

Bushnell Marine Services Ltd

**Flood Risk Assessment
for the
proposed development at
Meadowsweet, Loddon Drive,
Wargrave RG10 8HD**

Report K0505/2 (Rev 0)

January 2017

Prepared and submitted by



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EXECUTIVE SUMMARY OF REPORT

This report documents the work undertaken by Hydro-Logic Services for Bushnell Marine Services Ltd between December 2016 and January 2017. It follows earlier work undertaken in relation to a previous proposal at the same location between June 2014 and March 2015.

The purpose of the work was:

- Undertake and prepare a Flood Risk Assessment report suitable for submission to the planning authority for the development of two new properties to replace two existing properties.

The scope of the work included and was limited to the following, by agreement with David Bushnell:

- Undertake a site visit to inspect the location and surroundings of the proposed development, and adjacent watercourses.
- Analyse flood information sourced from the Environment Agency (including design levels and climate change allowance) and Wokingham Borough Council Strategic Flood Risk Assessment (SFRA), in order to determine the implications for the proposed development.
- Determine the main sources of flood risk at the proposed development.
- Determine and report the extent to which flood mitigation measures may be required to make the development safe from a flood risk perspective.

The work delivered the following outputs:

- This report, the key findings of which are provided in Section 5.

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Limitation of liability and use

The work described in this report was undertaken for the party or parties stated; for the purpose or purposes stated; to the time and budget constraints stated. No liability is accepted for use by other parties or for other purposes, or unreasonably beyond the terms and parameters of its commission and its delivery to normal professional standards.

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1. Introduction

1.1 Purpose of this Report

This report presents a Flood Risk Assessment (FRA) for the proposed redevelopment at the site currently known as *Meadowsweet*, an existing residential plot at Loddon Drive, Wargrave RG10 8HD.

1.2 Background

The National Planning Policy Framework (NPPF) was published on 27 March 2012 and sets out the Government's planning policies for England and how these are expected to be applied. Flooding is addressed, principally in paragraphs 100 to 104 of the NPPF. These seek to avoid inappropriate development in areas at risk of flooding by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere.

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.

A site-specific flood risk assessment must demonstrate the following:

- that the development will be safe for its lifetime taking account of the vulnerability of its users;
- it should not increase flood risk elsewhere
- it should if possible, reduce flood risk overall.

The NPPF Planning Practice Guide provides a pro-forma checklist for undertaking FRAs, and this is reproduced as Appendix A of this Report. The section titles in this report cross-reference the corresponding sections in the pro-forma (and vice-versa).

Hydro-Logic Services was appointed by Bushnell Marine Services Ltd in November 2017 to undertake a FRA for the proposed development. This work followed several revisions of a FRA for earlier proposals at the site, also undertaken by HLS, between June 2014 and March 2015. The previous scheme was refused planning permission on appeal due to concerns relating to scale, appearance and character, although not on flood risk grounds.

An inspection of the site, surrounding area and watercourses was undertaken on 24th June 2014 as part of the FRA for the previous development proposal. Information gained during this visit informed the review of the site and development proposals outlined in sections 2, 3 and 4.

1.3 Sources of Information and Consultation

The following sources of information were referenced during the development of this report.

- Foddy Consult and AJA Architects LLP provided details of the current and proposed development at the site.
- The Environment Agency website (<http://www.environment-agency.gov.uk/>) was referenced for flood related information in the Wargrave area. Further flood related information, Product 4 data and advice specific to the site was provided directly by the Environment Agency.

- The Wokingham Borough Council website (<http://www.wokingham.gov.uk/>) was referenced for the SFRA and associated flood maps, details of the designated flood zones, and planning guidance for developments in the flood zones.

1.4 Structure of this Report

This report has been structured in order to deal with each of the sections outlined in the NPPF Practice Guide FRA Checklist (reproduced as Appendix A of this Report). Each of the points is referenced in the appropriate headings. For example, in section 2.2 Environment Agency Flood Zone (3a), the suffix (3a) cross-references section 3a of the NPPF Practice Guide FRA Checklist.

Section 2 describes the spatial planning considerations for the existing site.

Section 3 presents an assessment of the existing flood risk at the application site.

Section 4 presents an assessment of flood risks associated with the proposed development along with any mitigation that may be required.

Section 5 presents a summary of the main findings.

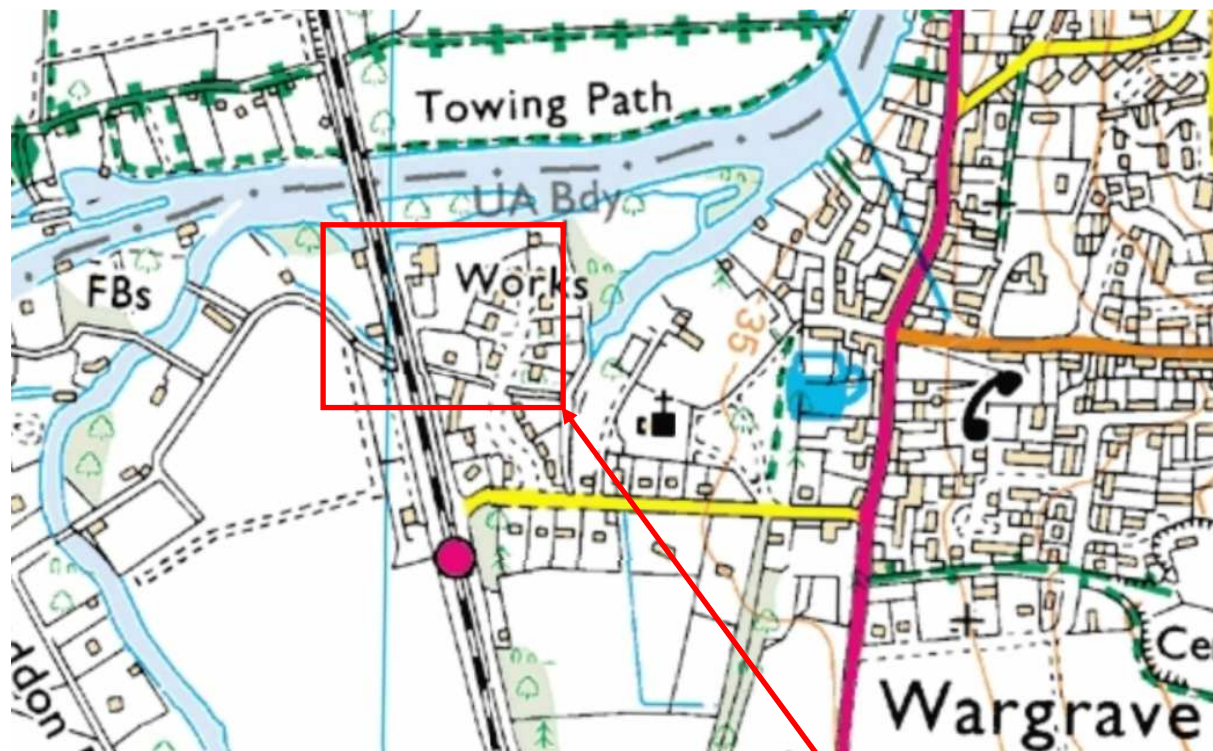
2. Spatial Planning Considerations

2.1 Location Plan and Site Plan (1a)

The site of proposed development (the site) is located at *Meadowsweet*, an existing residential plot at Wargrave RG10 8HD. The site is bounded by Bushnell's boatyard and Watermans Way to the north, a private access road running from Loddon Drive parallel to the railway viaduct to the west, a drainage channel to the south, and adjacent properties to the east. The site is located within the boundary of Wokingham Borough.

The location of the site is indicated in Figure 2-1. The inset shows the site boundary in red.

Figure 2-1 Location of the proposed development (inset, site boundary in red)



Reproduced under Licence 100041271



An aerial photograph of the site is reproduced in Figure 2-2. Again, the site boundary is indicated in red.

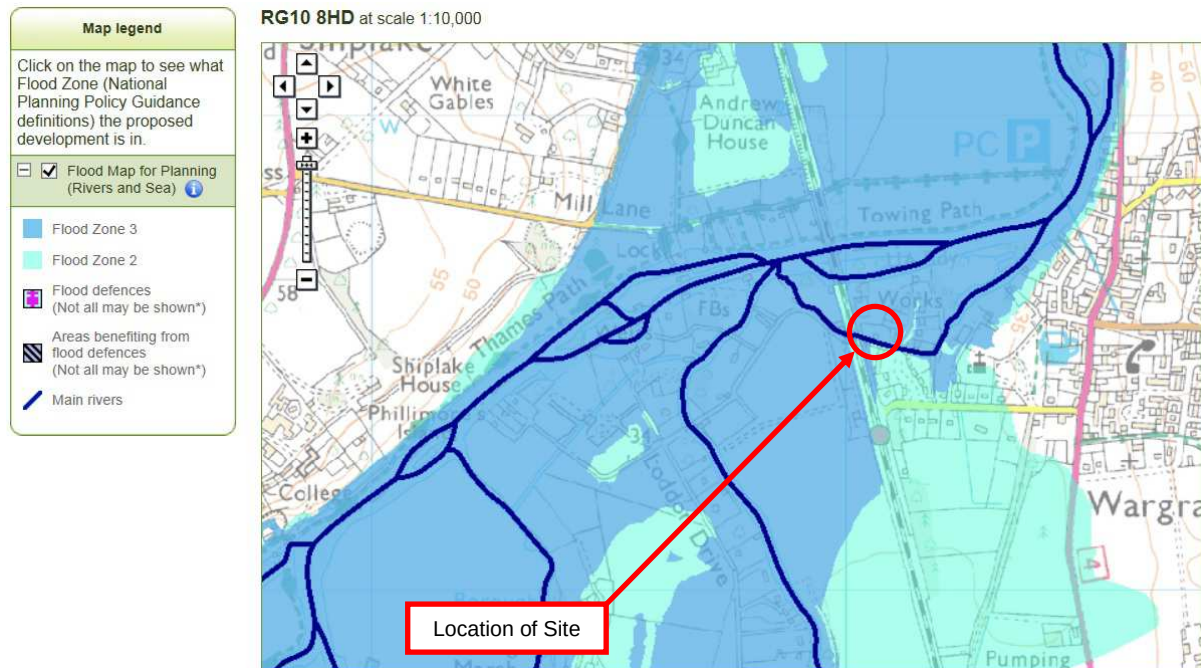
Figure 2-2 Aerial photograph of the proposed development (site boundary in red)



2.2 Environment Agency Flood Zone (3a)

The Environment Agency Flood Map for Planning shown in Figure 2-3 indicates that the site lies entirely in Flood Zone 3. The River Thames is approximately 85m north of the site at its closest point. The River Loddon is west of the site and joins the River Thames approximately 200m to the northwest of the site. These two watercourses are the predominant sources of flooding at the site.

Figure 2-3 Environment Agency Flood Map for Planning



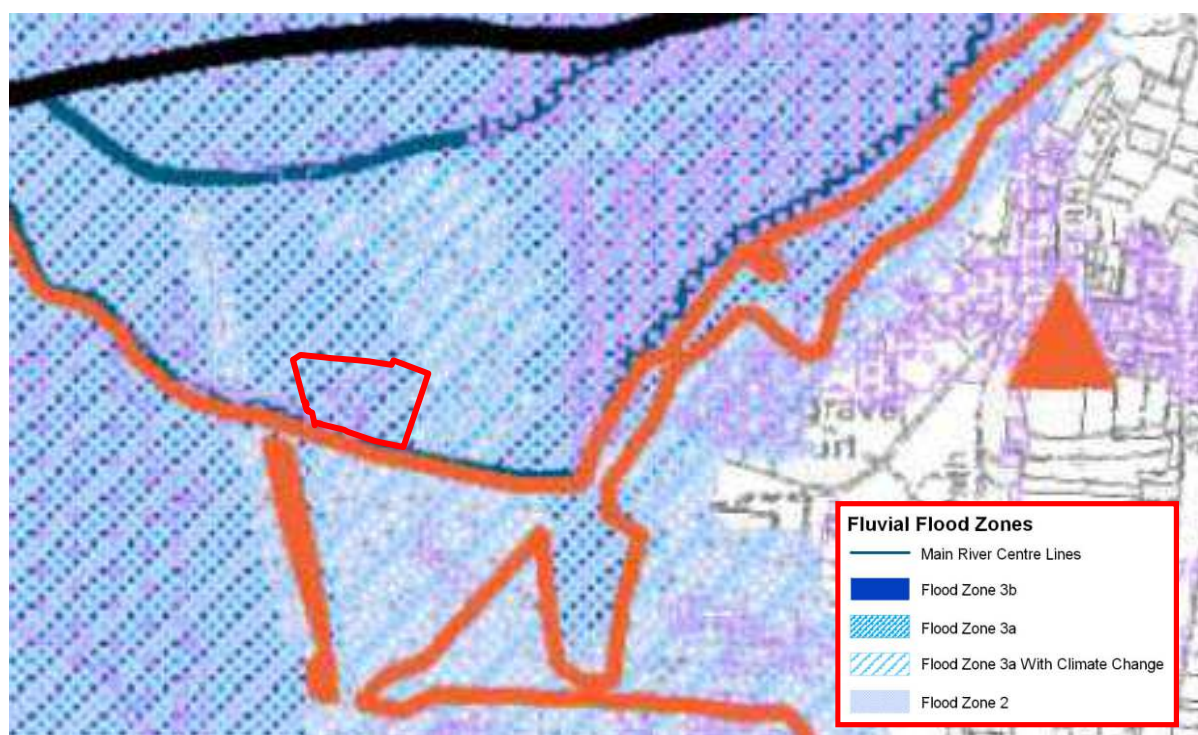
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2.3 The SFRA and Sequential Test (1b, 1c, 1d, 3b, 3c)

The Wokingham Borough Council (WBC) SFRA (Halcrow Group Ltd, February 2012) presents a detailed assessment of flood risk across the borough and forms part of the evidence base for the WBC Local Development Framework.

The SFRA Flood Maps are based entirely on information provided by the Environment Agency; no additional fluvial or pluvial modelling was carried out for the purposes of the SFRA. The SFRA Map 7-3 covers the Wargrave area, and part of the map close to the site is reproduced in Figure 2-4. Although the presentation styles of the SFRA map and the Environment Agency Flood Map for Planning are different, it may be seen that the flood extents on both maps are the same.

Figure 2-4 Wokingham Borough Council SFRA Flood Zone Map 7-3 at site (boundary in red)



The NPPF Technical Guide (DCLG, 2012b) provides a table describing flood risk classification by development type. This table is reproduced in Table 2-1 below, and confirms that the type of proposed development - *buildings used for dwelling houses* – is classified as *More Vulnerable*. This classification is of key importance in identifying flood risk vulnerability and flood zone compatibility.

The proposed development anticipates the replacement of two existing residential buildings and associated outbuildings on a like-for-like basis, with the emphasis on improving flood risk over the current situation. Consequently, the *Sequential Test* is not required for the proposed development.

Table 2-1 Flood risk vulnerability classification

Essential Infrastructure (EI)
Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk.
Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood.
Wind turbines
Highly Vulnerable (HV)
Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding.
Emergency dispersal points.
Basement dwellings.
Caravans, mobile homes and park homes intended for permanent residential use.
Installations requiring hazardous substances consent. ¹⁹ (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure' ²⁰).
More Vulnerable (MV)
Hospitals.
Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels.
Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels.
~~Non-residential uses for health services, nurseries and educational establishments.~~
Landfill and sites used for waste management facilities for hazardous waste.
Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable (LV)
Police, ambulance and fire stations which are not required to be operational during flooding
Buildings used for: shops; financial, professional and other services; restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non-residential institutions not included in 'more vulnerable'; and assembly and leisure.
Land and buildings used for agriculture and forestry.
Waste treatment (except landfill and hazardous waste facilities).
Minerals working and processing (except for sand and gravel working).
Water treatment works which do not need to remain operational during times of flood
Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).
Water-compatible Development (WC)
Flood control infrastructure.
Water transmission infrastructure and pumping stations.
Sewage transmission infrastructure and pumping stations.
Sand and gravel workings.
Docks, marinas and wharves.
Navigation facilities.
MOD defence installations.
Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.
Water-based recreation (excluding sleeping accommodation).
Lifeguard and coastguard stations.
Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.
Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

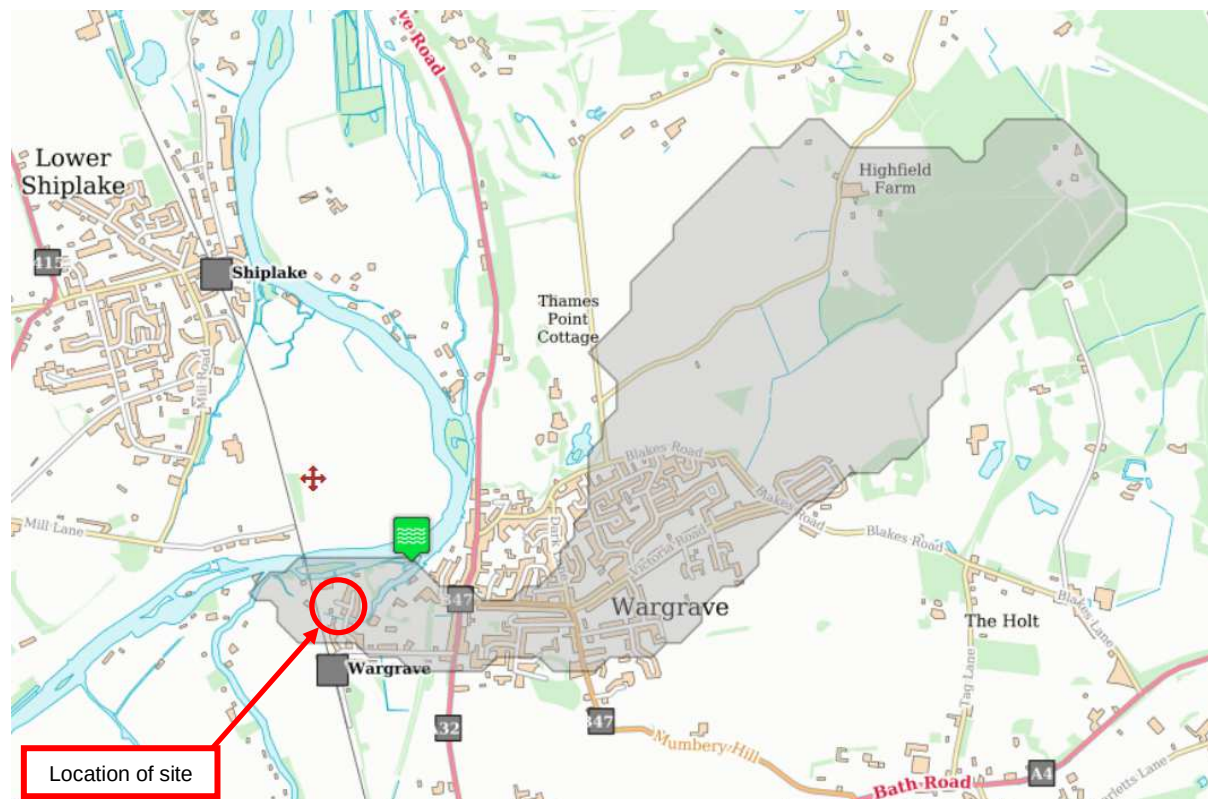
Table 2 from NPPF Technical Guide (DCLG, 2012b)

3. Flood Risk for Existing Site

3.1 Catchment Characteristics

The Flood Estimation Handbook (FEH) Web Service was used to generate the characteristics of the catchment that incorporates the site. The catchment boundary is indicated by the grey polygon in Figure 3-1. It may be seen that, although the site lies close to the River Thames and River Loddon, it is located within the small catchment that incorporates Upper Wargrave to the east of the site. The catchment drains into the River Thames approximately 380m northeast of the site.

Figure 3-1 FEH Web Service catchment at location of site (catchment as grey polygon)



Source: © Centre for Ecology & Hydrology (CEH) 2017

The catchment area is approximately 2.3km² at the site. The standard average annual rainfall (SAAR) value of 669mm is around the average for southern England. The standard percentage run-off index (SPRHOST) typically ranges from high values (50%) associated with relatively impermeable clay catchments, to low values (5%) associated with permeable geologies. The SPRHOST value for the catchment of approximately 27% is therefore intermediate in a UK context, reflecting the moderately well-draining nature of the soil in this area. The urban extent (URBEXT2000) registered in 2000 are approximately 13%, reflecting the low-density development and predominantly rural nature of the catchment as a whole. The catchment descriptors are reproduced in Table 3-1.

Table 3-1 Characteristics of the catchment

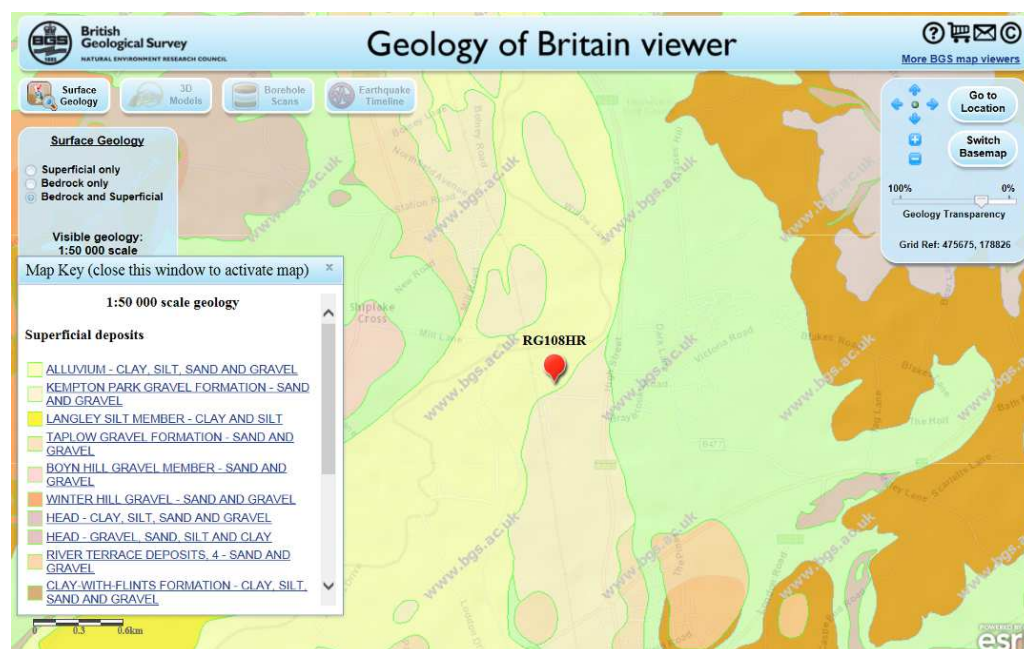
	Location:	Wargrave
	River:	
	NGR:	SU 78350 78700
AREA	Catchment area (km ²)	2.29
ALTBAR	Mean elevation (m)	74
ASPBAR	Mean aspect (degrees)	225
ASPVAR	Variance of aspect	0.59
BFIHOST	Base flow index	0.59
DPLBAR	Mean drainage path length (km)	2.01
DPSBAR	Mean drainage path slope (m/km)	41.6
FARL	Index of lakes	1
FPEXT	Prop. of catchment in 1% FP	0.1213
FPDBAR	Mean flood depth (catchment)	3.507
FPLOC	Avg dist of FP to outlet	0.366
LDP	Longest drainage path (km)	3.58
PROPWET	Proportion of time soil is wet	0.29
RMED-1H	Median 1 hour rainfall (mm)	12.1
RMED-1D	Median 1 day rainfall (mm)	32.1
RMED-2D	Median 2 day rainfall (mm)	42.1
SAAR	Average annual rainfall (mm)	669
SAAR4170	Ditto for 1941-1970 (mm)	701
SPRHOST	Percentage runoff	27.44
URBCONC2000	Urban concentration 2000	0.783
URBEXT2000	Urban extent 2000	0.1328
URBLOC2000	Urban location 2000	0.526

Source: © Centre for Ecology & Hydrology (CEH) 2017

3.2 Geology

The British Geological Society (BGS) Geology of Britain Viewer is shown in Figure 3-2 and indicates the site is an area with *chalk bedrock overlain by superficial deposits of alluvium* (clay, silt, sand and gravel).

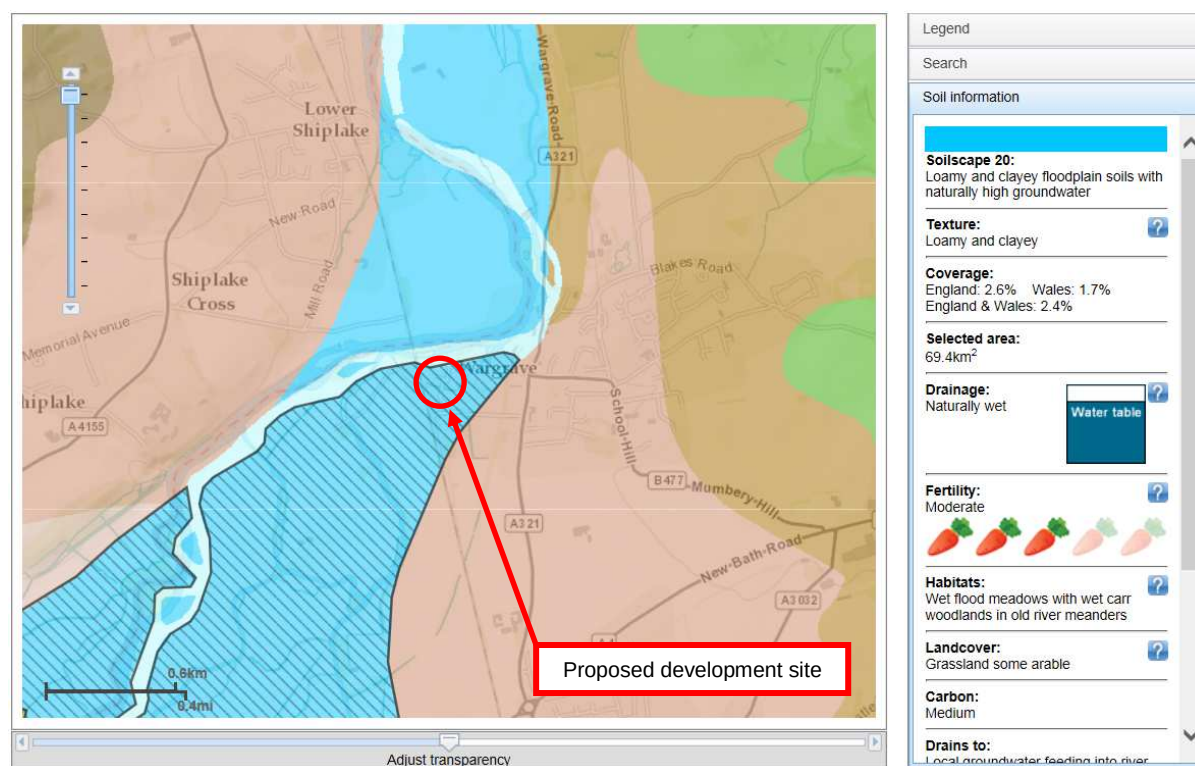
Figure 3-2 BGS Geology Viewer



British Geological Society (BGS)

The National Soil Resources Institute (NSRI) Soil Map shown in Figure 3-3 indicates the site is in an area characterised as *loamy and clayey floodplain soils with naturally high groundwater*.

Figure 3-3 NSRI Soil Map



National Soil Resources Institute (NSRI)

3.3 Infiltration Rates

The three indicators of the infiltration characteristics at the site – the catchment characteristic SPRHOST, the surface geology and the soil type – point to a range of potential drainage characteristics at the site. In order to determine the actual infiltration rates applying at the site, soil infiltration testing was undertaken at the site by Aviron Associates Limited on 16th October 2014¹ in accordance with BRE Digest 365. The test summary report is reproduced as Appendix B of the current report.

The test results indicate that an infiltration rate of $8.27 \times 10^{-6} \text{m/s}$ applies at the site. This rate corresponds to moderately well-draining soil and indicates that infiltration is a viable means of managing surface water runoff at the site. The utilisation of infiltration as a means of managing surface water is discussed further in Section 4.

¹ Undertaken for previous development proposal – see K0505_FRA_Meadowsweet_Rep1Rev4.

3.4 Source of Flood Risk (2a)

It is a requirement of NPPF that all possible sources of flood risk to proposed sites be investigated. Table 3-2 shows the sources and the risk they pose, with specific risks discussed further in the report.

Table 3-2 Possible sources of flood risk

Key sources of flooding	Possibility at Site
Fluvial (Rivers)	The site is located in Flood Zone 3, and is subject to fluvial flooding from the River Thames and River Loddon.
Tidal	None.
Groundwater	Given the topography of the site and its location within Flood Zone 3, high groundwater levels are likely to be associated with high river levels.
Sewers	The site is located within a small but concentrated built up area, and there are both foul and surface water sewers at and adjacent to the site. However, the WBC SFRA does not indicate there have been any instances of sewer flooding close to the site.
Surface water	The risk of surface water flooding is generally very low across most of the site. However, a small area of high risk is indicated at the south-eastern corner of the site. This is discussed further in Section 3.5 below.
Infrastructure failure	None.

Based on CLG (2009)

3.5 Flood Mechanisms (2b)

Table 3-2 indicates that flooding from tidal sources and infrastructure failure does not apply at the site. Groundwater flooding is likely to be associated with, and therefore dominated by, fluvial flooding due to high, out-of-bank river levels.

The main flood mechanism derives from the location of the site within Flood Zone 3, inside the 100 year return period fluvial flood extent. The River Loddon to the west of the site and the River Thames to the north of the site are the predominant sources of flooding at the site.

The small channel immediately to the south of the site, adjacent to the *Meadowsweet* plot, is shown on the Environment Agency Flood Map for Planning (Figure 2-3) as a designated main river. The location of the channel corresponds to the Flood Zone 2/3 boundary. The channel connects the River Thames northwest of the site with the culverted channel draining the 2.3km² Upper Wargrave catchment to the east of the site. The channel may have been constructed for the purpose of land drainage. Sections of the channel have been well maintained (Figure 3-4), while other sections are heavily silted and overgrown (Figure 3-4). Flows in the channel have been observed (by the client during times of high river levels) in an easterly direction, away from the River Loddon. The recently modified bridge tunnel under Watermans Way (Figure 3-6) has been observed (also by the client during times of high river levels) to surcharge.

The inability of this channel to adequately contain River Loddon flood water has likely contributed to flooding beneath the railway bridge to the southwest of the site. However, it is considered unlikely to be a direct source of flood risk at the site itself outside context of high water levels on the River Loddon.

Figure 3-4 Channel southeast of site



Figure 3-5 Channel southwest of site

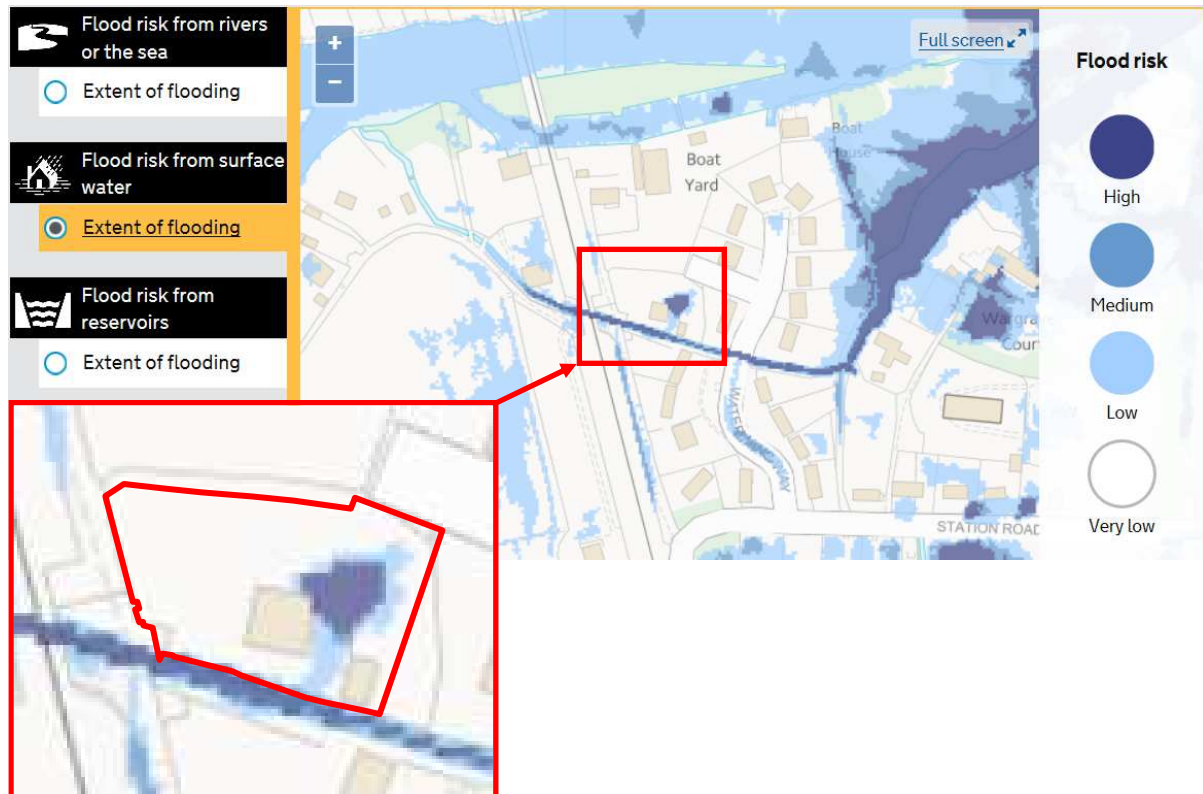


Figure 3-6 Bridge over channel, Watermans Way



The WBC SFRA Flood Map 6e: *Flood Map for Surface Water* does not show any surface water flooding at the site. The Environment Agency *Flood Risk from Surface Water* map is shown in Figure 3.7 and indicates that there is generally a *Very Low* risk of surface water flooding across most of the site. However, significant areas of *Low*, *Medium* and *High* risk are indicated toward the eastern part of the site.

Figure 3-7 Environment Agency Risk of Flooding from Surface Water



The eastern part of the *Meadowsweet* plot is currently given over to a patio (Figure 3-8) and significant areas of impermeable surface (Figure 3-9), and this region of the site corresponds to the area of *Low*, *Medium* and *High* risk of surface water flooding indicated in the Environment Agency *Flood Risk from Surface Water* map. Flooding on the patio has been observed by the owner after periods of heavy rain. However, the risk from this flooding is considered minor, given that the total area is low, no onward flow paths are indicated, and levels are well below that of fluvial flooding,

Figure 3-8 Patio at eastern part of site



Figure 3-9 Hardstanding at south-east of site



Flood risk from fluvial sources and surface water runoff is considered further in Section 4.3.

3.6 Existing Surface Water Drainage Arrangements (2c, 3d)

The site is currently occupied by two residential dwellings. Rainfall runoff from the roofs of these buildings is routed to the surface water drainage network at the site. As shown in Figure 3-8, the paved patio area also appears to be connected to the surface water drains, and it is possible that surface water flooding indicated would be caused by inadequate capacity or blockage. However, surface water would eventually infiltrate, either between or adjacent to the paving slabs.

The remaining impermeable surfaces at the site, such as the roofs of smaller outbuildings and driveways, are not connected to the surface water drainage network, and rainfall runoff from these areas would infiltrate at the adjacent permeable areas. Rain falling directly onto the permeable areas within the site would infiltrate due to the well-draining characteristics of the soil, unless groundwater levels were high.

The proposed surface water drainage arrangements are discussed in further detail in 4.3.1.

3.7 Probability of Site Flooding (3a, 3c)

As outlined previously in section 2.2 of this report, the Environment Agency Flood Map for Planning (Figure 2-3) shows that the site lies entirely within Flood Zone 3, inside the 100 year fluvial flood extent. The main identified source of flooding therefore is fluvial, specifically from the River Thames to the north of the site, and River Loddon to the west of the site. Flooding from the River Thames at this location would be a long duration event, with long lead and recession times. Flooding from the River Loddon would be of shorter duration. Flooding at the site could potentially be driven from both watercourses at the same time.

The Environment Agency Product 4 FRA flood maps centred on the site are shown in Figure 3-10 and Figure 3-11. The maps indicate the site is in the functional floodplain (Flood Zone 3b), with the latter map indicating the site is in partly in the 1 in 20 year flood extent and partly in the 1 in 5 year flood extent (see inset). These maps are similar to the map shown in Figure 2-3, but also show model nodes for the River Thames and land close to the site. The two model nodes closest to the site are nodes 100 and 106. Node 106 is to the west of the railway viaduct that would act as a significant constraint to eastward flood flows from the River Loddon, and for this reason it is considered that water levels at node 100 provide a more reliable indication of water levels at the site.

The Product 4 modelled flood levels for each node are reproduced in Table 3-3. The data indicates that at node 100, the 100 year modelled flood level is 34.487mAOD, and the 100 year plus 20% climate change modelled flood level is 34.791mAOD.

However, the guidance on climate change allowances has changed since the Product 4 data was produced (see Appendix D). Accordingly, in November 2016 the Environment Agency were contacted regarding the flood risk and climate change allowances that should be applied at the site. The reply (WA/2016/123299/02-L01) is reproduced as Appendix C of this report. The reply states:

if... the new proposal is a like for like replacement of... existing dwellings then we would have no in principle objection on locating 'more vulnerable' development in Flood Zone 3b.

The Environment Agency reply further states:

The simple linear extrapolation approach you have taken in establishing the 'higher central' allowance for peak 100 year plus climate change level is acceptable.

From Appendix D, Table D-1, the Thames river basin district, *Higher Central* allowance category, for the period 2070 to 2115 (corresponding to the 100-year design life of the proposed development), the potential change for river flow is 35%.

The *simple linear extrapolation approach* referenced in the reply may be interpreted to mean that an increase in the climate change allowance for river flows would lead to a proportionate increase in corresponding flood levels. For example, and with reference to Table 3-3, for Node 100:

- The 100 year flood level is 34.487mAOD;
- The 100 year +20%CC flood level is 0.304m above the 100 year level (34.791mAOD);
- The 100 year +35%CC flood level is therefore $(35/20) \times 0.304\text{m} = 0.532\text{m}$ above the 100 year level (35.019mAOD).

In accordance with Environment Agency advice the data in Table 3-3 has been extended and shows that **the recommended 100 year plus 35% climate change modelled flood level at the site is 35.019mAOD.**

Table 3-3 Environment Agency Product 4 modelled flood levels

Node	Levels (mAOD)							
	2 year	5 year	10 year	20 year	50 year	100 year	100 year +20%CC	100 year +35%CC
33.086	33.193	33.603	34.019	34.170	34.380	34.539	34.843	
106	33.173	33.572	33.992	34.144	34.351	34.510	34.819	
100	33.174	33.645	33.890	34.062	34.315	34.487	34.791	35.019
092	33.164	33.596	33.808	33.957	34.179	34.330	-	

The site flooded during the February 2014 flood event. The owner of the site has observed flood flow paths across the site, indicating that flooding was caused by eastward and northward flows from the River Loddon to the west of the site. The resulting high water mark left on the main building at Bushnell's boatyard has been surveyed at 34.05mAOD. The River Thames remained in-bank immediately to the north of the site, leaving a high-water mark on the slipway adjacent to the site office which was surveyed at 33.83mAOD.

There is evidence of further historic flooding at the site. The WBC SFRA Map 6a-1 – *Overview of Historical Fluvial Flooding (1947-1990)* confirms the site flooded in 1947 and 1974, and Map 6a-2 – *Overview of Historical Fluvial Flooding (1993-2009)* confirms the site flooded in 2000 and 2003. This record of flooding is entirely consistent with the Environment Agency Product 4 FRA maps.

The Environment Agency operates a flood warning service for areas at risk of flooding from rivers. Flood warnings are issued in the news media and on the Environment Agency website and personalised communications are available in specific Flood Warning Areas. The WBC SFRA identifies Wargrave as a Flood Warning Area, at risk of flooding from both the River Thames and the River Loddon.

The WBC SFRA Map 5 – *Topography* indicates that the topography at the site is such that the risk of flooding from surface water run-off is low, and both the Environment Agency and WBC SFRA surface water flood maps correspond to this observation.

Further consideration is given to flood risk from both fluvial sources and surface water run-off later in the Report in Section 4.3.

Figure 3-10 Environment Agency Product 4 FRA Map

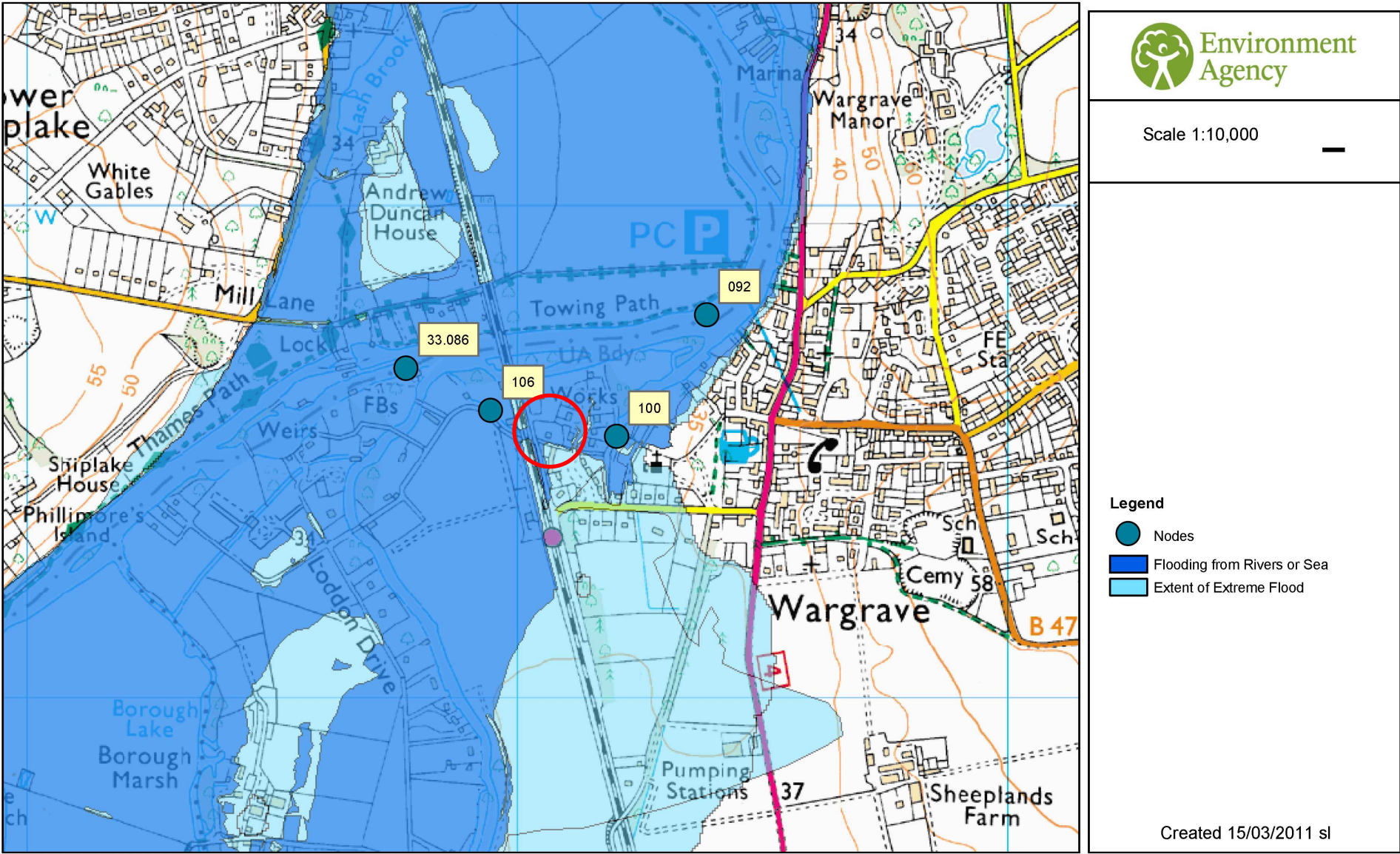
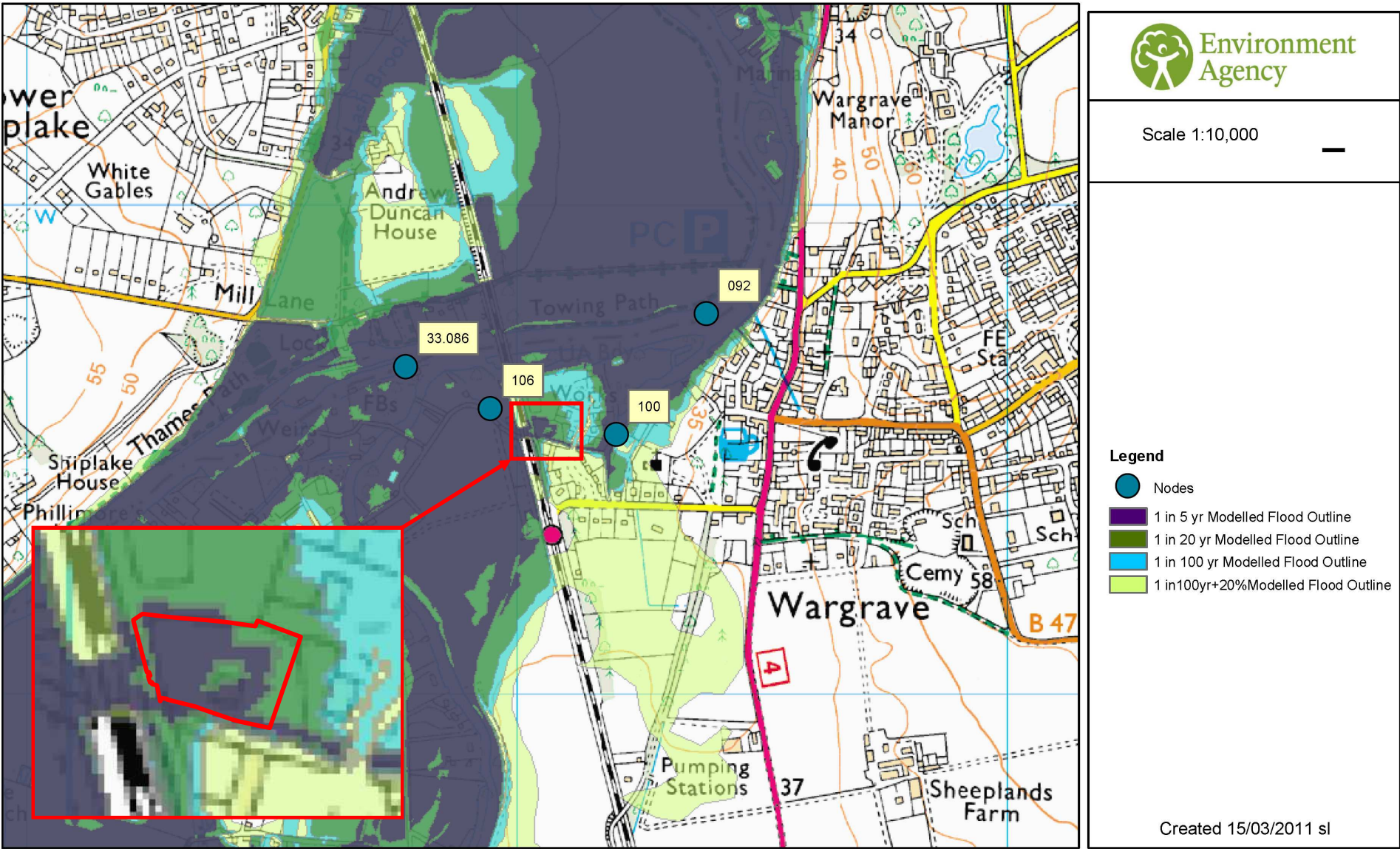


Figure 3-11 Environment Agency Product 4 FRA Map (return period detail)



4. Review of Development Proposals

This section describes the proposed development, addresses the impacts of the proposals, and reviews the methods to mitigate the effects of the proposals on flood risk.

4.1 Development Process (5)

The proposed layout plan is shown in Figure 4-1, with the site boundary indicated in red. The surface coverage is indicated by the colour coding described in the legend.

There are currently two residential buildings within the *Meadowsweet* plot, comprising the main building and a smaller building to the east. The location of the existing buildings is shown by the broken purple lines in Figure 4-1. The existing surface coverage is summarised in Table 4-1.

The proposed development anticipates the demolition of the two existing residential buildings and their replacement with two new residential buildings and two outbuildings (garages). The foundation slabs of the existing buildings would be broken up and removed to create a permeable surface. The two new outbuildings (garages) would be grounded and therefore occupy floodplain storage. However, both new residential buildings would be raised above the key 100 year plus climate change flood level, with voids beneath the floor slabs, such that the building at ground level would only consist of the chimney breasts, stairways and supporting structures required to raise the buildings, thereby liberating significant floodplain storage occupied by the current buildings. The proposed surface coverage is summarised in Table 4-2.

Table 4-1 Existing (pre-development) surface coverage at site

Description	area (m²)
Grounded residential dwellings (equivalent to roof area)	215
Total grounded footprint / roof area	215
Other impermeable surface (driveways, pathways, patios)	480
Total impermeable surface area	695
Total impermeable surface area connected to surface water drains	>215
Landscaped areas and gardens	1743
Total permeable surface area	1743
Total	2438

Table 4-2 Proposed (post-development) surface coverage at site

Description	area (m²)
Outbuildings (garages) grounded footprint	79
Plot 1 grounded footprint (support columns and ancillary structures)	8
Plot 2 grounded footprint (support columns and ancillary structures)	8
Total grounded footprint	95
Reduction in total grounded footprint	120
Roof area of new grounded outbuildings (garages)	79
Roof area of new non-grounded residential dwellings	257
Total impermeable surface area	336
Reduction in total impermeable surface area	359
Total impermeable surface area connected to surface water drains	0
Permeable driveways and paving	359
Landscaped areas and gardens	1743
Total permeable surface area	2102
Total	2438

Referencing Table 4-1 and Table 4-2 it may be seen that the proposed development would result in:

- a reduction in grounded building footprint of 120m²;
- a reduction in total impermeable surface area of 359m²;
- a reduction of greater than 215m² to zero in area draining to the existing surface water drainage network. Note that the uncertainty of this value is due to the uncertainty associated with the receptor of drainage from the existing patio area (see section 4.3.1).

The total bedroom count included in the proposed residential buildings would remain the same as the current buildings, resulting in no change in occupancy.

Figure 4-1 Proposed site layout plan



4.2 Flood Risk Management Measures (6)

4.2.1 Overview

The development site lies entirely within Flood Zone 3 and there is a very low risk of flooding from surface water, except at the eastern part of the site at the current location of the patio and driveway. It is important to ensure that the proposed changes described in Section 4.1 would not increase flood risk within the rest of the site. However, flooding from sources within the site is regarded as a low risk and no special measures are considered necessary.

The proposed development is based on the concept of *betterment*, whereby all aspects of the development represent an improvement over the existing situation in terms of flood risk. Thus, the development proposals would:

- reduce the amount of floodplain storage occupied by buildings;
- reduce the surface water runoff volumes and rates;
- allow an improved access/egress route.

4.2.2 Finished Floor Levels

As confirmed in Section 3.7, **the 100 year plus 35% climate change flood level at the site is 35.019mAOD**. In order to satisfy the requirement that the amount of floodplain storage occupied by the buildings should be reduced, the underside of the floor slabs should be above the flood level. Allowing 300mm for the thickness of the floor slabs would result in a **finished floor level (FFL) of 35.319mAOD**.

4.2.3 Access/Egress

Safe egress needs to be considered at the site. Flooding from the River Thames at this location will be a long duration event, with long onset and recession times. Flooding from the River Loddon is a shorter duration event, but will still allow sufficient time for evacuation warnings to be adequately communicated, enabling the buildings to be evacuated in good time, should this be required. As confirmed in Section 3.7, Wargrave is identified as a Flood Warning Area, for which the Environment Agency operates a flood warning service.

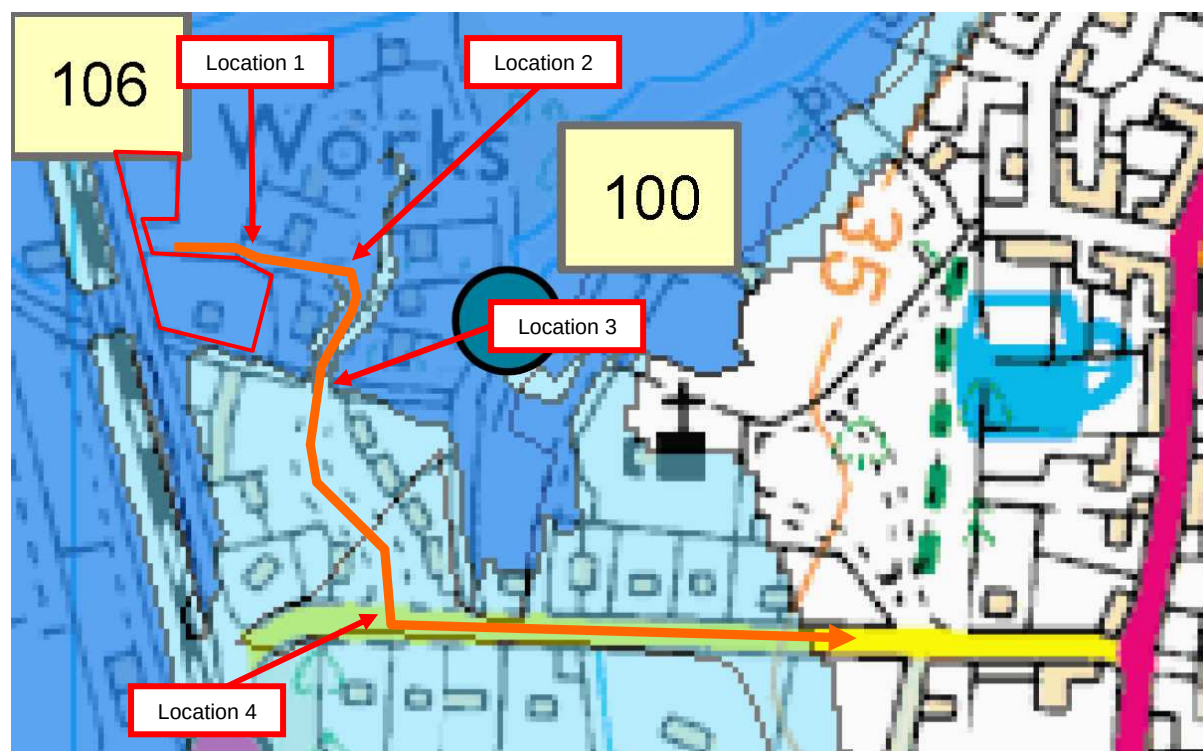
The egress route from the proposed buildings to safe ground, before or during a flood event, is shown by the orange arrow in Figure 4-2. The route may be summarised as:

- northwards from the buildings and onto Watermans Way;
- eastwards and southwards along Watermans Way and out of Flood Zone 3;
- continue southwards along Watermans Way, and then eastwards along Station Road and out of Flood Zone 2.

With reference to Figure 4-1, it may be seen that the driveway of Plot 2 leads directly onto Watermans Way, while the driveway for Plot 1 leads west and south onto Loddon Drive, although this latter route should not be used for egress during periods of flooding, due to greater water depths along this route; rather, access to Watermans Way should be provided through Bushnell's boatyard.

Photographs of the route along Watermans Way and Station Road are shown in Figure 4-4 to Figure 4-7, with locations cross-referenced in Figure 4-2.

Figure 4-2 Egress route (indicated in orange)



The deepest flood water encountered on the egress route would be at the start of the route directly to the north of the proposed buildings (Figure 4-4). The level at this location was surveyed by Brunel Surveys Ltd at 33.75mAOD. A generally consistent level is maintained on the route through Bushnell's boatyard to Watermans Way. The ground level at this location leads to a 100 year plus 35% climate change flood depth of approximately 1.27m.

Given the shallow topography and existing barriers to flow, and it is probable that flow velocity is likely to be negligible at this location. Accordingly, referencing the Defra Hazard Rating chart shown in Figure 4-3, a velocity of zero, a depth of 1.27m and a Debris Factor of 1, a Hazard Rating of between 1.50 and 1.75 is indicated, classified as *Danger for Most*. It should be noted that this hazard rating is no worse than the current situation.

Moving 50m eastwards along Watermans Way to the location where the road turns south (Figure 4-5), the level in the centre of the road rises to approximately 34.2mAOD, resulting in a 100 year plus 35% climate change flood depth of approximately 0.77m. Continuing 45m further south along Watermans Way leads to location of the small channel at the south of the site discussed in Section 3.5, corresponding to the boundary of Flood Zones 2 and 3 (Figure 4-6). The route continues southwards along Watermans Way for 110m through Flood Zone 2, and then left onto Station Road (Figure 4-7). The route continues for a further 190m when it reaches Flood Zone 1.

The route is 95m through Flood Zone 3 and 300m through Flood Zone 2. Analysis of the topography suggests that flood water along the route will be virtually stationary with no significant flow routes developing. The road is level, straight and well made, and the pavement is in good condition. The kerb height is generally between the 10 and 15cm, but in any case the centre of the road is the highest path along the route. The route is generally adjacent to buildings and/or high vegetation that will be above the flood level and act to reinforce the correct route. There are no turnings along the road which could be taken in error.

Figure 4-3 Defra Hazard to People Classification

HR	Depth of flooding - d (m)												
	DF = 0.5				DF = 1								
Velocity v (m/s)	0.05	0.10	0.20	0.25	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.0	0.03+0.5 = 0.53	0.05+0.5 = 0.55	0.10+0.5 = 0.60	0.13+0.5 = 0.63	0.15+1.0 = 1.15	0.20+1.0 = 1.20	0.25+1.0 = 1.25	0.30+1.0 = 1.30	0.40+1.0 = 1.40	0.50+1.0 = 1.50	0.75+1.0 = 1.75	1.00+1.0 = 2.00	1.25+1.0 = 2.25
0.1	0.03+0.5 = 0.53	0.06+0.5 = 0.56	0.12+0.5 = 0.62	0.15+0.5 = 0.65	0.18+1.0 = 1.18	0.24+1.0 = 1.24	0.30+1.0 = 1.30	0.36+1.0 = 1.36	0.48+1.0 = 1.48	0.60+1.0 = 1.60	0.90+1.0 = 1.90	1.20+1.0 = 2.20	1.50+1.0 = 2.55
0.3	0.04+0.5 = 0.54	0.08+0.5 = 0.58	0.15+0.5 = 0.65	0.19+0.5 = 0.69	0.23+1.0 = 1.23	0.30+1.0 = 1.30	0.38+1.0 = 1.38	0.45+1.0 = 1.45	0.60+1.0 = 1.60	0.75+1.0 = 1.75	1.13+1.0 = 2.13	1.50+1.0 = 2.50	1.88+1.0 = 2.88
0.5	0.05+0.5 = 0.55	0.10+0.5 = 0.60	0.20+0.5 = 0.70	0.25+0.5 = 0.75	0.30+1.0 = 1.30	0.40+1.0 = 1.40	0.50+1.0 = 1.50	0.60+1.0 = 1.60	0.80+1.0 = 1.80	1.00+1.0 = 2.00	1.50+1.0 = 2.50	2.00+1.0 = 3.00	2.50+1.0 = 3.50
1.0	0.08+0.5 = 0.58	0.15+0.5 = 0.65	0.30+0.5 = 0.80	0.38+0.5 = 0.88	0.45+1.0 = 1.45	0.60+1.0 = 1.60	0.75+1.0 = 1.75	0.90+1.0 = 1.90	1.20+1.0 = 2.20	1.50+1.0 = 2.50	2.25+1.0 = 3.25	3.00+1.0 = 4.00	3.75+1.0 = 4.75
1.5	0.10+0.5 = 0.60	0.20+0.5 = 0.70	0.40+0.5 = 0.90	0.50+0.5 = 1.00	0.60+1.0 = 1.60	0.80+1.0 = 1.80	1.00+1.0 = 2.00	1.20+1.0 = 2.20	1.60+1.0 = 2.60	2.00+1.0 = 3.00	3.00+1.0 = 4.00	4.00+1.0 = 5.00	5.00+1.0 = 6.00
2.0	0.13+0.5 = 0.63	0.25+0.5 = 0.75	0.50+0.5 = 1.00	0.63+0.5 = 1.13	0.75+1.0 = 1.75	1.00+1.0 = 2.00	1.25+1.0 = 2.25	1.50+1.0 = 2.50	2.00+1.0 = 3.00	3.50	4.75	6.00	7.25
2.5	0.15+0.5 = 0.65	0.30+0.5 = 0.80	0.60+0.5 = 1.10	0.75+0.5 = 1.25	0.90+1.0 = 1.90	1.20+1.0 = 2.20	1.50+1.0 = 2.50	1.80+1.0 = 2.80	3.40	4.00	5.50	7.00	8.50
3.0	0.18+0.5 = 0.68	0.35+0.5 = 0.85	0.70+0.5 = 1.20	0.88+0.5 = 1.38	1.05+1.0 = 2.05	1.40+1.0 = 2.40	1.75+1.0 = 2.75	3.10	3.80	4.50	6.25	8.00	9.75
3.5	0.20+0.5 = 0.70	0.40+0.5 = 0.90	0.80+0.5 = 1.30	1.00+0.5 = 1.50	1.20+1.0 = 2.20	1.60+1.0 = 2.60	3.00	3.40	4.20	5.00	7.00	9.00	11.00
4.0	0.23+0.5 = 0.73	0.45+0.5 = 0.95	0.90+0.5 = 1.40	1.13+0.5 = 1.63	1.35+1.0 = 2.35	1.80+1.0 = 2.80	3.25	3.70	4.60	5.50	7.75	10.00	12.25
4.5	0.25+0.5 = 0.75	0.50+0.5 = 1.00	1.00+0.5 = 1.50	1.25+0.5 = 1.75	1.50+1.0 = 2.50	2.00+1.0 = 3.00	3.50	4.00	5.00	6.00	8.50	11.00	13.50
5.0	0.28+0.5 = 0.78	0.60+0.5 = 1.10	1.10+0.5 = 1.60	1.38+0.5 = 1.88	1.65+1.0 = 2.65	3.20	3.75	4.30	5.40	6.50	9.25	12.00	14.75
Flood Hazard Rating (HR)		Colour Code	Hazard to People Classification										
Less than 0.75			Very low hazard - Caution										
0.75 to 1.25			Danger for some – includes children, the elderly and the infirm										
1.25 to 2.0			Danger for most – includes the general public										
More than 2.0			Danger for all – includes the emergency services										

Based on FD2320/TR2, Table 13.1, using the Hazard Rating formula ($HR = d \times (v + 0.5) + DF$)

In summary, the onset of flooding at the site would be off sufficient duration to allow evacuation warnings to be adequately communicated and buildings to be evacuated before peak flood levels are reached. The egress route identified for the proposed development is shorter than, and therefore an improvement on, the current route.

Figure 4-4 View east along Watermans Way (location 1)



Figure 4-5 View south along Watermans Way towards Flood Zone 3/2 boundary (location 2)



Figure 4-6 View south along Watermans Way from Flood Zone 3/2 boundary to Station Road (location 3)



Figure 4-7 View east along Station Road to Flood Zone 1/2 boundary (location 4)



4.3 Off Site Impacts (3d, 7a, 7b)

4.3.1 Runoff from impermeable surfaces

As described in section 4.1, and summarised in Table 4-1 and Table 4-2, the combined roof area of the current residential dwellings is 215m², and runoff from this area is routed to the local surface water drainage network. The patio area most likely also drains to the local surface water drainage network. However, no special arrangements currently exist to manage runoff from the other impermeable surfaces on site, such as the driveways, pathways, and the existing access road.

The approach recommended for the proposed development is to route runoff from all impermeable areas including the new residential buildings and garages to a system of soakaways where it will infiltrate on-site. This approach would:

- reduce the runoff routed to the local surface water drainage network to zero;
- reduce the likelihood of localised surface water flooding due to runoff from those areas currently not connected to the local surface water drainage network.

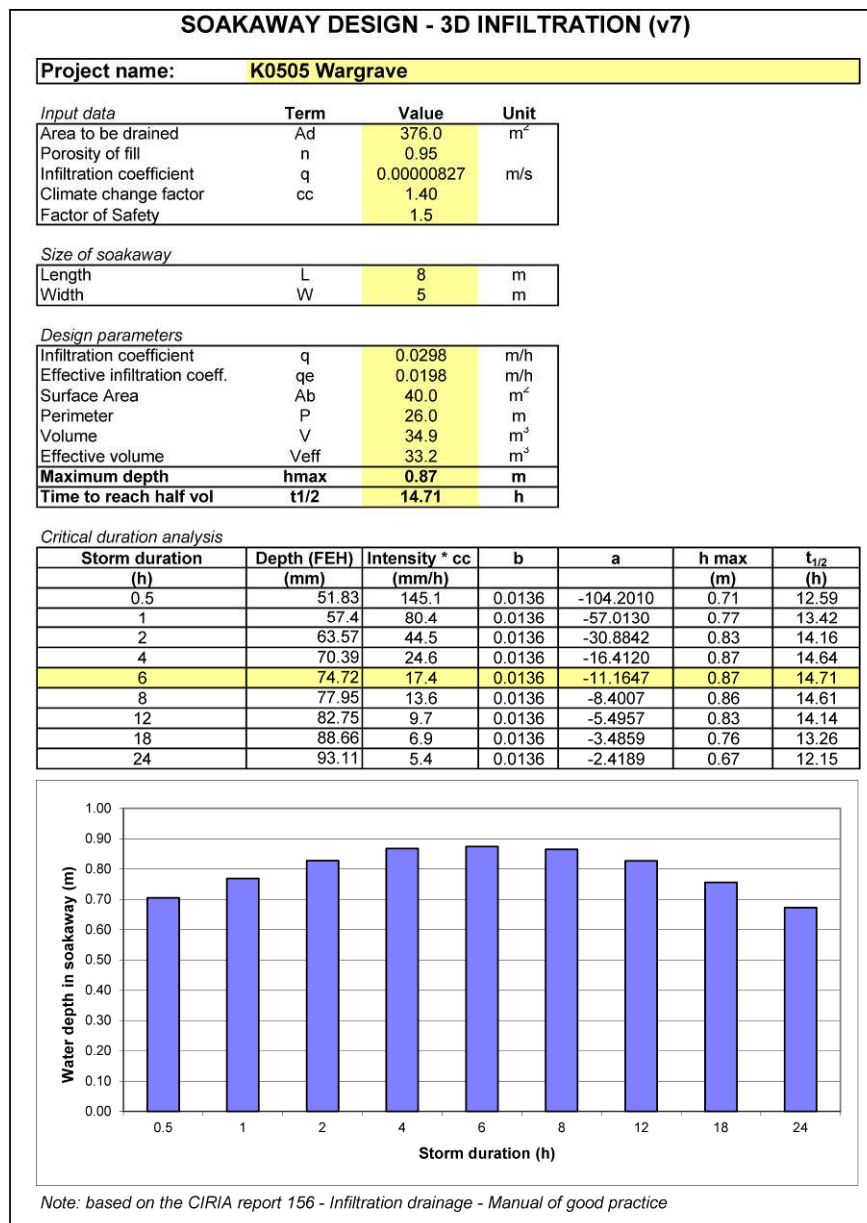
As previously described in Section 3.2, a range of potential infiltration characteristics and rates were indicated at the site. Consequently, it was considered necessary to undertake infiltration testing as described in section 3.3 and Appendix B. The test results indicated that an infiltration rate of 8.27x10⁻⁶m/s applies at the site, corresponding to moderately well-draining soil. The indicated rate was adopted for the purpose of preparing an outline soakaway design.

Outline soakaway designs were undertaken using the Hydro-Logic Services *Soakaway Design 3D Infiltration* tool which has been used for numerous such designs. The application requires the specification of rainfall depths for a range of durations, and the characteristics of the soakaway(s). The following assumptions were adopted for these calculations.

- Point rainfalls for the 100 year storm have been obtained from ReFH2 software (CEH, 2015).
- Increase in rainfall by 40% to allow for climate change in line with the requirements of NPPF.
- An infiltration rate of 8.27x10⁻⁶ m/s (equivalent to approximately 0.0298 m/h).
- A soakaway porosity of 95% corresponding to proprietary soakaway crates.
- A total runoff area of 376m² (336m² impermeable surface plus 40m² soakaway area (8m x 5m)).
- The depth of the soakaway should not exceed 1 m, in recognition that groundwater is approximately 1.5m below ground level under normal conditions.
- Factor of safety of 1.5, in recognition of the consequences of any design exceedance.

The 6 hour 100 year plus 40% climate change storm was found to be the critical duration, resulting in a maximum water depth of 87cm. The infiltration tool summary sheet is shown in Figure 4-8.

Figure 4-8 Soakaway design



It is recommended that the soakaway be located away from the buildings, for example in the gardens to the rear of the buildings, or beneath the permeable driveways to the front of the buildings. Consequently, the soakaway design also accommodates rain falling directly on to the permeable area covering the soakaway. This is achieved by adding the soakaway area to that of the impermeable area (336m²). In the example described above, a soakaway of dimensions 8m by 5m will represent an additional area of 40m², resulting in a total area of 376m².

Because of the significant area of impermeable surface on site, and the constraint on soakaway depth, it is required that the soakaway be constructed using material with the highest porosity available. Accordingly, the soakaway should be constructed using modular soakaways (also known as storm crates). Modular soakaways have a porosity coefficient of 95%, compared with traditional material such as pea-shingle which has a porosity coefficient of around 30%. The soakaway should be located at least 5m away from the building support structures (requirement H3 3.25a).

The results confirm a 8m long, 5m wide and 1m deep soakaway would comfortably accommodate the peak volume of direct rainfall and runoff from the impermeable surfaces on site. However, because the drainage rate of soakaways is a function of both area and perimeter, by creating a series of separate soakaways it would be possible to reduce the total area required to infiltrate at an equivalent rate. It is stressed that the soakaway dimensions described represent an outline design, and that alternative configurations, placements and indeed numbers of soakaways may also be viable. The final configuration will need to be determined by the developer.

Further, volumes are presented without detail of pipe dimensions and slope. This report does not present a design for runoff capture, transmission or distribution between soakaways. The general approach of placing soakaways close to the source of runoff and working with the existing topography should be adopted.

4.3.2 Flood plain storage

As described in section 4.1, and summarised in Table 4-1 and Table 4-2, the proposed residential buildings would be raised above the key flood level, with a void beneath the floor slabs, such that the proposed total building footprint would consist only of the chimney breast, stairways, and supporting structures required to raise the buildings, thereby liberating significant floodplain storage occupied by the current buildings. The grounded footprint of the current residential dwellings is 215m², while the grounded footprint of the proposed development is 95m², representing a reduction of 120m². The average ground level across the site is approximately 33.50mAOD, and the 100 year plus 35% climate change flood level is 35.019mAOD, corresponding to a difference in levels of approximately 1.52m. The gain in floodplain storage between ground level and the 100 year plus 35% climate change flood level is therefore approximately 182m³.

4.4 Residual Risks (8a, 8b)

The permeable surfaces on site, specifically the driveways, should be regularly inspected to ensure the surface is clear of debris and blockages that could impair the ability of the surface to infiltrate water.

Soakaways should be constructed to enable inspection in order to ensure they are free from debris and silt, and allow the soakaways to be cleaned as required. The manufacturers of the soakaway crates should be able to offer advice on maintenance procedures.

The sub-building spaces should be regularly inspected to ensure that they are empty of debris such that the original and intended volume is maintained. Whilst access to the voids should be allowed for cleaning, inspection and maintenance, no storage should be permitted within the voids, and no electrical services other than lighting for maintenance should be placed in the void space.

A further aspect of residual risk relates to the potential occurrence of flood levels above the design levels of the 1 in 100 year plus 35% climate change flood from the River Thames / River Loddon. However, the long period of onset of flooding at the site combined with the Environment Agency flood warning service outlined in section 3.7 would enable safe egress from the site at time of extreme flood levels.

4.5 Climate Change (4a)

NPPF requires a consideration of the impacts of climate change on the flood risk for any proposed development. A summary of the current guidelines is provided in Appendix D.

4.5.1 Peak River Flow Allowances

As described in section 3.7, the Environment Agency confirmed that the *Higher Central* allowance category for the period 2070 to 2115 (corresponding to the 100-year design life of the proposed development) should be applied at the site, corresponding to a potential increase in river flow of 35%.

The *simple linear extrapolation approach* also referenced in section 3.7 confirms that the **100 year +35%CC flood level at the site is 35.019mAOD.**

4.5.2 Peak Rainfall Intensity Allowances

From Appendix D Table D-2, for the period 2070 to 2115, the *Central* increase in rainfall intensity allowance is 20%, and the *Upper End* increase in rainfall intensity allowance is 40%. Since rainfall intensity is of key importance to the proposed development in terms of managing surface water runoff, and adopting a precautionary approach, **the 40% Upper End increase has been used for the rainfall runoff calculations** referenced in this report.

5. Summary

This report constitutes a Flood Risk Assessment for the proposed development at the *Meadowsweet* plot adjacent to Loddon Drive, RG10 8HD. The main findings are summarised below.

1. The proposed development site is wholly within Environment Agency Flood Zone 3. The main source of flood risk at the site is fluvial flooding from the River Thames to the north of the site, and River Loddon to the west of the site. The site is generally at low risk of flooding from surface water.
2. The proposed development anticipates the replacement of two existing residential buildings and associated outbuildings on a like-for-like basis, whilst seeking to improve flood risk over the current situation. The redevelopment of existing properties is permitted on a like-for-like basis. Under these circumstances neither the Sequential Test nor the Exception Test is required.
3. The proposed development anticipates a reduction in total impermeable surface area of 359m², resulting in an increase in rainfall runoff infiltrating on-site and a reduction in rates and volumes of rainfall runoff discharged to the local surface water drainage system to zero. Runoff from impermeable surfaces would be routed to an on-site soakaway. An outline design for this soakaway is presented.
4. The base of the floor slabs of the proposed residential buildings would be raised above the key 100 year plus 35% climate change flood level of 35.019mAOD, with a void beneath the floor slabs. Allowing for a floor slab thickness 300mm results in finished floor levels of 35.319mAOD. This arrangement results in a reduction in grounded building footprint of 120m², liberating much of the floodplain storage volume occupied by the current buildings; at the 100 year plus 35% climate change flood level the volume liberated is equivalent to approximately 182m³.
5. The onset of flooding at the site will be of sufficient duration to allow the buildings to be evacuated in good time. An egress route to safe ground outside the flood zones has been identified. The route is shorter than, and therefore an improvement on, the current route.
6. The residual risk at the site is considered low. An allowance for exceedance has been incorporated into the soakaway design. A maintenance programme should be put in place for the soakaway to ensure performance corresponds with design criteria. Residual risk also derives from exceedance of flood levels above the design levels of the 1 in 100 year plus 35% climate change flood from the River Thames / River Loddon. However, the long period of onset of flooding at the site combined with the Environment Agency flood warning service would enable safe egress from the site at time of extreme flood levels.
7. The impacts of climate change have been included in all run-off calculations by increasing rainfalls by a precautionary 40% in line with the recommendations of the NPPF. The Environment Agency modelled flood levels include the effects of climate change.

It is found that the risks to the development are low and the potential impact on other receptors can be mitigated using the measures described in this report. The development would then be in accordance with NPPF.

REFERENCES

Author	Date	Title/Description
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