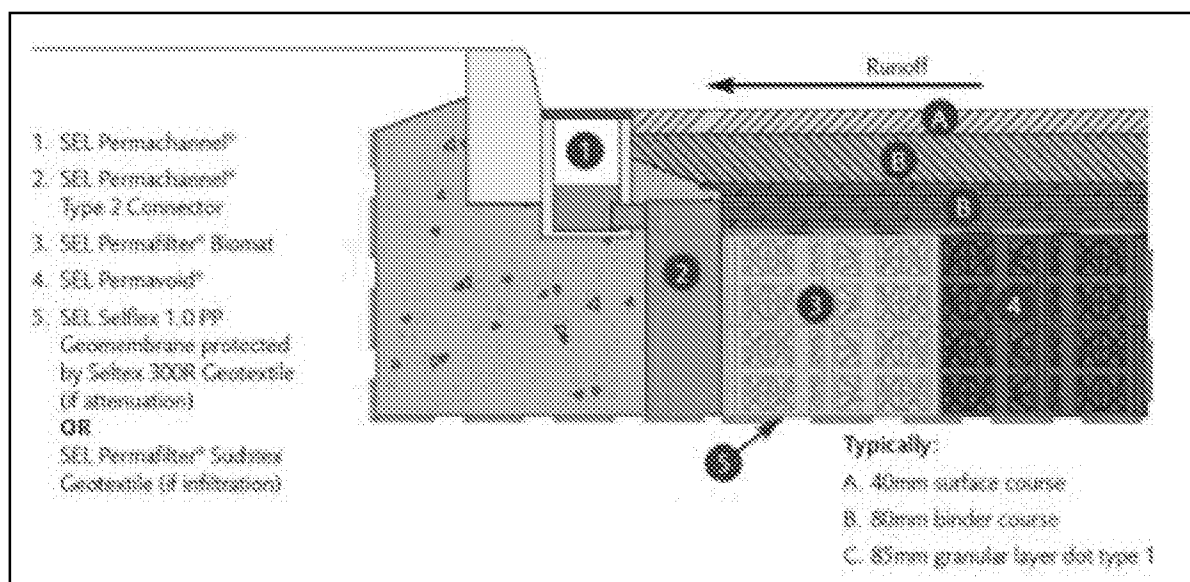


Figure 5-3 - Cross-section through Althon SUDS SEL Source Control System

In addition to attenuation of surface water within the sub-base, the Althon SUDS SEL Source Control System offers six stages of water treatment within the system, comprising:

- Stage 1 & 2 treatment conferred by the SEL Permachannel® providing oil separation to meet the criteria set out in PPG3 and silt deposition using low velocity (micro catchment) gravity separation;
- Stage 3 treatment conferred by the use of a floating SEL Permafilter® Biomat providing removal and degradation of residual hydrocarbons;
- Stage 4 treatment conferred by the SEL Permavoid®, whereby shallow attenuation within the modular storage provides effective dilution and dispersal over a large surface area;



- Stage 5 treatment conferred by the Flow Control Sump Chamber, in which simple, shallow, low head flow control is used for effective settlement of silt, whilst easy access facilitates simple inspection, monitoring and maintenance.
- Stage 6 treatment conferred by the SEL Permaceptor®, which provides a final polish for sensitive applications on high risk sites (e.g. protected aquifers). It also intercepts and contains hydrocarbons for subsequent removal and disposal where there is a high risk of a catastrophic spillage (e.g. refuelling areas or household recycling centres).

Where conditions such as poor infiltration and potential contamination, together with the proximity of building foundations, negate surface water infiltration to sub-surface strata, the system can be designed as a 'tanked' or non-infiltrating system. Roof water can also be discharged into the sub-base for storage (and re-used if required).

Specific benefits of using such a permeable pavement for rainwater collection and re-use include:

Quantity

- Reduction of the occurrence of run-off flooding;
- Reduction of retention requirements elsewhere in the drainage system;
- Delayed release of run-off with much-reduced peak outflow; and,
- Reduction of risk of overloading existing drainage systems during periods of heavy or frequent rain.

Quality

- Improvement of water quality by filtration;
- Retention of pollutants by attachment to the construction materials below the surface;
- Breakdown of hydrocarbons and containment of heavy metals within the pavement; and
- Prevention of storm water movement into contaminated sub-grades.

Amenity

- Provision of sustenance for trees and other planting close to paved areas;
- Potential for direct drainage of roof water into or onto the pavement;
- Elimination of standing water or puddles;
- Comparable or lower costs than conventional surfacing and drainage solutions;
- Minimal maintenance requirement offering lower whole-of-life costs;
- Simple laying, particularly suited to mechanised installation; and
- Compatibility of conventional and permeable block shapes allowing design differentiation within the pavement.

5.2.6. Maintenance of SuDS

It is intended that the SuDS will be compliant with the Non-statutory Technical Standards.

Anticipated maintenance will comprise:

- i. Permeable pavement: Annual inspections of channels/gullies/outfall(s) for litter/blockages and an annual sweep of permeable pavement external surfaces if a permeable surfacing is installed.



- ii. Annual (or as required) removal of sediment and debris from pre-treatment structures and existing drainage ditch system if used for discharge.

It is anticipated that maintenance for the above will be paid for collectively by the owners of the dwellings, by means of an appropriate standing charge.

5.2.7. Surface and Foul Water Sewerage

A connection to the local adopted foul sewerage is proposed to the west of the site into the existing foul sewer which runs along Shripney Road. It is recommended that surface water runoff is routed through traditional surface water drainage and discharged into the subsurface storage before ultimately infiltrating into the subsurface where possible. However, levels on the site are sufficient to allow the structures to discharge to the drainage ditch to the east of the site, if required.

All sewers will be constructed to an adoptable standard as per Sewers for Adoption (7th Edition)^{xxviii} and Part H of the Building Regulations^{xxix}. The suitability of design and quality of sewer construction will be ensured by adopting high standards of workmanship and adhering to the DEFRA Protocol on Design, Construction and Adoption of Sewers^{xxx}. All excavation works associated with managing surface water runoff and associated pipe-work will require the excavation of certain amounts of spoil which will be managed responsibly.

Furthermore, the introduction of low water consumption appliances (low-flow toilets, showers, taps & white goods) and recycling throughout the proposed development, wherever possible, will minimise the volumes of potable water consumption and foul water discharge resulting from the site activity. Such measures will be considered at the detailed design stage.

5.2.8. Pollution Minimisation during Construction

Minimisation of pollution events during the construction phase will be ensured by the adequate maintenance of vehicles, the responsible handling and storage of potentially polluting materials and liquids and suitable training of staff.

In order to reduce the impact of accidental spillages (*e.g.* from plant fuel) during construction, appropriate planning will identify such risks and the precautionary measures to be taken such as:

- Spillage response kits;
- Seals to drains;
- Bunding of high risk areas; and,
- Training of staff in emergency procedures.

Furthermore, the Control of Pollution (Oil Storage) (England) Regulations 2001 together with the EA's (former) Pollution Prevention Guidelines will be complied with. The Regulations cover the storage of oil of any kind, including petrol, mineral oil, heating oil, lubricating oil, vegetable oil, heavy oils such as bitumen, and oils used as solvents, such as paraffin and kerosene. The Regulations stipulate the strength, integrity and delivery systems of oil containers and prescribe secondary containment systems such as drip trays or bunds, which will ensure that the likelihood of oil spillages are minimised.



6. Assessment of Residual Risk

The ADC SFRA indicates that the proposed development is wholly located in the EA's Flood Zone 1. Consequently, there is no requirement to provide compensatory fluvial flood storage and the residual risk of fluvial/coastal flooding is deemed to be of **neutral/negligible significance**. However, part of the site is at risk of flooding during the undefended scenario by 2070 and the whole site during the undefended scenario by 2115. The site is currently protected by tidal flood defences, and there is a commitment by the EA to maintain them at their current SoP throughout the lifetime of the proposed development. Nevertheless, as a precautionary measure, the dwellings will be made resilient to this residual future flood risk. It is proposed that the finished ground floor levels are raised above the 2070 undefended flood level of 2.62 mAOD, which will mitigate the risk from the 2070 undefended scenario. Furthermore, a water exclusion strategy will be adopted for the 2115 undefended risk comprising the installation of flood proof external doors, along with flood resilient design and flood resilient materials used for construction of all of the properties. The residual risk with climate change taken into account would therefore be considered of **negligible/neutral significance**.

A review of EA and ADC information demonstrates that the site does not lie within an area susceptible to groundwater flooding. The residual risk of groundwater flooding to the proposed development is therefore considered of **negligible/neutral significance**.

EA and ADC resources demonstrate that the site is at low risk of surface water flooding. The residual risk of flooding of the proposed development from surface water flooding is therefore considered **negligible/neutral significance**.

Within the bounds of the proposed development site, throttled water butts and permeable paving with subsurface storage will be incorporated into the design to sustainably manage runoff from rainfall events up to and including the 1 in 100 year event (+40 % CC). As a consequence of the proposal, the rate of runoff generated from the site will be maintained at the current (greenfield) rate, whilst the runoff volume will be no more than the greenfield runoff volume for the site. In addition to providing water quality benefits, this approach will ensure that downstream flows are alleviated during extreme storm events. The residual effect of the proposed redevelopment on the rate and volume of surface runoff generated is, therefore, deemed to be of **negligible/neutral significance**.

There are no records of surface water sewer problems or flooding incidents from highway drainage within the vicinity of the site. Consequently, the residual risk of flooding of the site from sewers is therefore considered **negligible/neutral significance**.

It is anticipated that the proposed redevelopment will lead to a small increase in foul water discharges from the site (there would have been significant previous loadings on the foul sewer network associated with the former usage of the site). The developer will augment the existing sewer infrastructure accordingly. In accordance with Building Regulations Part G, it is also anticipated that low water consumption appliances (low-flow taps and white goods) will be introduced throughout the proposed redevelopment, which will minimise foul water discharges. Following the introduction of these measures, the residual impact of the proposed redevelopment on the local sewerage infrastructure is deemed to be of **neutral/negligible significance**.

Neither the ADC SFRA nor the EA identify any potential flooding from reservoirs, canals and/or other artificial sources specifically within the application site. The residual risk of flooding of the site from artificial drainage bodies is therefore considered **negligible/neutral significance**.



7. Summary and Conclusions

Castle Property Developments Ltd has commissioned Hilson Moran Partnership to prepare a NPPF-compliant FRA for its residential development located on the 0.72 ha plot of land at The Cottage, Shripney Road, Bognor Regis, PO22 9PA, National Grid Reference SU 93828 02318.

This document constitutes a formal FRA to NPPF guidelines, appropriate to the scale and nature of the development and risks involved.

The development of the site will be used as an opportunity for environmental enhancement and the sustainable management of surface water runoff at source, including a 40 % allowance for climate change, through the provision of SuDS and a suitable water exclusion strategy to manage future (undefended) residual risk from tidal flooding. However, assuming the current SoP of local defences is maintained by the EA (as assured), the risk from fluvial, coastal, groundwater and sewer flooding has been identified as negligible.

In light of the above, the principle of the proposed development is deemed acceptable on flood risk grounds and will provide a positive contribution to the sustainable management of surface water runoff.



Appendix 1 Explanation of the Levels of Significance Used in FRAs

Significance	Impact of Proposed Development on both local and catchment hydrology	Risk of flooding of Proposed Development following completion
Not Significant	Proposed Development does not affect the quantity/quality of surface run-off and does not alter surface/groundwater flow locally or elsewhere within the catchment.	Proposed Development is not located in a 1:100 year fluvial or 1:200 year tidal floodplain. Flooding as a result of the accumulation of surface run-off on site, or elsewhere in the catchment is highly unlikely.
Low Significance	Proposed Development has a minor effect on the quantity/quality of surface run-off or surface/groundwater flow either locally or elsewhere within the catchment. Such changes may be sustainable without mitigation measures.	Proposed Development is located in a 1:100 year fluvial and/or 1:200 year tidal floodplain, although no mitigation measures are required due to regional flood defences. Existing local drainage measures are sufficient to ensure that the accumulation of surface run-off does not result in flooding on site or increase the risk of flooding elsewhere within the catchment.
Moderate Significance	Proposed Development has a notable effect on the quantity/quality of surface run-off and has a discernible impact upon surface/groundwater flow either locally or elsewhere within the catchment. Mitigation measures may be required in order for the development to be sustainable throughout the duration of its intended lifetime.	Proposed Development is located in a 1:100 year fluvial and/or 1:200 year tidal floodplain and mitigation measures are required to reduce flood risk to an acceptable level. Surface run-off attenuation methods may be required to ensure that the accumulation of surface run-off does not result in flooding on site or increase the risk of flooding elsewhere within the catchment.
Moderate – High Significance	Proposed Development has a large effect on the quantity/quality of surface run-off and has a considerable impact upon surface/groundwater flow either locally or elsewhere within the catchment. A primary commitment to successful mitigation measures will be required in order for the development to be sustainable throughout the duration of its intended lifetime.	Proposed Development is located in a 1:100 year fluvial and/or 1:200 year tidal floodplain and significant mitigation measures are required to reduce flood risk to an acceptable level. A range of surface run-off attenuation methods will be required to ensure that the accumulation of surface run-off does not result in flooding on site or increase the risk of flooding elsewhere within the catchment.
High Significance	Proposed Development has a major effect on the quantity/quality of surface run-off and has a severe impact upon surface/groundwater flow locally or elsewhere within the catchment. The incorporation of even a wide range of practicable mitigation measures may not ensure that the development remains sustainable throughout the duration of its intended lifetime.	The Proposed Development is considered to be particularly susceptible to either tidal or fluvial flooding or a combination of both. Resultant changes in the rates of surface run-off as a result of the development will increase flood risk both on site and elsewhere in the catchment. The incorporation of even a wide range of practicable mitigation measures may not ensure that the development remains sustainable in terms of flood risk for the duration of its intended lifetime.

Appendix 2 Source Protection Zone Definitions

In assessing the potential risk of contamination to groundwater resources, the Environment Agency has subdivided groundwater source catchments into four zones (see Figure A.1).

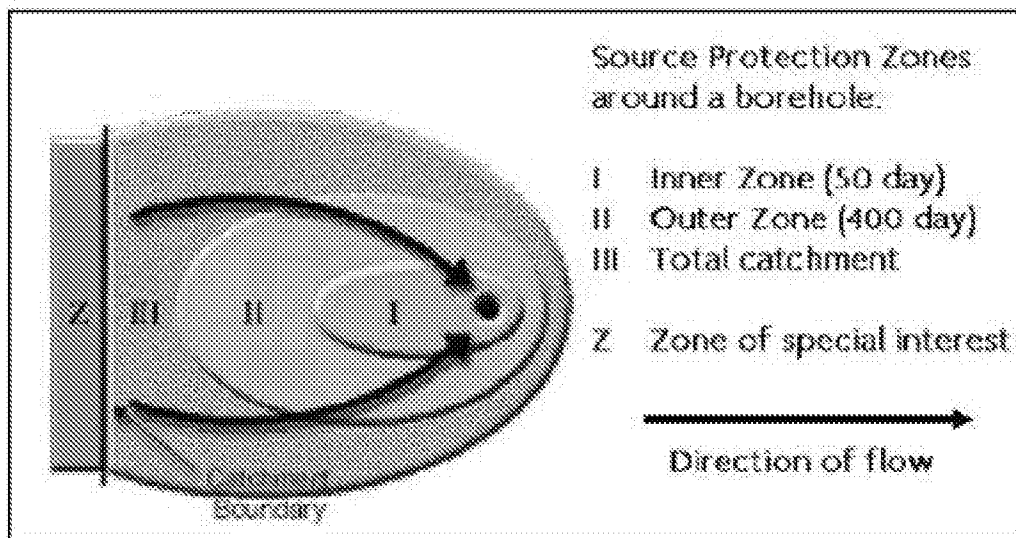


Figure A.1 EA Source Protection Zones

Two of these zones are defined by the travel time of potential pollutants, the third by the source catchment area itself and the fourth is a 'Zone of Special Interest'. The definitions for the zones are:

- **Zone I (Inner Protection Zone)** – This zone is defined by a travel time of 50-days or less from any point within the zone at, or below, the water table. Additionally, the zone has a minimum 50 m radius. It is based principally on biological decay criteria and is designed to protect against the transmission of toxic chemicals and water-borne disease;
- **Zone II (Outer Protection Zone)** – This zone is defined by the 400-day travel time, or 25% of the source catchment area, whichever is larger. The travel time is derived from consideration of the minimum time required to provide delay, dilution and attenuation of slowly degrading pollutants;
- **Zone III (Total Catchment)** – This zone is defined as the total area needed to support the abstraction or discharge from the protected groundwater source;
- **Zone of Special Interest** – For some groundwater sources an additional Zone of Special Interest may be defined. These zones highlight areas (mainly on non-aquifers) where known local conditions mean that potentially polluting activities could impact on a groundwater source, even though the area is outside the normal catchment of that source.

Appendix 3 Site Visit Photographs 12th April 2017



Photograph of the current site entrance



Photograph of the western edge of the site



Photograph of the northern side of the house and driveway



General photograph of the site, looking eastwards along the northern boundary



General photograph of the site, looking southwards from the northern boundary



Photograph of the drainage ditch to the east of the site



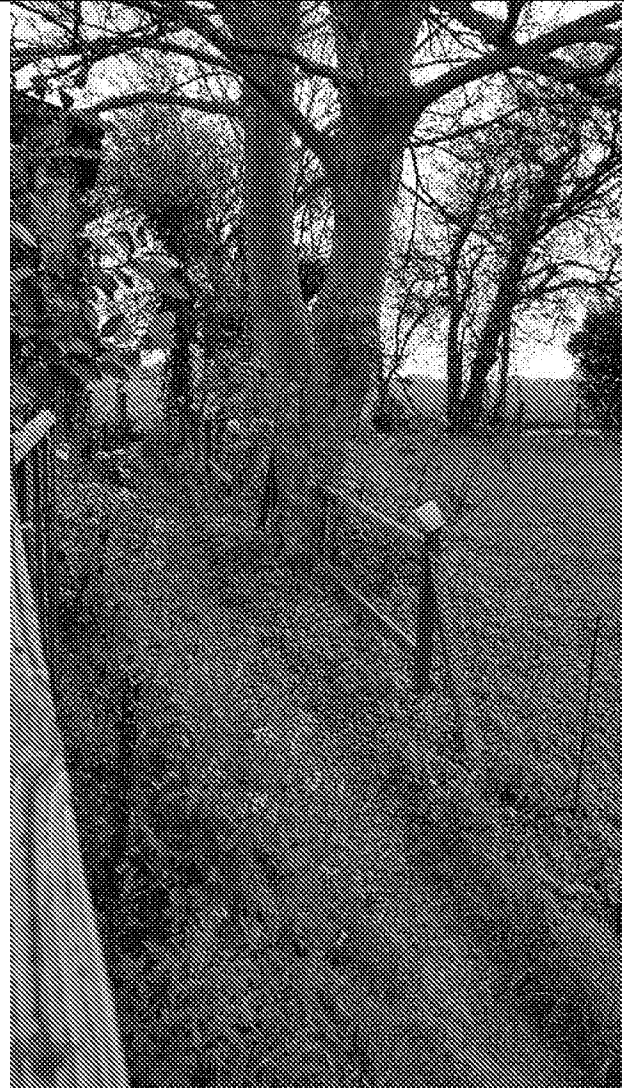
Photograph of concrete outbuilding in the south eastern corner of the site



General photograph of the site, looking northwards, including three disused greenhouse structures



Photograph of the public footpath through the site and the southern separated part of the site, looking westwards



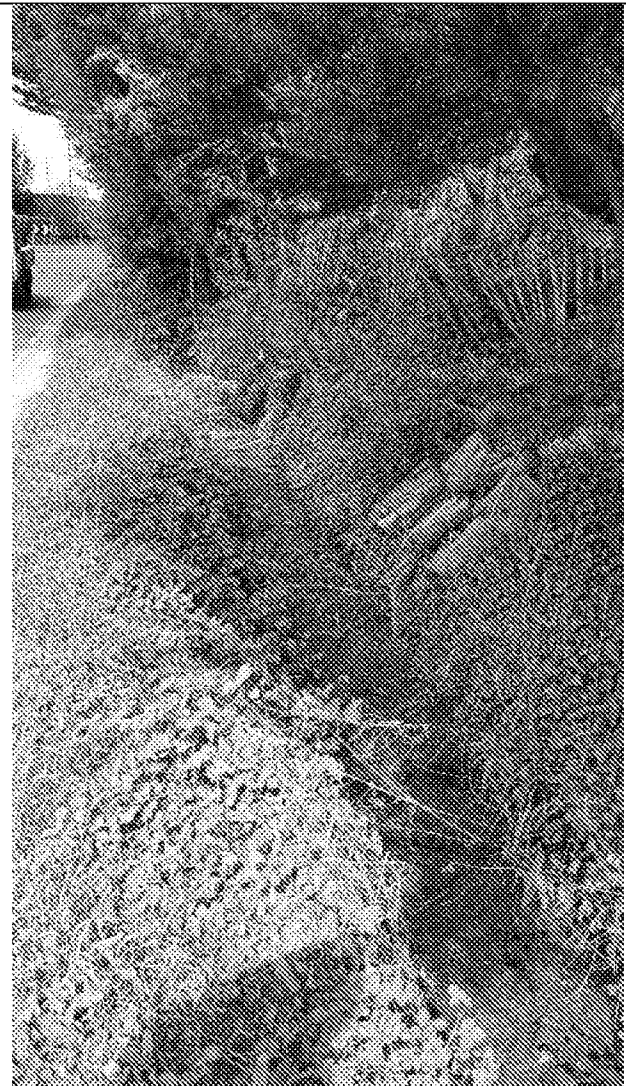
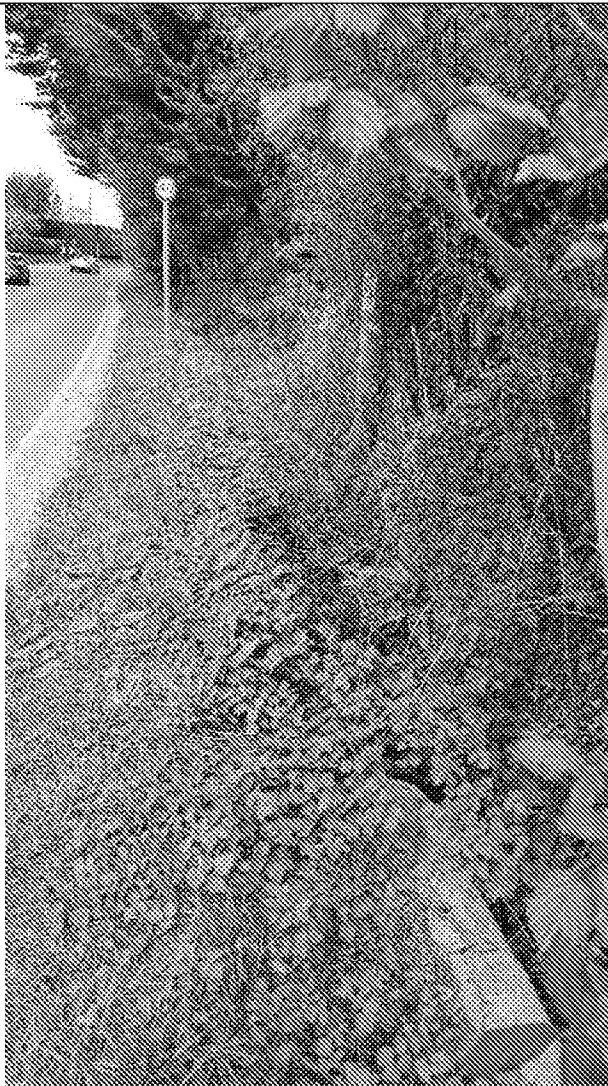
Photograph of the public footpath through the site, looking eastwards



Photograph of the slab covering the old cess pit. Stick to the bottom of the picture, approximately 500 mm long.



Photograph of a culvert feeding/connecting to the drainage ditch to the west of the site



Photograph of the drainage ditch to the west of the site, including the standing water on the right hand side.



Appendix 4 Environment Agency Product 4 Information

Pippa Messenger

Our ref: SSD/42262

Date: 29/03/2017

Dear Pippa

Provision of Product 4 for address: The Cottage, Bognor Regis, PO22 9PA

Thank you for your request 28th March 2017 to use Environment Agency data, Product 4. The information is attached.

The information on Flood Zones in the area relating to this address is as follows:

The property is in an area located within Flood Zone 1 shown on our Flood Map for Planning (Rivers and Sea).

Note - This information relates to the area that the above named property is in and is not specific to the property itself.

Please find attached a copy of the Flood Map for Planning (Rivers and Sea) for the area relating to your address.

Further details about the Environment Agency information supplied can be found on the GOV.UK website:

<https://www.gov.uk/browse/environment-countryside/flooding-extreme-weather>

If you have requested this information to help inform a development proposal, then you should note the information on GOV.UK on the use of Environment Agency Information for Flood Risk Assessments

<https://www.gov.uk/planning-applications-assessing-flood-risk>

<https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion>

Guildbourne House, Chatsworth Road, Worthing, West Sussex, BN11 1LD
Customer services line: 03708 506 506

www.environment-agency.gov.uk
98_07_SD01

Supporting Information

Flood Defences

Based on our records, there are currently no formal raised defences in this area.

Whilst there are no defences within the vicinity of the site the flood extents suggest that the site still does benefit from flood defences. This is likely due to the sea defences in Bognor Regis, which consists of a foreshore and wave return wall to a standard of protection of a 1 in 200 year flood.

Model Information

The flood outlines, depths and levels are taken from the River Arun to East Head 2016 model, completed by JBA Consulting.

Flood History

We do not have any records of previous flood events affecting this site. I would suggest contacting Arun District Council for a more comprehensive flood history check.

Please note our records are not comprehensive and may not include all events, you can contact your Local Authority to check if they hold any relevant information regarding your application.

You are encouraged to use and re-use this information freely and flexibly, with only a few conditions. Details of which can be found here:

<http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>

We respond to requests for recorded information that we hold under the Freedom of Information Act 2000 (FOIA) and the associated Environmental Information Regulations 2004 (EIR).

If you are not satisfied with our response to your request for information you can contact us within 2 calendar months to ask for our decision to be reviewed.

If you have any queries or would like to discuss the content of this letter further please call us on 03708 506506.

Yours faithfully
Freddie Fielding
PSO West Sussex

Enc. Flood Map for Planning (Rivers and Sea) / Node point locations / Flood levels/depths / Modelled flood outlines / Flood Defence Locations

Use of Environment Agency Information for Flood Risk Assessments

Important

If you have requested this information to help inform a development proposal, then we recommend that you undertake a formal pre-application enquiry using the form available from our website:-

<https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion>

Depending on the enquiry, we may also provide advice on other issues related to our responsibilities including flooding, waste, land contamination, water quality, biodiversity, navigation, pollution, water resources, foul drainage or Environmental Impact Assessment.

You should refer to the Environment Agency's Flood Risk Standing Advice, Planning Practice Guidance, and the existing PPS25 Practice Guide for information about what flood risk assessment is needed for new development in the different Flood Zones. These documents can be accessed via:

<https://www.gov.uk/flood-risk-assessment-standing-advice>

<http://planningguidance.planningportal.gov.uk/>

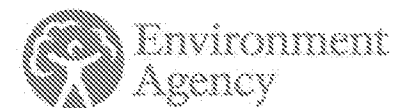
<http://www.planningportal.gov.uk/planning/planningpolicyandlegislation/previousenglishpolicy/ppqpps/pps25>

You should also consult the Strategic Flood Risk Assessment produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk Assessment (FRA) where one is required, but does not constitute such an assessment on its own.
2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or overland runoff. The information produced by the local planning authority referred to above may assist here.
3. Where a planning application requires a FRA and this is not submitted or deficient, the Environment Agency may well raise an objection.
4. For more significant proposals in higher flood risk areas, we would be pleased to discuss details with you ahead of making any planning application, and you should also discuss the matter with your local planning authority.

Flood Map for Planning (Rivers and Sea). Centred PO22 9PA. Created 29/03/2017.



Scale 1: 10,000



Flood Map for Planning (Rivers & Sea)

- Defences
- Flood Storage Areas
- Areas benefiting from flood defences
- Flood Zone 3
- Flood Zone 2

Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

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Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Product 4 Flood Risk Data Requested by: Pippa Messenger

Site: The Cottage, Bognor Regis, PO22 9PA

Table 1: Water Levels: Tidal Undefended

Node Reference	NGR		Modelled Flood Levels in Metres				
	Easting	Northing	Undefended Annual Exceedance Probability				
			5%	0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	493802	102337	-	-	-	3.60	-
2	493812	102305	-	-	2.62	3.60	-
3	493863	102349	-	-	-	3.60	-
4	493875	102319	-	-	-	3.60	-

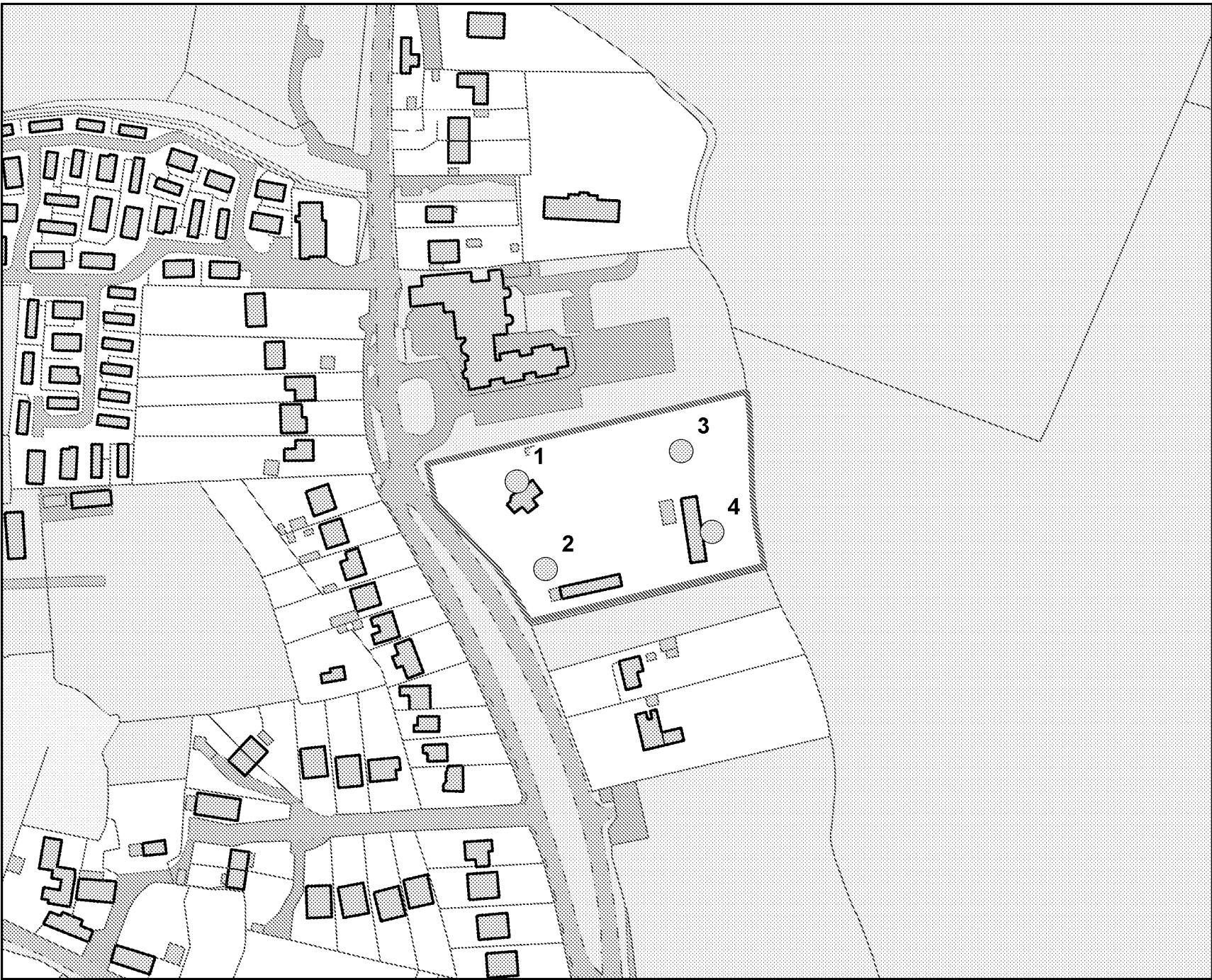
Table 2: Water Depth: Tidal Undefended

Node Reference	NGR		Modelled Flood Depth in Metres				
	Easting	Northing	Undefended Annual Exceedance Probability				
			5%	0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	493802	102337	-	-	-	0.51	-
2	493812	102305	-	-	0.22	1.19	-
3	493863	102349	-	-	-	0.29	-
4	493875	102319	-	-	-	0.58	-

All levels taken from: River Arun to East Head 2016 model, completed by JBA Consulting

There is no additional information or health warnings for these levels/depths or the model from which they have been produced.

Produced on 18/04/2017



Environment
Agency



Legend



Site Nodes



Site Boundary

Scale: 1:2,000



0 0.025 0.05

Kilometers

Flood Defence Locations. Centred PO22 9PA. Created 29/03/2017.

Legend

Defences

- Embankment
- Wall
- Flood Gate
- Demountable Defence
- Bridge Abutment
- High Ground
- Beach
- Barrier Beach
- Promenade
- Quay
- Cliff
- Dunes
- Culvert







Environment
Agency



Legend

- Site Boundary
- Main River
- 5% AEP (Defended Tidal)
- 0.5% AEP (Defended Tidal)
- 0.1% AEP (Defended Tidal)
- 0.5% AEP (2070) NPPF (Defended Tidal)
- 0.5% AEP (2115) NPPF (Defended Tidal)

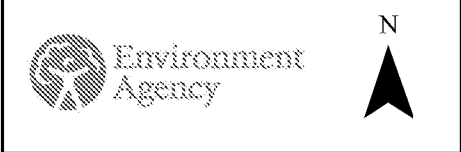
Scale: 1:10,000

0

0.125

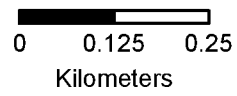
0.25

Kilometers



- Legend**
- Site Boundary
 - Main River
 - 5% AEP (Un defended Tidal)
 - 0.5% AEP (Un defended Tidal)
 - 0.1% AEP (Un defended Tidal)
 - 0.5% AEP (2070) NPPF (Un defended Tidal)
 - 0.5% AEP (2115) NPPF (Un defended Tidal)

Scale: 1:10,000





References

- i Ministry of Housing, Communities and Local Government (2018) National Planning Policy Framework
- ii Department for Communities and Local Government (2014) Planning Practice Guidance – Flood Risk and Coastal Change. Accessed through <http://planningguidance.planningportal.gov.uk>.
- iii Arun District Council (ADC) Arun Local Plan 2011 – 2031 Adopted 18th July 2018.
- iv HM Government (2015): Building Regulations Part H (Drainage and Waste Disposal). Accessed through <http://www.planningportal.gov.uk>.
- v Environmental Protection Act (1990), HMSO.
- vi Flood and Water Management Act (2010), HMSO.
- vii British Geological Survey (2017): Geology of Britain Viewer. Accessed through <http://mapapps.bgs.ac.uk> [accessed 28/03/2017]
- viii National Soil Resources Institute (2017): Soilscape Map. Accessed through <http://www.landis.org.uk> [accessed 28/03/2017]
- ix Arun District Council (2016) Strategic Flood Risk Assessment. Level 1: Final Report, August 2016.
- x Arun District Council (2016) Arun Strategic Surface Water Management Study Stage 2 Report, August 2016
- xi West Sussex (2013) Local Flood Risk Management Strategy (2013-2018)
- xii Environment Agency (2013) Arun & Western Streams Catchment Abstraction Licensing Strategy March 2013.
- xiii Environment Agency (2009) Arun and Western Streams Catchment Flood Management Plan Summary Report December 2009
- xiv West Sussex County Council (2014): Lidsey Surface Water Management Plan.
- xv DEFRA/Department for Communities and Local Government/CIRIA (2007). Improving the flood performance of new buildings: Flood resilient construction. May 2007.
- xvi BSI (2014). PAS 1188-1:2009. Flood protection products. Specification. Building aperture products. BSI Standards Publication.
- xvii BSI (2015). BS 85500:2015. Flood resistant and resilient construction. Guide to improving the flood performance of buildings
- xviii CIRIA (2015): Sustainable Drainage System Manual 2015. CIRIA C753. ISBN: 978-0-86017-760-9
- xix Office of the Deputy Prime Minister (2004): Interim Code of Practice for Sustainable Drainage Systems. National SuDS Working Group, July 2004.
- xx Marshall, D. C. W. And Bayliss, A. C. (1994): Flood Estimation for Small Catchments. Institute of Hydrology.
- xxi Natural Environment Research Council (1975): Flood Studies Report. 5 Volumes. NERC, London.
- xxii Hall, M. J., Hocking, D. L. And Ellis, J. B. (1993): Design of Flood Storage Reservoirs. CIRIA Book 14.
- xxiii Institute of Hydrology (1999): Flood Estimation Handbook CD-ROM, Version 2.0.
- xxiv Department of the Environment, National Water Council (1981): Wallingford Procedure for Design and Analysis of Urban Storm Drainage, 3 Volume Set. Ref: WP5 CD, Standing Technical Committee Reports No 31.
- xxv Environment Agency (2016): Guidance - Flood risk assessments: climate change allowances internet website at <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-2> [accessed 10/06/2016].
- xxvi DEFRA (2015). Sustainable Drainage Systems: Non-statutory technical standards for sustainable drainage system, March 2015
- xxvii DEFRA (2015). Sustainable Drainage Systems: Non-statutory technical standards for sustainable drainage system, March 2015
- xxviii WRC (2012): Sewers for Adoption 7th Edition.
- xxix Office of the Deputy Prime Minister (2000): The Building Regulations 2000: Drainage and Waste Disposal – H3: Rainwater Discharge.



^{xxx} Department for Environment, Food & Rural Affairs (2002): Protocol on Design, Construction and Adoption of Sewers in England and Wales. April 2002. HMSO.