FLOOD RISK ASSESSMENT STATEMENT

at

23 Melbourne Road,
Teddington
TW11 9QX

Contents Page

1 Background and Scope of Appraisal

2 Development Description and Planning Context
2.1 Site Location and Existing Development
2.2 Proposed Development
2.3 The Sequential T est
2.4 Thames Upstream Inundation Modelling
2.5 The Exception Test

3 Definition of Flood Hazard
3.1 Site Specific Information
3.2 Potential Sources of Flooding
3.3 Existing Flood Risk Management Measures

4 Climate Change
4.1 Potential Changes in Climate
4.2 Impacts of Climate Change on the Development Site

5 Probability and Consequence of Flooding
5.1 The Likelihood of Flooding
5.2 The Extent of Flooding
5.3 Depth and Velocity of Flooding
5.4 Rate of Rise of Floodwater

6 Offsite Impacts and Other Considerations
6.1 Displacement of Floodwater
6.2 Public Safety and Access
6.3 Proximity to Watercourse and Flood Defence Structures
6.4 Impact on Fluvial Morphology & Impedance of Flood Flows

7 Flood Mitigation Measures
7.1 Application of the Sequential Approach at a Local Scale
7.2 Raising Floor Levels & Land Raising
7.3 Flood Resistance and Resilience
7.4 Flood Warning

8 Surface Water Management Strategy
8.1 Background and Policy
8.2 Surface Water Management Overview
8.3 Existing Drainage
8.4 Opportunities to Discharge Surface Water Run-Off
8.5 Foul Drainage
8.6 Constraints and Further Considerations
8.7 Sustainable Drainage Systems (SuDS)
8.8 Proposed Surface Water Management Strategy (SWMS)
8.9 Additional Opportunities for SuDS
8.10 Management and Maintenance

9 Conclusions

10 Recommendations

1 Background and Scope of Appraisal

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

- whether a proposed development is likely to be affected by current or future flooding from any source
- whether the development will increase flood risk elsewhere within the floodplain
- whether the measures proposed to deal with these effects and risks are appropriate
- whether the site will be safe to enable the passing of the Exception Test (where appropriate)

This appraisal has been undertaken in accordance with the requirements of the National Planning Policy Framework (March 2012) and the accompanying Planning Practice Guidance Suite. To ensure that due account is taken of industry best practice, it has been carried out in line with the CIRIA Report C624 'Development and flood risk - guidance for the construction industry'.
Reference is also made to the National Planning Practice Guidance Suite (March 2014) that has been published by the Department for Communities and Local Government. The *Flood Risk and Coastal Change* planning practice guidance included within the Suite represents the most contemporary technical guidance on preparing FRAs.

2 Development Description and Planning Context

2.1 Site Location and Existing Development

The site is located off Melbourne Road, London. In total the site covers an area of approximately 437sqm and currently comprises a single three storey residential dwelling.

2.2 Proposed Development

The application proposes to construct a single storey rear extension a roof extension and a new outbuilding both with a flat roof. Full refurbishment internally with installation of water saving devices .

2.3 The Sequential Test

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

The National Planning Policy Framework (NPPF) requires the Sequential Test to be applied at all stages of the planning process and generally the starting point is the Environment Agency's flood zone maps. These maps and the associated information are intended for guidance, and cannot provide details for individual properties. They do not take into account other considerations such as existing flood defences, alternative flooding mechanisms and detailed site based surveys. They do, however, provide high level information on the type and likelihood of flood risk in any particular area of the country. The flood zones are classified as follows:

Zone 1 – *Low probability of flooding* – This zone is assessed as having less than a 1 in 1000 annual probability of river or sea flooding in any one year.
Zone 2 – *Medium probability of flooding* – This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding or between 1 in 200 and 1 in 1000 annual probability of sea flooding in any one year.
Zone 3a – *High probability of flooding* - This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding or 1 in 200 or greater annual probability of sea flooding in any one year.
Zone 3b – *The Functional Floodplain* – This zone comprises land where water has to flow or be stored in times of flood and can be defined as land which would flood during an event having an annual probability of 1 in 20 or greater. This zone can also represent areas that are designed to flood in an extreme event as part of a flood alleviation or flood storage scheme.

The development site is to be located within Flood Zone 3 and to be benefiting from existing flood defences that have been constructed in the last 5 years. This mapping does not distinguish between high risk areas and the functional floodplain, i.e. Zones 3a and 3b. This is an important differentiation that needs to be made by the FRA because the NPPF states that no development, other than essential transport and utilities infrastructure, should be located within the functional floodplain.

The functional floodplain is defined by the NPPF as land where water has to flow or be stored in times of flood during events that have a probability of occurrence of 1 in 20 (5%) or greater in any one year. The Planning Practice Guidance goes on to further clarify this by adding the following definition:

> *The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain. Areas which would naturally flood with an annual exceedance probability of 1 in 20 (5%) or greater, but which are prevented from doing so by existing infrastructure or solid buildings will not normally be defined as functional floodplain.*

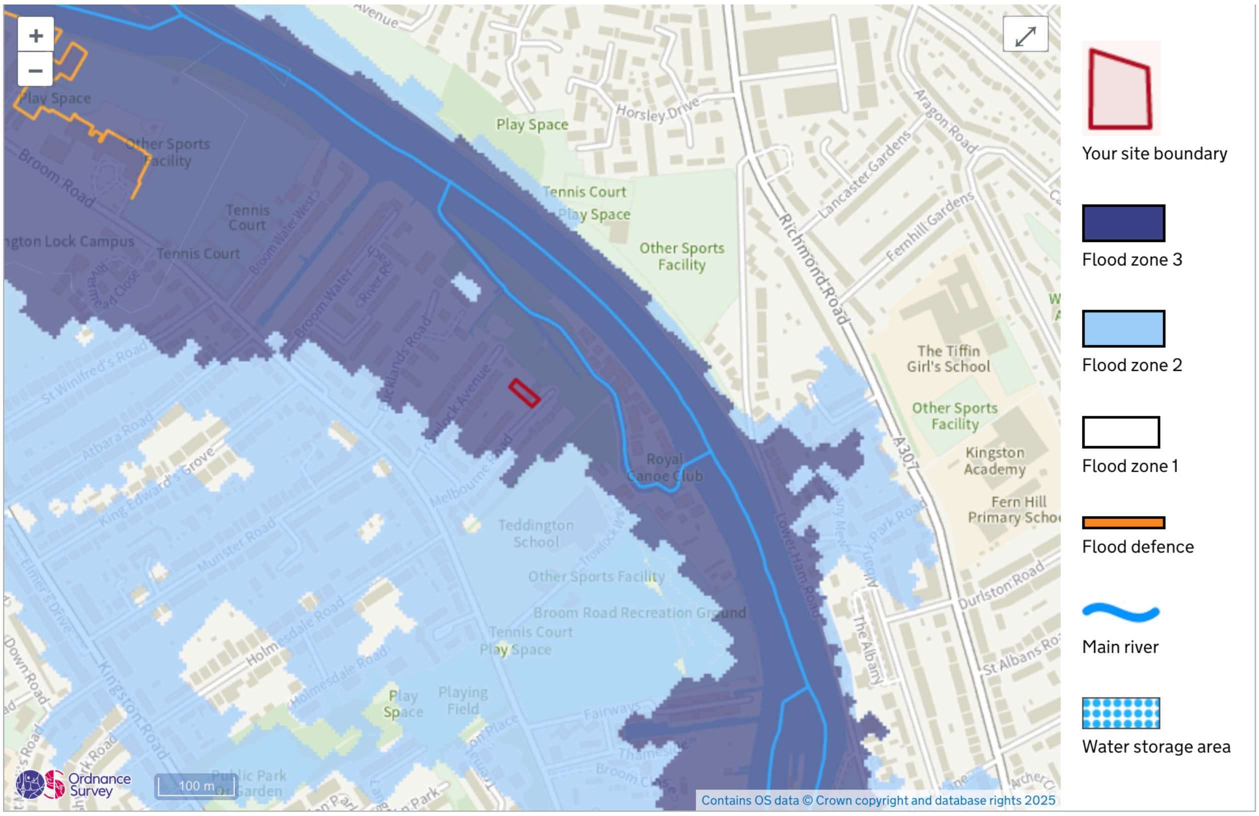

Figure 1.2 – Showing Flood Zone 3 Location

Based on information provided by the Environment Agency and that derived as part of this appraisal, the following functional floodplain test is applied:

Do predicted flood levels show that the site will be affected by an event having a return period of 1 in 20 years or less?	NO
Is the site defended by flood defence infrastructure that prevents flooding for events having a return period of 1 in 20 years or greater?	YES
Does the site provide a flood storage or floodwater conveyance function?	NO
Does the site contain areas that are 'intended' to provide transmission and storage of water from other sources?	NO
Is site within the functional floodplain (Zone 3b)	NO

Table 2.1 – Functional floodplain test

The flood zone mapping and associated information has been summarised in Table 2.2 below.

Flood Zone (percentage of site within zone)		Source of flooding	Benefiting from existing flood defences*
Zone 1	0%		
Zone 2	0%		
Zone 3a	100%	River (Tidal)	Yes
Zone 3b	0%		
(*) The flood zone maps only recognise defences constructed within the last 5 years			

Table 2.2 – Flood zone classification

The NPPF states that the LPA should apply the sequential approach as part of the identification of land for development in areas at risk from flooding. The overarching objective of the Sequential Test is to ensure that lower risk sites are developed before sites in higher risk areas. When applying the Sequential Test, it is also necessary to ensure that the subject site is compared to only those sites that are available for development and are similar in size.

This requires a comprehensive knowledge of development sites within the district and is generally applied as part of the Local Development Framework (LDF) process. However, when applying the Sequential Test to sites that have not been assessed as part of the LDF it is necessary to apply a bespoke test, and the Flood Risk Assessment can help to provide additional evidence to better quantify the true risk of flooding, enabling an informed judgement to be made.
However, for minor developments and for change of use, paragraph 104 of the NPPF states that such applications need not be subject to the Sequential Test. The development that is the subject of this FRA fits this category and therefore **the Sequential Test is not applicable**.

The second level of appraisal is through the application of the more detailed and refined flood risk information contained within the Strategic Flood Risk Assessments (SFRA). Such a document has been prepared for the London Borough of Richmond upon Thames and this has been referenced as part of this site-specific FRA.

The most detailed stage at which the sequential approach can be applied is at a site based level. Careful consideration of the site's topography and development uses can provide opportunities to locate more vulnerable buildings on the higher parts of the site and placing less vulnerable elements such as car parking or recreational use in the areas exposed to higher risk. This approach is examined later on in this FRA.

2.4 Thames Upstream Inundation Modelling

Industry standard practice is to appraise the risk of flooding from a tidal source for the 1 in 200 year event with an appropriate allowance for climate change, in line with the requirements set out in the NPPF. This is termed the 'design event'.

From the information in Section 2.3 above the site has been shown to be at risk of flooding from an event with an annual probability greater than 1 in 200 years. Although this mapping does not take into account the presence of defence infrastructure, development within the Thames basin area is protected by the Thames Barrier. Water levels upstream of the Barrier are controlled by closure rules depicted in the TE2100 plan, rather than being dictated by extreme weather events with a certain return period (for further details refer to Section 3.3).

In the absence of flood return period data, Maximum Likely Water Levels (MLWL) have been calculated (by others) for a number of time epochs, chosen to represent the impact of climate change on the water levels in the River Thames for the years 2014, 2065, and 2100. These time epochs are commensurate with the planning horizons defined by the NPPF for each type of development, e.g. residential development (2100) and commercial development (2065).

The development site for which this FRA has been prepared is classified as residential, and therefore the lifetime of the development has been conservatively estimated as 100 years (refer to Section 4). In the absence of flood level data in respect to event return periods, the site has been appraised to the 2100 epoch MLWLs, and this is henceforth termed the 'design event'.

In order to quantify the risk of flooding to sites in this area in consideration of the Thames Barrier operation, the River Thames was re-modelled in 2015 as part of the Thames Upstream Inundation Modelling Study. The model is based on the 2008 TE2100 in-channel levels, which are the highest levels permitted by the Thames Barrier. The outputs from this model have been provided as part of the Environment Agency's response.

The TE2100 plan includes an allowance for raising the future defences to reflect the predicted increase in water levels within the River Thames, as a result of climate change. However, similar to the Environment Agency Flood Zone mapping, the Thames Upstream Inundation Model assumes that all linear defences are removed. Consequently, the mapping in Figure 2.3 provides an unrealistic picture of the risk of flooding from the River Thames and should only be used as a consultation tool by planners to highlight areas where more detailed investigation of flood risk is required.

From the mapping above it can be seen that the site is located within the 2065 and 2100 MLWL extents. Consequently, the risk of flooding from this source shall be investigated further within this FRA. It should be noted that the above mapping does not replace the Flood Zone classification.

2.5 The Exception Test

According to the NPPF, if following the application of the Sequential Test it is not possible, consistent with wider sustainability objectives, for the development to be located in zones of lower probability of flooding, the Exception Test can be applied.

As part of this process it is necessary to consider the type and nature of the development. The Planning Practice Guidance: *Flood Risk and Coastal Change* defines the type and nature of different development classifications in the context of their flood risk vulnerability. This has been summarised in Table 2.3 below.

Flood Risk Vulnerability Classification	Zone 1	Zone 2	Zone 3a	Zone 3b
Essential infrastructure – Essential transport infrastructure, strategic utility infrastructure, including electricity generating power stations	✓	✓	e	e
High vulnerability – Emergency services, basement dwellings caravans and mobile homes intended for permanent residential use	✓	e	×	×
More vulnerable – Hospitals, residential care homes, buildings used for dwelling houses, halls of residence, pubs, hotels, non-residential uses for health services, nurseries and education	✓	✓	e	×
Less vulnerable – Shops, offices, restaurants, general industry, agriculture, sewerage treatment plants	✓	✓	✓	×
Water compatible development – Flood control infrastructure, sewerage infrastructure, docks, marinas, ship building, water-based recreation etc.	✓	✓	✓	✓

Key :

✓ Development is appropriate

× Development should not be permitted

e Exception Test required

Shaded cell represents the classification of this development

Table 2.3 – Flood risk vulnerability and flood zone compatibility

Whilst from Table 2.3 above it can be seen that the development falls into a classification that would normally require the Exception Test to be applied, paragraph 104 of the NPPF states that for minor developments and for change of use, such applications need not be subject to the Exception Test.

The development that is the subject of this FRA fits this category and therefore the **Exception Test is not applicable.** Notwithstanding this, NPPF does require all development in Flood Zones 2 and 3 to be subject to a FRA and to meet the requirements for flood risk reduction. This is therefore the primary focus of this document.

3 Definition of Flood Hazard

3.1 Site Specific Information

In addition to the high level flood risk information shown in the Environment Agency (EA) flood zone maps, additional data from detailed studies, topographic site surveys and other information sources is referenced. This section summarises the additional information collected as part of this FRA.

Site specific flood level data provided by the EA – The Environment Agency has been consulted as part of the development of this FRA

High level information contained within the SFRA and PFRA – The London Borough of Richmond upon Thames SFRA (2010) and Preliminary Flood Risk Assessment (PFRA) (2011) contains detailed mapping of flood extents from a wide range of sources. This document has been referenced as part of this site-specific FRA.

Information on localised flooding contained within the SWMP – A Surface Water Management Plan (SWMP) is a study to understand the flood risks that arises from local flooding, which is defined by the Flood and Water Management Act 2010 as flooding from surface run-off, groundwater, and ordinary watercourses. Such a document has been prepared for the London Borough of Richmond upon Thames (2011) and has therefore been referenced as part of this site-specific FRA.

Information provided by Thames Water – Thames Water has provided the results of an asset location search for the site.

Site specific topographic surveys –A site-specific topographic survey has not been undertaken at this stage, however, inspection of OS mapping and LiDAR data records show that the land levels of the site vary between 4.60m and 5.28m Above Ordnance Datum Newlyn (AODN). Land levels fall toward the north and south, with the highest elevations where the existing property is located.

Geology – Reference to the Geological Survey map shows that the underlying solid geology in the location of the subject site is London Clay Formation. Overlying this are superficial deposits of Kempton Park Gravel Formation (Sand and Gravel).

Soils – Soil type provides a generic description of the drainage characteristics of soils. This will dictate, for example, the susceptibility of soils to water logging or the capacity of a soil to freely drain to allow infiltration to groundwater. Soil type may only be fully determined after suitable ground investigations, although the mapped soil types (soil association) found beneath the study area may be used as an indicator of permeability and infiltration potential. Reference to the National Soil Resources Institute mapping shows that the general soil type in this location is 'freely draining slightly acid loamy soils'.

Historic flooding – Inspection of the information provided by the Environment Agency and the Richmond upon Thames PFRA and SWMP, it can be seen that the site has not been subject to flooding from any source. No information on historic flooding in this area has been provided or revealed through desktop searches.

3.2 Potential Sources of Flooding

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

Flooding from Rivers (Tidal) – The site lies within Flood Zone 3 of the tidal reaches of the River Thames (main river) as shown on the Environment Agency's flood map. The flood zone maps are used as a consultation tool by planners to highlight areas where more detailed investigation of flood risk is required. Consequently, given the location of the site within Flood Zone 3, the risk of flooding from this source has been examined in more detail as part of this FRA.

Flooding from Ordinary or Man-made Watercourses – Natural watercourses that have not been enmained and man-made drainage systems such as irrigation drains, sewers or ditches could potentially cause flooding.
Inspection of the site and surrounding area reveals that there are no non-main rivers or artificial watercourses within close proximity of the site and therefore the risk of flooding from this source is considered to be *low*.

Flooding from the Sea – The site is a significant distance inland and whilst the River Thames is still tidally influenced at this location, the risk of flooding from the sea is considered to be extremely low and is not investigated further as an independent source of flooding.

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

However, the prediction of flooding from surface water can be difficult, as it is hard to forecast the exact intensity and extent of rainfall of a storm. Under the Flood Risk Regulations 2009, the Environment Agency was therefore tasked with producing and publishing flood maps for surface water.

Maps showing the risk of flooding, and the associated approximate depth and velocity have been produced using information from Lead Local Flood Authorities, such as drainage rates, percentage run-off rates and critical storm durations. The maps pick out natural drainage channels, rivers, low areas within the floodplain and flow paths between buildings. In addition, the maps also consider the influence of buildings, roads and other structures within the floodplain which could obstruct flows, and account for a reduction in rainfall due to drains, sewers and infiltration. They do not, however, take into account individual property threshold heights and assume a single drainage rate for all urban areas.

Consequently, the surface water maps and the associated information are intended for guidance only, and cannot provide details for individual properties. They do, however, provide high level information and indicate areas in which surface water flooding issues should be investigated further. The risk categories are classified as follows:

- *Very low probability of flooding* – This zone is assessed as having less than a 1 in 1000 annual probability of surface water flooding.

- *Low probability of flooding* – This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of surface water flooding.

- *Medium probability of flooding* - This zone comprises land assessed as having between a 1 in 30 and 1 in 100 annual probability of surface water flooding.

- *High probability of flooding* – This zone is assessed as having greater than a 1 in 30 annual probability of surface water flooding.

The development site is located in an area identified as having a 'very low' to 'low' risk of flooding from surface water. Nevertheless, due to the nature of the development proposals (extension of an existing cellar), the risk of flooding from surface water is explored in more detail below.

The site is not located in a critical drainage area and is only affected by less than 0.1m of surface water flooding during a 1 in 100 year return period rainfall event (including an allowance for 100 years of climate change). This is congruent with shallow sheet flow.

Given that the proposals show no topographical low spots, which would otherwise encourage floodwater to pond, it is considered that flooding through this mechanism is unlikely at this location. In addition, inspection of the Richmond upon Thames PFRA identifies that the site has not been subject to surface water flooding in the past.

Consequently, based on the information outlined above, the site-specific risk of flooding from this source is considered to be *low*.

In addition to the above, the proposals for development shall include drainage provisions to ensure that the post-development run-off does not exceed that of the existing site (refer to Section 8). Consequently, the risk of flooding to the site and surrounding area from this source will not increase as a result of the proposed development.

Flooding from Groundwater – Water levels below the ground rise during wet winter months, and fall again in the summer as water flows out into rivers. In very wet winters, rising water levels may lead to the flooding of normally dry land, as well as reactivating flow in 'bournes' (streams that only flow for part of the year). Where land that is prone to groundwater flooding has been built on, the effect of a flood can be very costly, and because groundwater responds slowly compared with rivers, floods can last for weeks or months. Groundwater flooding generally occurs in rural areas although it can also occur in more urbanised areas where the process known as groundwater rebound can cause localised flooding of basements. This increase in the water table level is occurring as a result of the decrease in groundwater extraction that has taken place since the decline in urban aquifer exploitation by heavy industry.

Data on groundwater flooding has been compiled by the British Geological Society and is illustrated on mapping, which is the product of integrating several datasets: a digital model of the land surface, digital geological map data and a water level surface based on measurements of groundwater level made during a particularly wet winter. This dataset provides an indication of areas where groundwater flooding may occur, but is primarily focussed on groundwater flooding potential over the Chalk of southern Britain as Chalk shows some of the largest seasonal variations in groundwater level, and is thus particularly prone to groundwater flooding incidents.

Inspection of this groundwater flood risk mapping data shows that the general area in which the development site lies is identified as being at low risk from groundwater flooding. The more detailed mapping on groundwater emergence provided as part of the Defra Groundwater Flood Scoping Study (May 2004), which shows areas where groundwater flooding has occurred in the past and also areas that are potentially vulnerable to groundwater emergence has also been referenced as part of this FRA. This shows that no groundwater flooding events were recorded during the very wet periods of 2000/01 or 2002/03 and that the site itself is not located within an area where groundwater emergence is predicted.

The geology in this location is London Clay Formation overlain by Kempton Park Gravel Formation. In certain circumstances groundwater flows can occur within the alluvial deposits at the interface with the more impervious clay deposits. In most cases with this geological make-up, groundwater emergence only occurs in deep excavations or where a significant obstruction to groundwater flow exists, however, in this instance neither of these situations are present. Notwithstanding this, the proposals for development include the extension of an existing basement and therefore the risk of groundwater flooding needs to be considered in more detail.

Inspection of nearby borehole records indicates that groundwater flows were detected over 7m below ground level. Furthermore, inspection of the Richmond upon Thames SWMP identifies that the site has not been subject to groundwater flooding in the past. Consequently, it can be inferred that the proposed development will not interfere with groundwater flows at this location and therefore, will not have any negative impacts on nearby properties. Nevertheless, it is acknowledged that the proposed basement will need to be appropriately designed to prevent groundwater ingress, in the unlikely and unexpected event that high groundwater levels become elevated.

This type of system could comprise a waterproof membrane (tanked design), or alternatively a drained cavity underground waterproofing system. The latter system enables water to pass through walls and floors into a cavity formed by placing an impermeable membrane to the walls and floor. Drainage channels at floor to wall intersections take the water to a sump where it is pumped out to drainage outlets. Either system will ensure that no internal flooding will occur as a result of groundwater.

Flooding from Sewers – In urban areas, rainwater is frequently drained into surface water sewers or sewers containing both surface and wastewater known as "combined sewers". Flooding can result when the sewer is overwhelmed by heavy rainfall, becomes blocked, or is of inadequate capacity; this will continue until the water drains away. When this happens to combined sewers, there is a high risk of land and property flooding with water contaminated with raw sewage as well as pollution of rivers due to discharge from combined sewer overflows.

Inspection of the Thames Water Asset Location data identifies that there are separate foul and surface water sewers in this area. Nevertheless, there is still a risk that these could become surcharged during a heavy rainfall event. Section 4.7 of the Richmond upon Thames Planning Advice Notice (Good Practice Guide on Basement Developments) (2015) identifies that "*basements should have adequate mitigation measures such as non-return valves or pumped sewage devices to prevent back-flows from the system during sewer flooding*"

Consequently, a suitable pumped device should be installed at the proposed development, in conjunction with a non-return valve fitted to the outlet; which will prevent the ingress of water into the basement development, in the unlikely event that the positive pump system was to fail.

The Richmond upon Thames SWMP reveals that there has been no sewer flooding incidents in this area in recent years. Furthermore, inspection of OS mapping of the wider area has revealed that the land levels in the main road and slope toward the east. Therefore, in the unlikely event that the surrounding sewers were to surcharge, floodwater would simply be retained within the highway, where it would subsequently flow away from the site towards the east.

Taking the above into consideration, and assuming the proposals will include the installation of a positive pump system as required by local policy, it is concluded that the risk of flooding from sewers is *low*.

Flooding from Reservoirs, Canals and other Artificial Sources – Non-natural or artificial sources of flooding can include reservoirs, canals and lakes where water is retained above natural ground level, operational and redundant industrial processes including mining, quarrying and sand and gravel extraction, as they may increase floodwater depths and velocities in adjacent areas. The potential effects of flood risk management infrastructure and other structures also need to be considered. Reservoir or canal flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure.

Inspection of the Ordnance Survey mapping for the area shows that there are no artificial sources of flooding within close proximity to the site. However, the Environment Agency's 'Risk of Flooding from Reservoirs' website (Figure 3.3) shows that the site is located within an area considered to be at risk of flooding from three reservoirs – Queen Mary reservoir, Queen Elizabeth II reservoir and Queen Mother reservoir, which are all over 16km from the site.

However, when considering the risk of flooding from this source it is necessary to take into account the fact that these reservoirs are located a significant distance from the site and are owned and operated by Thames Water Ltd, who have a duty under the Reservoirs Act to ensure that they are maintained in a good working order and are inspected regularly. Consequently, due to the high standard of protection the risk of flooding from these man-made water bodies is considered to be *low*.

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

Source of flooding	Initial level of risk	Appraisal method applied at the initial flood risk assessment stage
Rivers (tidal)	Low *	Environment Agency flood zone map
Rivers (fluvial)	N/A	Environment Agency flood zone map
Sea/Estuaries	N/A	Environment Agency flood zone map
Ordinary and man-made watercourses	N/A	Site based appraisal and historical evidence
Overland flow	Low	Site based appraisal, historical records contained within the PFRA and Environment Agency 'Risk of Flooding from Surface Water' flood maps
Groundwater	Low	BGS groundwater flood hazard maps, historical records contained within the SWMP, Defra Groundwater Flood Scoping Study and site-specific geological data
Sewers	Low	Site based appraisal and Thames Water historic sewer records contained within the SWMP
Artificial sources	Low	Site based appraisal and Environment Agency 'Risk of Flooding from Reservoirs' flood map

3.3 Existing Flood Risk Management Measures

The design standard of protection of the flood defences in this area of the Thames is 0.1% AEP; this means they are designed to defend London up to a 1 in 1000 year flood event. The defences along the tidal Thames in this area are all raised, man-made and privately owned. The Environment Agency inspect them twice a year to ensure that they remain fit for purpose, although they must be maintained by their owners to a crest level of 5.54m AODN (the Flood Defence Level in this reach of the Thames). The current condition grade for defences in the area is 2 (Good) – 3 (Fair), on a scale of 1 (very good) to 5 (very poor).

The Thames Barrier is a significant feature of the Thames Tidal Defences and is located between Newham and Greenwich. It became operational in October 1982 and was closed for the first time in February 1983. The Barrier is part of a system of tidal defences that currently protect London to extremely high standards. However, this level of protection is expected to decline in the future.

The Thames Estuary 2100 project sets out the strategic direction for managing flood risk in the Thames estuary up to the year 2100. The TE2100 plan is now live and forms the overarching flood management strategy for the Thames Estuary. The TE2100 takes into account operation of the Thames Barrier when considering future levels.

The Thames Barrier requires regular maintenance and with additional closures the opportunity for maintenance will be reduced. When this happens, river levels for which we would normally shut the barrier, will have to be allowed through to ensure that the barrier is not shut too often. For this reason, levels upstream of the barrier will increase and the tidal walls will need to be heightened to match.
The 'Thames Estuary 2100' document can be found on the Environment Agency's website for the short, medium and long term Flood Risk Management strategy for London.

4 Climate Change

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

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

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

To ensure that any recommended mitigation measures are sustainable and effective throughout the lifetime of the development, it is necessary to base the appraisal on the extreme flood level that is commensurate with the planning horizon for the proposed development. The NPPF and supporting Planning Practice Guidance Suite state that residential development should be considered for a minimum of 100 years, but that the lifetime of a non-residential development depends on the characteristics of the development. For commercial development, a 60 year design life is assumed. The development that is the subject of this FRA is classified as residential.

4.1 Potential Changes in Climate

Extreme Sea Level

Global sea levels will continue to rise, depending on greenhouse gas emissions and the sensitivity of the climate system. The relative sea level rise in England also depends on the local vertical movement of the land, which is generally falling in the south-east and rising in the north and west. The accompanying Planning Practice Guidance Suite to the NPPF provides allowances for the regional rates of relative sea level rise and these are shown in Table 4.1.

Administrative Region	Net Sea Level Rise (mm/yr) Relative to 1990			
	1990 to 2025	2026 to 2050	2051 to 2080	2081 to 2115
East of England, East Midlands, London, SE England (south of Flamborough Head)	4.0	8.5	12.0	15.0
South West	3.5	8.0	11.5	14.5
NW England, NE England (north of Flamborough Head)	2.5	7.0	10.0	13.0

Table 4.1 – Recommended contingency allowances for net sea level rise

The development site is not subject to coastal flooding, however, the River Thames is a tidal river and therefore the figures above are still applicable.

Peak Rainfall Intensity

The recommended allowances for increases in peak rainfall intensity were also updated in February 2016 and although the allowance is applicable nationally, there is a range of values provided which correspond with the central and upper end percentiles (the 50^{th} and 90^{th} percentile respectively) over three time epochs. The recommended allowances are shown in Table 4.2 below.
Central +5% +10% +20%

Allowance Category (applicable nationwide)	Total potential change anticipated for each epoch		
	2015 to 2039	2040 to 2069	2070 to 2115
Upper End	+10%	+20%	+40%
Central	+5%	+10%	+20%

Table 4.2 – Recommended peak rainfall intensity allowance for small and urban catchments (1961 to 1990 baseline)

All of the above recommended allowances for climate change should be used as a guideline and can be superseded if local evidence supports the use of other data or allowances. Additionally, in the instance where flood mitigation measures are not considered necessary at present, but will be required in the future (as a result of changes in climate), a "managed adaptive approach" may be adopted whereby development is designed to allow the incorporation of appropriate mitigation measures in the future.

4.2 Impacts of Climate Change on the Development Site

From the values presented above it can be seen that the extreme sea levels will change with time and that this change is not linear. The flood levels provided by the Environment Agency already include for the impacts of climate change for the period up to and including the year 2100 and these are summarised in Table 5.1.

From these figures it can be seen that there is a noticeable increase in water levels between the current day and climate change scenarios. Notwithstanding this, the existing defences will continue to provide a standard of protection of 1 in 1000 years up until the year 2070. From this point on the standard of protection will decrease over time. However, the Thames Estuary 2100 project has studied options to manage flood risk in the Thames estuary up to the year 2100.

In addition to the impact on tidal flood risk at the site, climatic changes will also impact on the way in which the proposed development affects flood risk elsewhere. These impacts are primarily linked to the surface water discharge from the site; therefore potential increases in future rainfall need to be taken into account when designing surface water drainage systems. For a residential development a design life of 100 years is assumed and therefore an increase of 20% in peak rainfall intensity has been used in the calculations in the outline surface water management strategy (refer to Section 8).

5 Probability and Consequence of Flooding

5.1 The Likelihood of Flooding

When appraising the risk of flooding to new development it is necessary to assess the impact of the 'design flood event' to establish depths, velocities and the rate of rise of floodwater under such conditions. Flood conditions can be predicted for a range of return periods and these are expressed in either years or as a probability, i.e. the probability that the event will occur in any given year, or Annual Exceedance Probability (AEP). The design flood event is taken as either the 1 in 100 year (1% AEP) event for fluvial flooding or the 1 in 200 year (0.5% AEP) event for sea or tidal flooding.

However, as outlined in Section 2.4, the operation of the Thames Barrier means that water levels upstream of the barrier are controlled by closure rules depicted in the TE2100 plan, rather than by events of certain return periods. Consequently, the design flood event has been redefined as the Maximum Likely Water Level's (MLWL) for the epoch 2100.

Detailed information provided by the Environment Agency delineates the highest water levels permitted by the operation of the Thames Barrier. These are shown in Table 5.1 below for the closest modelled node to the subject site (Node 2.18). The future defence levels provided below are the minimum levels to which the defences should be maintained.

	TE2100 Water Levels		
	Present Day	2065 to 2100	2100
Extreme water levels (m AODN)	5.04	5.50	5.94
Defence Level (m AODN)	5.54	6.25	6.70

Table 5.1 – Modelled flood levels provided by the Environment Agency (at Node 2.18) showing the highest levels permitted by the Thames Barrier and the future defence level.

When the design flood level is compared with the land levels at the site and surrounding area it can be seen that the depth and extent of flooding could be extensive. The River Thames is, however, defended along this section to a standard of 1 in 1000, i.e. the defences protect against a tidal flood event that has a 0.1% probability of occurring in any one year. Therefore, comparing extreme water levels predicted within the defended channel of the River Thames directly with site elevations is an extremely crude method of appraising the risk of flooding, as it does not take into account the presence of the tidal flood defences.

Whilst the Thames tidal defences do provide a very high standard of protection, and are also maintained to a safe and serviceable standard, there is always the risk that a small section of this infrastructure could fail; either as a result of structural failure, or through less predictable mechanism such as ship impact or an act of terrorism. This is known as the *residual risk* of flooding.

The only way that the impact of such a scenario can be quantified is through the use of detailed numerical breach modelling. This type of modelling has been undertaken as part of the Thames Tidal Breach Modelling study completed by CH2M HILL in March 2015, and the results of this study are included in the information provided by the Environment Agency.

The results provided delineate the predicted flood extents for a series of tidal breaches along the River Thames from Teddington to the Mar Dyke and River Darent. This appraisal has therefore used the results of this breach modelling to appraise the *residual* risk of flooding at the site and the findings are discussed in the following sections of this report.

5.2 The Extent of Flooding

Actual Risk
The present day maximum water level permitted by the Thames Barrier at the closest node point to the subject site is 5.04m AODN. The statutory defence level along this reach of the Thames is 5.54m AODN and therefore it can be seen that the predicted water levels are below the statutory level of defence. When taking into account future climate change scenarios, reference to Table 5.1 above shows that the highest water level permitted by the Thames Barrier will increase to 5.94m AODN by the year 2100. The tidal defence system is to be raised and adapted where required as part of the TE2100 Plan to keep new Barrier closures within operational constraints. It is anticipated that by 2100 the tidal walls along both banks of the river will be raised to a minimum of 6.70m AODN in this area of the River Thames. Consequently, based on this information it can be considered that there is **no *actual* risk of tidal flooding to the subject site.**

5.3 Depth and Velocity of Flooding

Inspection of the EA model identifies that the site is not affected under *actual* flood risk and therefore both the depth of floodwater and velocity of floodwater at the site is zero.

Inspection of the data provided by the EA identifies that the design flood level at the nearest Node to the development site (Node 3) is 5.49m AODN. Inspection of the LiDAR data for the site identifies that land levels vary between 4.60m and 5.28m.

Flood depths of 0.89m would be experienced at the lowest part of the site (garden), with flood depths getting shallower toward the existing dwelling, which would experience 210mm of flooding under the 2100 epoch.

Flow velocities in this area are estimated to be less than 0.5m/sec.

5.4 Rate of Rise of Floodwater

As well as the source of flooding, the size and nature of the flood compartment has a major influence on the rate of rise of the floodwaters. For a small, steep sided compartment, the rate of rise will be rapid, whereas for a compartment that is relatively large with respect to the source of flooding and has shallow sloping sides, the rate of rise will be more gradual. The flood compartment in which the proposed development is located fits the description of the latter.

Under the three residual risk scenarios modelled by the EA, the site has been shown to be within 2100 epoch flood extents. Furthermore, the Richmond upon Thames SFRA has identified that the site is not within a rapid inundation zone and therefore it is likely to be over 2 hours between a breach in the defence infrastructure and floodwater reaching the site.

6 Offsite Impacts and Other Considerations

6.1 Displacement of Floodwater

The construction of a new building within the floodplain has the potential to displace water from that area and to increase flood risk elsewhere by raising flood levels. Whilst the impact of a single development within a large floodplain such as this is negligible, it is the cumulative effect of all development in the area that the NPPF seeks to prevent. It achieves this by requiring any displacement that has the potential to increase risk elsewhere to be compensated for as part of a compensatory flood storage scheme.

In defended tidal areas such as this one, it is generally considered that there is only potential for new development to have an adverse impact on flood risk if the floodplain in which it is to be built is confined. For example, if the defences were to breach, the extent of flooding would be restricted by geographical features such as railway embankments or higher ground.

However, when the extent of flooding that would result from a breach in the defences that protect this particular site is considered, it can be seen that the floodplain is not confined and does in fact extend for some considerable distance. It is therefore concluded that the proposed development will not have an adverse impact on maximum flood levels and therefore the provision of compensatory storage is not required.

6.2 Public Safety and Access

The NPPF states that, where required, safe access and escape is available to/from new developments in flood risk areas. The Practice Guide goes on to state that access routes should be such that occupants can safely access and exit their dwellings in design flood conditions and that vehicular access to allow the emergency services to safely reach the development will also normally be required.

When the proposed development is considered, it can be seen that the site is currently protected from tidal flooding under the design flood event, and consequently safe access and escape from the dwellings can be achieved.

It is only in the extremely unlikely event that a breach should occur in the defence infrastructure (residual risk event), that flood depths would affect access/egress to the site. The EA model indicates that floodwater depths under this event could be in excess of 0.89m deep in the main road (adjacent to the development). Consequently, once floodwater has reached the site it is unlikely that access and egress to/from the property will possible.

However, given that the majority of the London Borough of Richmond upon Thames would also be affected by deep floodwater under the residual event, it is considered that this risk is mainly of strategic concern. Reference to the hazard mapping outputs from the SFRA supports this, identify that most of the London Borough of Richmond upon Thames will be classified with a hazard rating of 'low-significant' under such an event, with the proposed development site location within a ‘low’ hazard area. Therefore when the impact of this is considered in respect to new development within the Borough, it is evident that if new development is prohibited on this basis it would not only impact the study site, but nearly all new development within Richmond upon Thames.

Notwithstanding this, occupants should be prepared to evacuate the site *before* an extreme flood occurs and return to their permanent place of residence. Furthermore, it is imperative that the residents of the building sign up to the Environment Agency’s Early Flood Warning System (refer to Section 7.4 below).

6.3 Proximity to Watercourse and Flood Defence Structures

Under the Water resources Act 1991 and Land Drainage Byelaws, any proposals for development in close proximity to a 'main river' would need to take into account the Environment Agency's requirement for an 8m buffer zone between the river bank and any permanent construction such as buildings or car parking etc. This is to allow access for maintenance, to provide biodiversity opportunities and also to provide room for the river banks to erode without threatening any development. Consequently, prior consent of the Environment Agency is required for any development within the bye-law distance and this consent is in addition to planning permission.

The development site is approximately 488m from the River Thames and as such will not compromise any of the Environment Agency's maintenance or access requirements.

6.4 Impact on Fluvial Morphology & Impedance of Flood Flows

The development site is a significant distance from the nearest river and is not within the functional floodplain. As such it is considered that the development will not affect fluvial morphology.
In terms of the way in which the development would interact and modify flood flows, its location and size with respect to the flood risk area and the flow path has to be considered. Given the distance from the source of flooding, and the nature and topography of the surrounding area, it is considered that the proposals will not significantly impede or change flood flow regimes.

7 Flood Mitigation Measures

The key objectives of flood risk mitigation are:

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

Up to this point in the report the risks to the site have been appraised and the consequences of these risks occurring have been considered. The following section of this report examines ways in which flood risk can be mitigated.

Mitigation Measure	Appropriate	Comment
Careful location of development within site boundaries (i.e. Sequential Approach)	x	See Section 7.1
Raising floor levels	x	Not required (See Section 7.2)
Land raising	x	Not required (See Section 7.2)
Compensatory floodplain storage	x	See Section 6.1
Flood resistance & resilience	✓	See Section 7.3
Alterations/ improvements to channels and hydraulic structures	x	Not required
Flood defences	x	Not required
Flood warning	✓	See Section 7.4
Management of development run-off	✓	See Section 8

7.1 Application of the Sequential Approach at a Local Scale

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

However, given that this development is simply a change of use and a minor subterranean extension, there is no scope to apply this approach in this instance.

7.2 Raising Floor Levels & Land Raising

The Environment Agency normally recommends that the minimum floor level of buildings at risk of flooding should be 300mm above the design flood level, which is the 1 in 200 year extreme water level plus the appropriate allowance for climate change. The Environment Agency's guidance also requires that all sleeping accommodation be raised a minimum of 600mm above the design flood level. Nevertheless, in this circumstance the proposals are for a conversion to an existing building where the floor levels are fixed, and therefore it is recognised that raising floor levels may not be an appropriate or practical form of mitigation in this instance.

When the proposed development is considered, it can be seen that the main source of flood risk to this site is from tidal flooding. However, when this risk is considered in more detail it is evident that the site is currently protected from a tidal flood event under the design flood conditions by defence infrastructure offering a high standard of protection. Therefore, floor raising is not considered necessary at this development given the *actual* risk of flooding is low.

Notwithstanding this, the modelled results provided by the EA do identify that the land levels at the development site are located below the predicted design flood level under the residual event for a tidal breach scenario. Therefore, the ground floor and basement of the proposed building could be subject to internal flooding during such an event. However, when considering the extremely low probability of the defence infrastructure either failing, or being overtopped, and the fact that the majority of the London Borough of Richmond would be affected during this scenario; it is not considered necessary to set finished floor levels for the ground floor and basement above the level defined under this residual risk event.

Nevertheless, by adopting the precautious approach promoted within the NPPF, it is acknowledged that new development located within a flood risk area should be designed such that the occupants should not be placed at undue risk. The scheme design takes this residual risk into consideration by locating the more vulnerable sleeping accommodation at first and second floor level, whilst less vulnerable uses (i.e. living accommodation) has been sited within the proposed basement extension.

The upper floors are located above the design flood level and can be accessed from the basement level via an internal access. Consequently, a means of safe refuge will be available in the unlikely scenario that floodwater should reach the basement and ground floor level during a tidal breach (residual risk) scenario.

The only risk of flooding to the development site is therefore classified as *residual* risk, and although the mitigation options for raising the ground floor levels and land raising are not considered necessary in this instance, it is recommended that a 300mm threshold is placed on the ground floor in order to help prevent the ingress of floodwater into the basement during the residual risk event.

This raised threshold will also provide added protection against a localised surface water flooding event, for example, under a scenario whereby the local drainage system fails or becomes blocked.

7.3 Flood Resistance and Resilience

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

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

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

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

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

It has been shown that the proposed development could be affected by floodwater, albeit that the risk of such occurrence is considered to be very low. Nevertheless, by incorporating flood resilience into the design of the building it will be possible to increase its resilience to flooding and thereby reduce the impact of such an event.

Flood proofing measures which can be implemented to reduce the damage to buildings and property are becoming more common in areas that are subject to flooding. Typical examples of flood resilience measures which may be appropriate for the development site include (but are not limited to) the following:

- Raising floor slab level further
- Bringing the electrical supply in at first floor
- Placing boilers and meter cupboards on the first floor
- Water-resistant plaster/tiles on the walls of the ground floor
- Solid stone or concrete floors with no voids underneath
- Covers for doors and airbricks
- Non-return valves on new plumbing works
- Avoidance of studwork partitions on the ground floor

Furthermore, adopting a precautious approach, the proposed basement will be sufficiently tanked and the surface water drainage system will use a pumped sump system and non-return valve (fitted on the outfall), which will further prevent flooding from the sewer (i.e. under a surcharge event).

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

7.4 Flood Warning

The Environment Agency operate a flood forecasting and warning service in areas at risk of flooding from rivers or the sea, which relies on direct measurements of rainfall, river levels, tide levels, in- house predictive models, rainfall radar data and information from the Met Office. This service operates 24 hours a day, 365 days a year.

Whilst the probability of an event of sufficient magnitude to cause floodwaters to reach the levels discussed in this report is very low, the risk of such an occurrence is always present. With the sophisticated techniques now employed by the Environment Agency to predict the onset of flood events the opportunity now exists for all residents within the flood risk area to receive early flood warnings.

This forewarning could be sufficient to either allow residents to evacuate the area or prepare themselves and their property for a flood event. It is therefore recommended that the Environment Agency's Floodline Service is contacted to find out if it is possible to register for Floodline Warnings Direct, which is a free service that provides flood warnings direct by telephone, mobile, fax or pager.

Reference to the Environment Agency's website shows that the site is located within two flood warning areas as shown below;

Flood Warning Area	Quickdial number
Tidal Thames from Putney Bridge to Mortlake High Street East	174101
Tidal Thames in the boroughs of Wandsworth and Richmond-upon-Thames	174105

For further details call Floodline on 0345 988 1188, select Option 1 and enter either quickdial number.

8 Surface Water Management Strategy

8.1 Background and Policy

As part of the Government's continuing commitment to protect people and property from flood risk, the Department for Environment, Food and Rural Affairs (Defra) consulted on a proposal to make better use of the planning system to secure sustainable drainage systems (2014).

These changes came into effect from 6 April 2015, and relate to The Floods and Water Management Act 2010 National Standards (Schedule 3 – paragraph 5) for design, construction, maintenance and operation of Sustainable Drainage Systems (SuDS). These (non-statutory) Technical Standards for SuDS specify criteria to ensure sustainable drainage is included within developments of 10 dwellings or more; or equivalent non-residential, or mixed development (as set out in Article 2(1) of the Town and Country Planning (Development Management Procedure) (England) Order 2010).

These Technical Standards (S1 -14) provide additional detail and requirements not initially covered by the NPPF. However, it is recognised that SuDS should be designed to ensure that the maintenance and operation requirements are economically proportionate.

In this instance, the proposed development is for the extension of an existing basement, ground floor and a loft conversion. Consequently, the National Standards do not apply.

Nonetheless, the current requirement of National Policy is that all new developments in areas at risk of flooding should give priority to the use of SuDS. Within this section of the FRA, reference is therefore made to the new SuDS criteria, ensuring the proposed scheme is compliant with the current planning standards for the lifetime of the development.

In addition to the national technical standards Policy 5.13 of the London Plan states developments should incorporate SuDS wherever possible within schemes, unless there is a practical reason for not doing so.

Whilst the aspirational objective of the London Plan is to restrict the discharge of surface water run- off from all sites to the greenfield run-off rate, the mandatory requirements for brownfield sites where SuDS options are available are a 50% reduction in run-off rates discharged to receiving watercourses or sewers.

Policy 5.13 of the London Plan also states that when implementing SuDS within developments developers should follow the drainage hierarchy, prioritising the discharge of surface water run-off as close to source as possible. The drainage hierarchy is outlined below:

- Store surface water run-off for later use, either internally or externally.
- Use infiltration techniques, such as porous surfaces in non-clay areas to discharge run-off as close to source as possible.
- Attenuate surface water run-off in ponds or open water features for gradual release.
- Attenuate surface water run-off by storing in tanks or sealed water features for gradual
- release.
- discharge surface water run-off direct to a watercourse
- discharge surface water run-off to a surface water sewer/drain.
- discharge surface water run-off to the combined sewer.

The proposed development must therefore attempt, where possible, to incorporate SuDS features in accordance with the requirements of the London Plan and any other adopted local policies pertaining to drainage. Consequently, the potential options for incorporating SuDS and their viability within the proposed scheme is outlined further in the following sections of this report.

8.2 Surface Water Management Overview

The requirements for managing rainfall run-off from developments depends on the pre-developed nature of the site. For undeveloped greenfield sites, the impact of the proposed development will require mitigation to ensure that the run-off from the site replicates the natural drainage characteristics of the pre-developed site.

In the case of brownfield sites, drainage proposals will be measured against the existing performance of the site, although it is preferable for solutions (where practical) to provide run-off characteristics that are similar to greenfield behaviour.

The main characteristics of the site and the proposed development that affect the surface water drainage strategy are summarised in Table 8.1 below.

Site Characteristic	Value
Total area of site	270 m^2
Impermeable area (existing)	**109 m^2**
Impermeable area (proposed)	**155 m^2**
Current site condition	Brownfield site
Greenfield run-off rate	1.5 l/sec/ha (based on IoH Report 124 methodology)
Infiltration coefficient	0.1-0.001m/hr (assumed based on underlying geology and typical soil conditions)
Standard Percentage Run-off (SPR)	35.4%
Current surface water discharge method	Assumed to discharge to existing public sewer system
Is there a watercourse within close proximity to site?	No
Is site within groundwater Source Protection Zone?	No

Synthetic rainfall data has been derived using the variables obtained from the Flood Studies Report (FSR) and the routines within the Micro Drainage Source Control software. The peak surface water flows generated on site for the existing and post-development conditions have been calculated by using the Modified Rational Method. Run-off rates have been calculated for a range of annual return probabilities including the 100 year return period event with a 20% increase in rainfall intensity to account for future climatic changes.

These values are summarised in Table 8.2 for a range of return periods. The critical storm duration is shown in brackets.

Return period (years)	Peak run-off (l/sec)	
	Existing site	Developed site
1	1.8 (15 mins)	2.4 (15 mins)
30	4.2 (15 mins)	5.7 (15 mins)
100	5.4 (15 mins)	7.5 (15 mins)
100 + 20%	6.5 (15 mins)	8.9 (15 mins)

Table 8.2 – Summary of peak run-off

The total volume of water discharged from the site from the 100 year 6 hour event (including for a 20% increase for climate change) is summarised in Table 8.3 below for both the existing and proposed site conditions.

Site condition	Total volume discharged
Existing site	8 m^3
Proposed development (before mitigation)	11 m^3

Table 8.3 – Total volume discharged from the 100 yr+20%cc 6 hour event

Reference to Tables 8.2 and 8.3 above show the proposed development will increase the percentage of impermeable area within the boundaries of the site and consequently this will increase the volume of surface water run-off from the site. It will therefore be necessary to provide mitigation measures to ensure the rate of run-off discharged from the site is not increased as a result of the proposed development.

Furthermore, the potential use of sustainable drainage techniques within the proposed development will be considered in order to assess the practicality of better replicating greenfield behaviour, in accordance with best practice guidance the London Plan and S3 and S5 of the National Technical Standards for SuDS.

The general surface water management requirement for all new development is to ensure that the peak discharge rate and the discharge volume of surface water run-off does not exceed that of the existing site. Additionally, surface water run-off up to the 100 year return period event should preferably be contained within the site at designated temporary storage locations unless it can be shown to have no material impact in terms of nuisance or damage, or increase river flows during periods of river flooding (Preliminary rainfall run-off management for developments - EA/DEFRA W5-074/A).

At this stage a detailed surface water drainage design has not been undertaken, however, it is necessary for the FRA to demonstrate that the surface water from the proposed development can be discharged safely and sustainably. The following calculations have therefore been undertaken to demonstrate that this is achievable. The proposed method of surface water discharge and the associated constraints is described below.

8.3 Existing Drainage

Although the exact nature of the onsite drainage network has not been confirmed, Thames Water has provided the results of an asset location search for the site Figure 8.1 below. This mapping identifies the nearest public sewer to the site is a surface water sewer located within the main road. Given the location of this existing sewer, and inspection of the existing site using aerial photography and Google Street View mapping, it has been deemed likely that the existing site currently discharges surface water run-off into this sewer system, via a pipe located under the access road to the garages sited at the rear of the properties.

Further investigation may be required as part of the detailed design to confirm the exact layout of the existing underground drainage network and the potential to utilise any pre-existing, or new connections to the public sewer system.

8.4 Opportunities to Discharge Surface Water Run-Off

For any given development, the National Standards in relation to SuDS state that the preferred option for discharging surface water run-off from the site is to **infiltrate** water into the ground as this deals with the water at source, and serves to replenish groundwater. If this is not viable (due to a high water table, local impermeable soils, contamination issues including source protection zones etc.), then the next option of preference is for the run-off to be discharged into a **watercourse**. Only if neither of these options is possible should the water be conducted into the **public sewer** system.
Infiltration – Whilst site-specific ground investigations have not been carried out at this stage in the development process, the Standard Percentage Run-off (SPR) value has been established for this site from the Flood Estimation Handbook (FEH) database. This parameter is used to indicate the percentage of rainfall which becomes direct response run-off to a watercourse. A higher run-off percentage means that less rainfall is infiltrated into the soil, indicating lower permeability soil.

Flood Risk Assessment
The SPR for this site is 35.4%, suggesting that the soils have poor permeability. This is partially supported by the geology and soil characteristics for this area, which show the site to be located on typically semi permeable superficial deposits form the Kempton Park Gravel Formation (Sands and Gravels), overlying the more impermeable London Clay Formation (Clay and Silt) bedrock. It is therefore considered that the percolation rate of the soils in this area could be sufficient for some infiltration techniques to be utilised. Although this may need to be confirmed via site-specific soakage tests at the detailed design stage.

For the purpose of this assessment, it has been assumed that infiltration will not be a suitable method for discharging all surface water run-off from the site. Although the use of permeable paving may still be appropriate across any proposed hardstanding surfaces.

Discharge to Watercourses – There are no watercourses within close proximity of the site to permit a direct connection. Consequently, there is no opportunity to utilise a direct connection to an existing watercourse as a means of managing surface water run-off from the proposed development.

Discharge to Public Surface Water Sewer & Existing Connections – It is likely that the existing site discharges surface water into the Thames Water surface water sewer in the main road. Whilst utilising a connection into the surface water sewer would be the most convenient option for discharging surface water, it is the least preferential in the hierarchy of discharge options.

It is therefore likely that any discharge into this system will be required to be restricted and attenuated accordingly, in line with the National Standards for SuDS; which state that for previously developed sites the peak rate of run-off must be as close as reasonably practical to the greenfield run-off rate.

Nevertheless, given that there will be minimal changes to the existing drainage at the site and there is an existing connection to the public sewer system, providing the rate at which surface water run- off is discharged to the public sewer does not exceed the existing run-off rate, then this is likely to be deemed acceptable to the sewerage undertaker.

8.5 Foul Drainage

With regard to foul drainage, it is likely that the proposed development will continue to discharge foul waste via the (assumed) existing connection into the foul sewer located within the main road.
At the detailed design stage, it will be necessary to confirm that there is adequate capacity in the foul sewer system and onsite drainage runs to accommodate any additional foul waste from the development.

8.6 Constraints and Further Considerations

In order to determine whether or not infiltration will be appropriate at the site, infiltration testing may be required at the detailed design stage to refine the outline designs put forward as part of this surface water management strategy. It may also be necessary to confirm the depth below the ground level of the groundwater table.

As part of the development some existing structures will be retained there may be limited scope for the incorporation of SuDS across parts of the existing building. Retrofitting SuDS into the retained parts of the development may present an unsustainable or unattainable situation if a large part of the existing drainage onsite remains unchanged. Nevertheless, it will still be necessary to ensure the post development discharge of surface water run-off into the public sewer system is managed to ensure run-off rates do not exceed that of the existing site.

Inspection of the site and scheme layout shows that whilst there are opportunities for the inclusion of Sustainable Drainage Systems (SuDS), there is very little open space in which to incorporate SuDS features that require significant areas of land such as wetland areas and detention basins etc. The SuDS options are discussed in more detail in the following section.

8.7 Sustainable Drainage Systems (SuDS)

Appropriately designed SuDS can be utilised such that they not only attenuate run-off but also provide a level of improvement to the quality of the water passed on to watercourses or into the groundwater table. This is known as source control and is a fundamental part of the SuDS philosophy. The London Plan highlights the importance of using SuDS in new developments wherever possible in Policy 4C.8:

> *"Boroughs should seek to ensure that surface water run-off is managed as close to its source as possible. The use of SuDS should be promoted for developments unless there are practical reasons for not doing so. Such reasons may include the local ground conditions or density of development. In such cases the developer should seek to manage as much run-off as possible on site and explore sustainable methods of managing the remainder as close as possible to the site."*

A range of typical SuDS components that can be used to improve the environmental impact of a development is listed in Table 8.4 below along with the relative benefits of each feature and the appropriateness for the subject site.

SuDS Feature	Environ-mental benefits	Water quality improve ment	Suitability for low permeability soils (k<10-6)	Ground-water recharge	Suitable for small/ confined sites?	Site-specific restrictions	Appropriate for subject site?
Wetlands	✓	✓	✓	x	x	Insufficient space	No
Retention ponds	✓	✓	✓	x	x	Insufficient space	No
Detention basins	✓	✓	✓	x	x	Insufficient space	No
Infiltration basins	✓	✓	x	✓	x	Insufficient space	No
Soakaways	x	✓	x	✓	✓	Insufficient infiltration	No
Underground storage	x	x	✓	x	✓	None	Yes
Swales	✓	✓	✓	✓	x	Insufficient space	No
Filter strips	✓	✓	✓	✓	x	Insufficient space	No
Rainwater harvesting	x	✓	✓	✓	✓	None	Yes
Permeable paving	x	✓	✓	✓	✓	None	Yes
Water butts	✓	x	✓	x	✓	None	Yes
Green roofs	✓	✓	✓	x	✓	Dependant on proposed roof construction	Unknown at this stage

Table 8.4 – Suitability of SuDS

From Table 8.4 it can be seen that there are a number of SuDS elements that are potentially suitable for this site. However, at this stage in the planning process it is envisaged that underground storage located to the rear of the property will be used to discharge the surface water run-off from the entire site, at an attenuated rate, into the public sewer system.

8.8 Proposed Surface Water Management Strategy (SWMS)

At this stage a detailed surface water drainage design has not been undertaken, however, it is necessary for the FRA to demonstrate that the surface water from the proposed development can be discharged safely and sustainably. The objective of the SWMS is to ensure that a sustainable drainage solution can be achieved which reduces the peak discharge rate and discharge volume to that of the existing site. For brownfield sites the aspiration is to replicate the surface water run- off characteristics of a greenfield site wherever reasonably practicable, (in line with Technical Standard S3).

The SWMS for each of the different elements of the scheme is set out below along with the calculations that have been undertaken to demonstrate how the overall objectives have been achieved. This does not represent a detailed surface water drainage design, it is simply an assessment to demonstrate that the objectives and requirements of the NPPF can be met at the planning stage.

In this case it has been assumed that it will be feasible to discharge surface water run-off from the entire developed site to the proposed SuDS. Notwithstanding this, if retrofitting SuDS across the existing parts of the development is deemed unfeasible at the detailed design stage, then it will only be necessary to mitigate run-off from the proposed extension and additional hardstanding area.

Ideally run-off discharged from the site to either the public sewer or a watercourse should be restricted to the greenfield run-off rate, however, in order to minimise the risk of flooding through a failure in the local drainage system (i.e. as a result of blockage), a discharge rate of 5.0 l/s is typically used. In this instance, 5.0 l/s is less than the existing site currently discharges under present day climate change conditions. Consequently, it is likely that a rate of 5.0 l/s will likely be acceptable to both the LPA and sewerage undertaker.

Drainage Options for Hardstanding and Roof Drainage

The surface water run-off from the entire roof area can be discharged to the public sewer at an attenuated rate, via a cellular storage system, utilising a flow control device to restrict the discharge rate. This is based upon an assumed negligible infiltration rate.

A summary of the Micro Drainage analysis for the hardstanding and roof areas is shown in Table 8.5 below.

Parameter	Value
Area draining to attenuation system	155 m2
Assumed infiltration	None
Flow control device	Orifice plate
Maximum allowable rate of discharge	5.0 l/sec
Peak discharge for 100yr+cc	4.6 l/sec
Critical storm duration	15 minutes
Half drain time	4 minutes
Required storage	5m^2 x 0.4 (deep)

Table 8.5 – Summary of Micro Drainage analysis for the cellular storage system (100 yr+20%cc)

8.9 Additional Opportunities for SuDS

If at the detailed design stage, capacity checks and discussions with Thames Water result in an imposed limit on the rate of discharge from the site to the public sewer, it may be necessary to further reduce the rate of discharge from the site. This can be achieved by utilising additional SuDS options which could be explored at the detailed design stage, some of which are outlined below:

Permeable Paving – An additional enhancement that could be investigated to further reduce the volume of run-off from the site is the use of permeable paving for any patios, paths or other hardstanding areas. Adequate oil interception devices and geotextile membranes should be implemented, where deemed appropriate, across any areas of permeable hardstanding in order to ensure hydrocarbons are not leaked into the ground at this location. If any new hardstanding areas are proposed, it is recommended that the use of permeable paving be explored further at the detailed design stage following site-specific infiltration tests.

Rain Gardens – For small areas of isolated hardstanding such as garden paths and sheds, it may be possible to discharge run-off to dedicated areas of landscaped rain gardens. These rain gardens could be profiled to allow run-off to pond and infiltrate into a thin soil substrate of permeable sand or gravel. In turn this would reduce the volume of run-off from these areas discharged directly to the sewer if minimal infiltration is discovered at the detailed design stage.

Green Roofs – Surface water run-off from all or part of the roof area of the proposed development could be discharged through a green roof. The incorporation of a green roof will act to store and filter a large amount of run-off from the roof area within the soil substrate of the planted areas. Any areas of hardstanding could be profiled to drain into the surrounding green roof in order to maximise its potential benefits.

The incorporation of a green roof will, however, depend on whether the roof construction type is suitable. It will also be necessary to provide adequate drainage at the base of the green roof to avoid stagnation, as well as provide a means of attenuating run-off in the event that the roof is saturated prior to a rainfall event.

Water Butts – Given the nature of the development there is some scope for the incorporation of water butts within the proposed scheme. Typical sizes and dimensions of water butts are outlined below.

Typical House Water Butt Options	Dimensions of a typical house water butt	Volume of storage provided (litres)
Type 1 (wall mounted – Small)	1.22m high x 0.46m x 0.23m	100
Type 2 (Standard house water butt)	0.9m high x 0.68m diameter	210
Type 3 (Large house water butt)	126m high x 124m x 80m	510
Type 4 (Column tank – Very large)	2.23m high x 1.28m diameter	2000

Table 8.6 – Estimated storage capacity of available water butts

8.10 Management and Maintenance

In order for any surface water drainage system to operate as originally designed, it is necessary to ensure that it is adequately maintained throughout its lifetime. For commercial development this is generally taken as 60 years and residential 100 years is assumed. Therefore over the lifetime of a development there is a strong possibility that the system could either fail or its performance be reduced if it is not correctly maintained. This is even more important when SuDS form a part of the surface water management system, as these require a more onerous maintenance regime than a typical piped network.

The key requirement of any management regime is routine inspection and maintenance and therefore at the stage when the development is taken forward to the detailed design stage an 'owners manual' will need to be prepared. This will include:

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

- An explanation of the consequences of not carrying out the specified maintenance

For the SuDS features recommended by this assessment, the most obvious maintenance tasks will be the de-silting of underground storage areas. It is important to ensure that the design must recognise the need for this operation and thus incorporate silt traps and easy access for emptying.

At this point in time there are no formal arrangements for SuDS to be adopted; however, for developments such as this that rely to some extent on the ongoing inspection and maintenance of the SuDS features, it will be necessary to ensure that measures are in place.

As the site consists of a single house the most suitable option is likely to be to task the residents with the maintenance responsibilities for the property and the associated drainage features. However, measures will need to be put in place to ensure occupants are made aware of maintenance schedules.

8.11 Residual Risk

For development located outside of identified flood risk areas there is also a requirement to assess the impact of an exceedance rainfall event or the failure of the surface water drainage system.

The mitigation measures discussed previously within this section of the report will significantly reduce the risk of the development being affected by flooding from surface water run-off and reduce the risk of flooding to areas outside the boundaries of the site; however, they do not completely remove the risk. The impact of a residual risk event has therefore been assessed in this part of the FRA.

In accordance with current climate change guidance a sensitivity test utilising a 40% increase in surface water run-off has been undertaken to determine the effect this increase in surface water run-off would have on the proposed cellular storage system. In this case approximately $0.2m^3$ would overflow from the cellular storage system and result in flooding at the site. Given the relatively low volume of water discharged and the large area of garden to the rear of the property it is unlikely this will result in any internal flooding at the site.

8.12 Summary of Proposed Surface Water Management Strategy

The overarching objective of a SWMS is to identify a sustainable surface water drainage system that reduces the peak rate and volume of run-off from the site to a value that is less than would be experienced with the existing site condition. This helps to reduce the amount of surface water discharged from the site and passed onto systems further downstream and thus in doing so helps to reduce the risk of flooding.

The plan that has been identified at this early stage in the development design process achieves the aspirational objective of reducing peak discharge rates to the limiting discharge rate of 5.0 l/s, which is less than the existing site. This has been achieved by redirecting the existing site drainage into a cellular storage system and discharging all surface water run-off from the development via a flow control device to the public surface water sewer system.

In furthering the design of the proposed strategy it may be necessary to undertake site-specific ground investigations in order to quantify the available infiltration, the groundwater level and the level of contamination that may be present in the soils. This in turn will confirm the suitability of infiltration SuDS at the site.

Other potential opportunities to incorporate SuDS measures within the scheme have been explored, including the use of permeable paving, and green roofs. These options could be used to provide additional storage onsite, thereby reducing the required capacity within the proposed cellular crate system. Further detailed site investigations may be required at the detailed design stage to confirm which are the most suitable for incorporation into the scheme.

The above calculations are indicative only and whilst they do not comprise a detailed drainage scheme, they do at this stage demonstrate that the proposed strategy for managing surface water run-off is achievable.

9 Conclusions

The key aims and objectives for a development that is to be sustainable in terms of flood risk are summarised in the following bullet points:

- the development should not be at a significant risk of flooding, and should not be susceptible to damage due to flooding
- the development should not be exposed to flood risk such that the health, safety and welfare of the users of the development, or the population elsewhere, is threatened
- normal operation of the development should not be susceptible to disruption as a result of flooding and safe access to and from the development should be possible during flood events
- the development should not increase flood risk elsewhere
- the development should not prevent safe maintenance of watercourses or maintenance
- and operation of flood defences by the Environment Agency
- the development should not be associated with an onerous or difficult operation and maintenance regime to manage flood risk; the responsibility for any operation and maintenance required should be clearly defined
- the development should not lead to degradation of the environment
- the development should meet all of the above criteria for its entire lifetime, including consideration of the potential effects of climate change

In determining whether the proposals for development are sustainable in terms of flood risk and are compliant with the NPPF and its Planning Practice Guidance, all of the above have been taken into consideration as part of this FRA.

In this case a bespoke Sequential Test assessment has not been undertaken in support of this FRA. However, given that the development proposals are simply for a ground floor rear extension to an existing building, and a loft conversion and therefore the application of the Sequential or Exceptions Test is not considered relevant in this instance.

The risk of flooding has therefore been considered across a wide range of sources and it is only the risk of tidal flooding from the River Thames that has been shown to have any bearing on the development. However, when this risk is examined in detail, it has been demonstrated that the risk of flooding from this source is limited to the failure of the defence infrastructure (i.e. the residual risk event).

Considering the high standard of protection provided by these defences, the good condition they are maintained to, and the low probability of their failure, it is considered that the likelihood of these defences failing over the lifetime of the development is very low. Nevertheless, it has also been shown that with appropriate mitigation incorporated into the building the development will be safe and will not exacerbate the risk of flooding.

Furthermore, this FRA has demonstrated that the development will not increase flood risk elsewhere and by incorporating appropriate mitigation measures and SuDS features within the design of the surface water drainage system, it will be possible to limit the impact with respect to surface water run-off. Consequently, it has been shown that the development will meet the requirements of the NPPF and is therefore appropriate for its location within a flood risk area.

10 Recommendations

The findings of this report conclude that the development will not increase flood risk at the site, or elsewhere. There are, however, a number of mitigation measures and recommendations that are required to reduce the risk to the development and other areas within the floodplain.

- A 300mm threshold is placed along the ground floor in order to prevent internal flooding during the design event.

- The surface water management strategy for the development will need to be developed to a detailed design stage and this will need to take into account the requirements set out in Section 8.1 and 8.2.

- It will be necessary to undertake site-specific investigations at the detailed design stage in order to quantify the available infiltration, the groundwater level and the level of contamination that may be present in the soils.

- The use of appropriate SuDS techniques as discussed in Section 8 should be considered for incorporation into the scheme design. For this development the use of cellular storage, which discharges surface water run-off at an attenuated rate into the public sewer.

- The flood resilience measures outlined in Section 7.3 of this report are to be incorporated into the design of the building where possible.

- The owner and occupants of the proposed dwelling should sign up to the Environment Agency's floodline warnings. The flood warnings provide residents with the opportunity to evacuate in the unlikely event than an exceedance event should occur.

With the above mitigation measures incorporated into the design of the development the proposals will meet the requirements of the NPPF and its Planning Practice Guidance and will therefore be acceptable and sustainable in terms of flood risk.