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Client : Phoenix Community Housing

Flood Risk Assessment for Proposed Development at Riverpark Gardens, Bromley

August 2014

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Contents Amendment Record

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1	0	Draft report issued by email	5 August 2014	AC	SMB
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1 Background and Scope of Appraisal

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

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

Herrington Consulting has been commissioned by Phoenix Community Housing to prepare a Flood Risk Assessment for the proposed development at Riverpark Gardens, Bromley, BR2 0BQ.

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. Whilst it is recognised that PPS25 is no longer a valid policy document, the supporting technical guidance included within the Suite represents the most contemporary technical guidance on preparing FRAs.

2 Development Description and Planning Context

2.1 Site Location

The site is located within the Phoenix Riverpark Gardens Estate in the London borough of Bromley and is bordered by the Ravensbourne River. In total the site covers an area of approximately 0.07 hectares, and currently comprises a shop with flatted accommodation above (disused and boarded up), a block of garages, and an electricity sub-station. The location of the site in relation to the surrounding area and the Ravensbourne River is shown in Figure 2.1. The site plan included in Appendix A.1 of this report gives a more detailed reference to the site location and layout.

Figure 2.1 – Location map (Contains Ordnance Survey data © Crown copyright and database right 2014)

2.2 The Development

The proposals for development are to demolish the existing building and garages and construct a block of flats comprising 8 self-contained units.

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

2.3 The Sequential Test

Local Planning Authorities (LPA) are encouraged to take a risk-based approach to proposals for development in or affecting flood risk areas through the application of the Sequential Test 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 location of the site is shown on the Environment Agency's flood zone map in Figure 2.2 and the information provided by this map has been interrogated and summarised in Table 2.1 below.

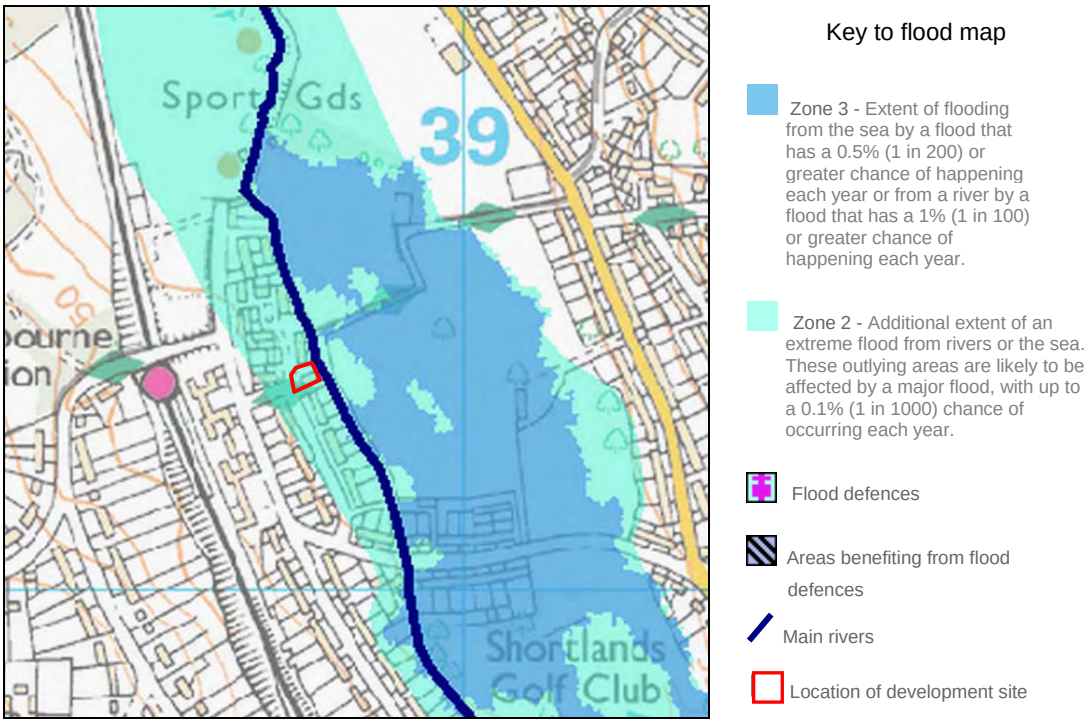


Figure 2.2 – Flood zone map showing the location of the development site (© Environment Agency)

The above mapping shows the development site to be located within Flood Zone 2 and not to be benefiting from existing flood defences that have been constructed in the last 5 years.

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	**100%**	Fluvial	No
Zone 3a	**0%**		
Zone 3b	**0%**		
(*) The flood zone maps only recognise defences constructed within the last 5 years			

Table 2.1 – Flood zone classification

The NPPF states that the Local Planning Authority 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 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 test to sites that have not been assessed as part of the LDF it is often necessary to apply a bespoke test.

In this case a Sequential Test assessment has not been undertaken in support of this FRA, however, from the work that has been undertaken as part of this site specific appraisal it is possible to provide evidence that can help in the application of the Sequential Test and this is summarised in the conclusions of this report.

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 Bromley Borough Council 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 The Exception Test

In addition to the Sequential Test, it is also necessary to consider the type and nature of the development and whether or not the Exception Test is applicable. The National Planning Practice Guidance Suite to the NPPF defines the type and nature of different development classifications in the context of their flood risk vulnerability. This has been summarised in Table 2.2 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 2.2 - Flood risk vulnerability and flood zone compatibility

From Table 2.2 above it can be seen that the development falls into a classification that does not require the Exception Test to be applied. Notwithstanding this, Paragraph 104 of the 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 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 Environment Agency – The Environment Agency has been consulted as part of the development of this FRA and a copy of their response is included in Appendix A.2 of this report.

High level information contained within the SFRA – The Bromley Borough Council Strategic Flood Risk Assessment (SFRA) contains detailed mapping of flood extents from a wide range of sources. This document has been referenced as part of this site-specific FRA.

Site specific topographic surveys – A topographic survey has been undertaken for the site and a copy of this is included in Appendix A.1. From this it can be seen that typical land levels across the site range between 32.21m and 32.46m Above Ordnance Datum Newlyn (AODN). Land levels fall across the site towards the north east. Land levels in the highway (Riverpark Gardens) fall towards the north.

Geology – Reference to the Geological Survey map for this location shows that the underlying solid geology in the location of the subject site is Thanet Sand Formation. Overlying this are superficial deposits of Alluvium.

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 very acid sandy and loamy soils'.

Historic flooding – As part of the information provided by the Environment Agency a summary of historic flooding in this location has been provided. This suggests that the subject site has been affected by fluvial flooding from the Ravensbourne River on two occasions in the past: November 1965 and September 1968. No details regarding flood depths or extents during these events have been provided, however, the quality of flood extents data from events during the 1960s is relatively poor and therefore the historic flood records should be treated as indicative only.

No further information on recent historic flooding in this area has been provided or revealed through desk top searches.

Other Information – No further information has been provided.

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 (Fluvial) – The site lies within Flood Zone 2 of the Ravensbourne River (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 2, the risk of flooding from this source has been examined in more detail as part of this FRA.

Flooding from Rivers (Tidal) – There are no tidally influenced watercourses within close proximity of the subject site and therefore the risk of flooding from this source is considered to be negligible. Consequently the risk of tidal flooding from rivers is not considered further within this appraisal.

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 negligible.

Flooding from the Sea – The site is located a significant distance inland and is elevated well above predicted extreme tide levels. Consequently the risk of flooding from this source is considered to be negligible and therefore the affects of flooding from the sea are not considered further in this appraisal.

Flooding from Land (overland flow and surface water runoff) – 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 runoff 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 required to produce and publish 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 runoff rates and critical storm durations. The maps pick out natural drainage channels, rivers, low areas within floodplains and flow paths between buildings. They do not take into account flooding that occurs from overflowing watercourses, drainage systems or public sewers, nor the construction or threshold of individual properties, only flooding caused by direct rainfall runoff.

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.

Figure 3.1 below is an extract of the Environment Agency's 'Risk of Flooding from Surface Water' map and identifies the location of the site. This map has been interrogated to assist in this review, helping to identify whether the site is located in an area at specific risk of surface water flooding.

Key to flood map

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

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

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

Location of development site

Figure 3.1 – Surface water flooding map showing the location of the development site (© Environment Agency)

The above mapping shows the development site is located in an area identified as having a very low risk of flooding from surface water. The surrounding highways including Riverpark Gardens and Ravensbourne Avenue are also predicted to have a low risk of flooding from this source.

From the detailed topographic survey (refer to Appendix A.1) it can be seen that land levels in Riverpark Gardens fall away from the site towards the north. Consequently, any potential floodwater following an extreme rainfall event is unlikely to pond at the site, but instead will flow away towards the low lying land at the northern end of the road. This is highlighted in the Environment Agency's mapping above. When considering the local topography and the results of the numerical modelling, it is considered that the risk of surface water flooding at the development site is *low*.

Flooding from Groundwater – Water levels below the ground rise during wet winter months, and fall again in the summer as water flows out into rivers. In very wet winters, rising water levels may lead to the flooding of normally dry land, as well as reactivating flow in 'bournes' (streams that only flow for part of the year). 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 high risk from groundwater flooding. More detailed mapping on groundwater emergence provided as part of the Defra Groundwater Flood Scoping Study (May 2004), shows the site to be located close to the boundary of an area potentially vulnerable to groundwater emergence.

The underlying bedrock geology of the site is Thanet Sands overlying Chalk, both presenting potentially permeable sources for groundwater. Land levels within the area surrounding the site fall towards the base of a shallow valley; as a result, bedrock deposits of Lambeth Clay Silt and Sand, Hardwitch Sands and London Clay can be found directly to the west of the site located stratigraphically above the Thanet Sands.

Further analysis of the Defra Groundwater Flood Scoping Study (May 2004), shows historic records of areas where groundwater flooding has occurred in the past. Analysis of these records shows that one incident of groundwater flooding was recorded approximately 900m south east of the site on bedrock deposits of Thanet sands during the very wet periods of 2000/01 or 2002/03. However there have been no historic records of groundwater flooding at the development site itself.

Analysis of the FEH catchment descriptors identifies that the base flow index (BFIHOST) for the area of the catchment that drains into the Ravensbourne River is 84%. Consequently, there is likely to be significant groundwater flow within the base of the river. Given the close proximity of the site to the river there is potential for the groundwater table to become elevated.

However, inspection of topographic data for the site shows that the western bank of the stream (i.e. the side the development site is located) is raised up to 0.9m higher than the eastern bank. Therefore, if the groundwater table were to become elevated, any out-of-channel flooding that may occur would affect the eastern side of the watercourse first, initially flooding the playing fields to the east and north of the site. Inspection of the wider topographic area reveals that there is sufficient storage within the floodplain to the east of the site to ensure that water levels would not rise above the height of the western bank.

Additionally, reference to the scheme drawings identifies that there are no proposed obstructions (i.e. a basement development) to existing groundwater flow. Taking all of the above information into account, the site specific risk of groundwater flooding is considered to be low.

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, and 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.

There are no known records of flooding from sewers in this area, and reference to the SFRA identifies that sewage flooding is not a widespread problem in Bromley. The historic records set out in the SFRA identify that the site falls within a large region where there has been only 1 property flooded by foul water from overloaded sewers in the last 10 years.

Additionally, the sloping nature of Riverpark Gardens suggests that any above ground flooding that might occur as a result of a surcharged sewer would not pond at the site, but would instead flow away towards the north. The site-specific risk of flooding from this source is therefore considered to be 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. In addition, the Environment Agency's 'Risk of Flooding from Reservoirs' website shows that the site is not within an area considered to be at risk of flooding from reservoirs.

Source of flooding	Initial Level of risk	Appraisal method applied at the initial flood risk assessment stage
Rivers (fluvial)	Low *	Environment Agency flood zone maps
Rivers (tidal)	Low	Environment Agency flood zone maps
Sea/Estuaries	Low	Environment Agency flood zone maps
Ordinary and man-made watercourses	Low	Site based appraisal and historical evidence
Overland flow	Low	Environment Agency surface water flood maps and site based appraisal
Groundwater	Low	BGS groundwater flood hazard maps, Defra Groundwater Flood Scoping Study and site specific geological data
Sewers	Low	Site based appraisal
Artificial sources	Low	Site based appraisal and Environment Agency 'Risk of Flooding from Reservoirs' flood maps

*Table 3.1 – Summary of flood sources and risks (***** denotes the principal flood risks to the site)*

3.3 Existing Flood Risk Management Measures

The flood defences in this area of the Ravensbourne River comprise of bank protection between the footbridge in Beckenham Place Park and Farnaby Road. The bank protection is maintained by the Local Authority and provides the development site with a 1 in 70 year standard of protection. The current condition grade for defences in the area is 3 (Fair), on a scale of 1 (very good) to 5 (very poor).

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.

4.1 Potential Changes in Climate

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 National 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	2025 to 2055	2055 to 2085	2085 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 from the NPPF

The development site is not subject to coastal flooding and therefore these figures are included for background information purposes only.

The National Planning Practice Guidance Suite to the NPPF also provides guidance on sensitivity allowances for other climatic changes such as increased rainfall intensity and peak river flows. These are shown in Table 4.2 below and where appropriate have been applied as part of this appraisal.

Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%		+20%	
Offshore wind speed		+5%		+10%
Extreme wave height		+5%		+10%

Table 4.2 - Recommended national precautionary sensitivity ranges from the NPPF

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. For residential development this is taken as 100 years and for commercial development a 60 year design life is assumed. The development that is the subject of this FRA is classified as residential.

4.2 Impacts of Climate Change on the Development Site

The flood levels provided by the Environment Agency as part of the FRA process are based on the modelling of extreme rainfall events and the flow in watercourses generated by such events. The rainfall data used in this analysis is based on current climatic conditions; however, the hydraulic models were also used to calculate the impact of climate change using an increase in flood flows of 20%. The impact of this increase in flow is quantified in Section 5.1.

In addition to the impact on fluvial 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.

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.

Information that has been provided by the Environment Agency for this FRA contains water levels for a range of return period events. These are shown in Table 5.1 below for 11 nodes within and surrounding the development site. A map showing the location of the points from which the data in Table 5.1 is taken is shown in Figure 5.1 below.

Node ID	Modelled Defended Water Levels (m AODN)		
	1% AEP	1% AEP +cc	0.1% AEP
1	No Flood	No Flood	No Flood
2	No Flood	No Flood	No Flood
3	No Flood	No Flood	No Flood
4	No Flood	No Flood	31.76
5	No Flood	No Flood	No Flood
6	No Flood	No Flood	31.55
7	No Flood	31.61	32.02
8	No Flood	31.34	31.83
9	30.81	31.83	31.87
10	30.57	30.78	31.78
11	31.68	32.11	32.13

Table 5.1 – Modelled flood levels provided by the Environment Agency

Inspection of the flood level information provided by the Environment Agency (summarised in Table 5.1 above and Figure 5.1 below) reveals that the site is located outside of the modelled flood extents for the design flood event (i.e. the 1 in 100 year plus climate change event).

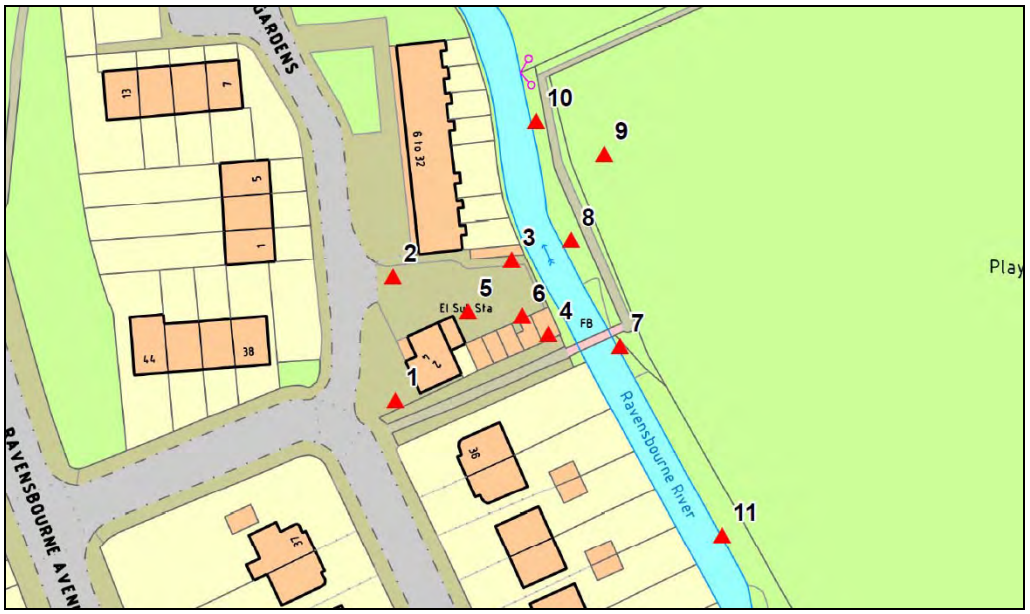


Figure 5.1 – Modelled node location map, site outlined in blue.

5.2 The Extent of Flooding

The predicted extents of flooding under the design event conditions have also been provided by the Environment Agency as part of their response and are shown in Figure 5.2. This mapping confirms that the development site is located beyond the predicted 1 in 100 year design flood extents (light green).

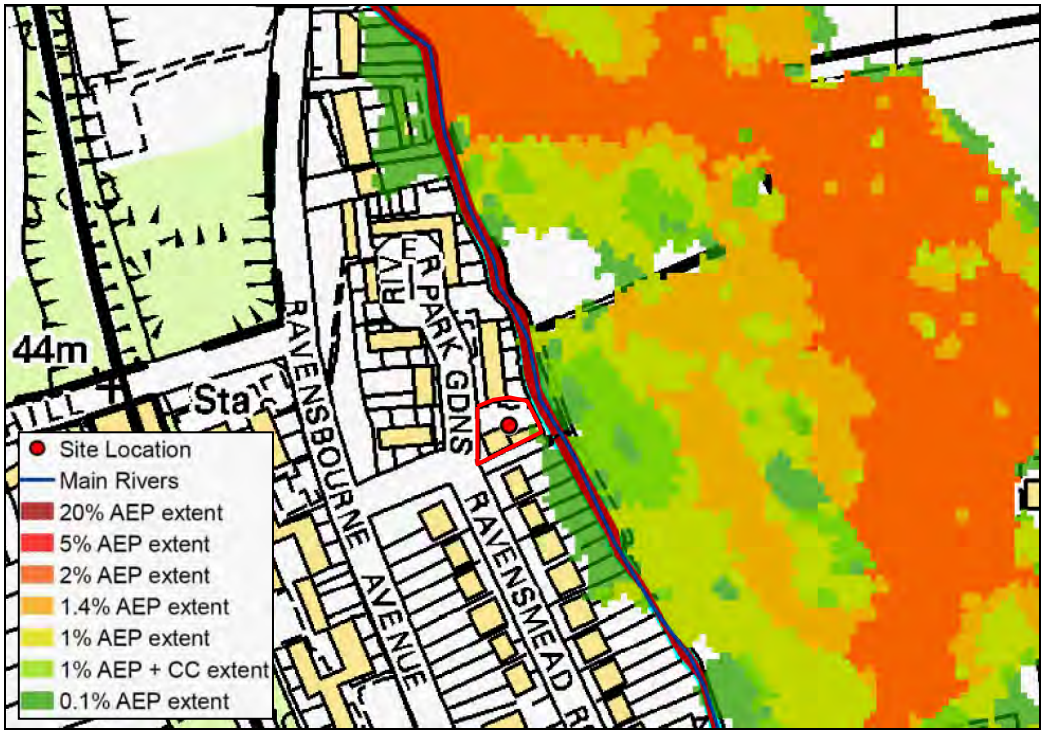


Figure 5.2 – Plotted extents of flooding under a number of return period events (provided by the Environment Agency). Development site outlined in red.

From the above mapping it can be seen that under the 1 in 1000 year (0.1% AEP) extreme event floodwater is predicted to encroach upon the south-eastern corner of the site. However, when the predicted 0.1% flood level (31.76m AODN at Floodplain Node 4) is compared to measured land levels in this part of the site (>31.86m AODN), it can be seen that even under this exceedance event floodwater is unlikely to reach the site.

5.3 Depth and Velocity of Flooding

Inspection of the Environment Agency's model results identify that the development site is located outside the predicted extents of flooding under the design flood event. Consequently the depth of floodwater at the site is zero, even when an allowance for climate change impacts is made.

Flow velocities (at the point of the nearest floodwater) are estimated to be less than 0.5m/sec.

5.4 Rate of Rise of Floodwater

The site has been shown to be located outside of the maximum extents of the design flood event and therefore the rate of rise and speed of flooding is not of direct concern.

6 Flood Mitigation Measures

The key objectives of flood risk mitigation are:

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

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	✓	See Section 6.1
Raising floor levels	✓	See Section 6.2
Land raising	X	Not required
Flood Warning	✓	See Section 9.3
Flood resistance & resilience	✓	See Section 9.1
Alterations/ improvements to channels and hydraulic structures	X	Not required
Flood defences	X	Not required
Compensatory floodplain storage	X	Not required
Management of development runoff	✓	See Section 7.1

Table 6.1 - Appropriateness of mitigation measures

6.1 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.

The development site has been shown to be located outside of any areas at significant risk of flooding and therefore there is little merit in applying this approach in this instance.

6.2 Raising Floor Levels & Land Raising

The Environment Agency 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 100 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.

In this instance the site and proposed dwellings have been shown to be located outside of the predicted flood extents and not to be at significant risk from other sources of flooding. Consequently, floor raising and land raising are not considered to be a necessary form of mitigation at this site when considering fluvial flooding alone.

Notwithstanding this, it is recommended that the finished floor levels of the building be raised a minimum of 150mm above the ground level to provide mitigation against any localised surface water flooding, and to help prevent the ingress of floodwater into properties during shallow flooding events. It is understood that ramped access will be provided to the entrance of the building to ensure at least a 150mm freeboard between the finished floor levels and external ground levels can be achieved.

7 Surface Water Management Strategy

7.1 Surface Water Management Overview

The requirements for managing rainfall runoff from developments depends on the pre-developed nature of the site. If it is an undeveloped greenfield site then the impact of the development will need to be mitigated so that the runoff 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 to provide runoff 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 7.1 below.

Site Characteristic	Value
Total area of site	0.07 ha
Impermeable area (existing)	0.07 ha
Impermeable area (proposed)	Roof area = 0.024 ha Car parking and hardstanding = 0.033 ha Sub-station = 0.002 ha (to be relocated) Total = 0.059 ha
Current site condition	Brownfield site
Greenfield runoff rate	4.2 l/sec/ha (based on IoH Report 124 methodology)
Infiltration coefficient	10-0.01 m/hr (assumed based on typical soil conditions)
Standard Percentage Runoff (SPR)	15.6%
Current surface water discharge method	Assumed to discharge to public sewer and Ravensbourne River
Is there a watercourse within close proximity to site?	Yes
Is site within groundwater source protection zone?	Yes (Zone 2)

Table 7.1 – Site characteristics affecting rainfall runoff

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. Runoff rates have been calculated for a range of annual return probabilities including the 100 year return period event with a 30% increase in rainfall intensity to account for future climatic changes.

These values are summarised in Table 7.2 for a range of return periods. The critical storm duration is shown in brackets.

Return period (years)	Peak runoff (l/sec)	
	Existing site	Developed site
1	10.9 (15min)	9.1 (15min)
30	26.4 (15min)	22.3 (15min)
100	34.4 (15min)	28.9 (15min)
100 + 30%	44.6 (15min)	37.4 (15min)

Table 7.2 – Summary of peak runoff

The total volume of water discharged from the site from the 100 year 6 hour event (including for a 30% increase for climate change) is summarised in Table 7.3 below for both the existing and proposed site conditions.

Site condition	Total volume discharged
Existing site	56m^3
Proposed development (before mitigation)	47m^3

Table 7.3 – Total volume discharged from the 100 yr+30%cc 6 hour event

The general surface water management requirements for all new development are to ensure that the peak discharge rate and the discharge volume of surface water runoff does not exceed that of the existing site. Additionally, flood flows up to the 1% AEP 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 runoff management for developments - EA/DEFRA W5-074/A).

Developers in London should be encouraged to reduce runoff rates from previously developed sites as far as possible and supplementary planning guidance of the London Plan outlines the Mayors “essential” and “preferred standards” to include the importance of the use of SUDS wherever practical and the need to achieve:

“at least 50% attenuation of the undeveloped site’s surface water runoff at peak times” (essential standard)

“100% attenuation of the undeveloped sites surface water runoff as peak times” (preferred standard)

Areas located within the critical drainage areas should apply the preferred standard.

Inspection of the scheme drawings reveals that the proposed development will decrease the percentage of impermeable area within the boundaries of the site. This is reflected in Tables 7.2 and 7.3 above, which show that the peak discharge rate and discharge volume will not be increased by the proposed development. Consequently, it will not be necessary to seek to include mitigation measures within the scheme design to reduce this impact.

Notwithstanding this, the potential to use sustainable drainage techniques within the proposed development will still be considered in order to assess the practicality of better replicating Greenfield behaviour (in line with the preferred standards of the London Plan).

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 proposed method of surface water discharge and the associated constraints is described below.

7.2 Existing Drainage

The existing site is served by a public sewer which is believed to discharge directly from the site to the Ravensbourne River (although this has not been confirmed).

7.3 Opportunities

In order to discharge surface water from the site there are a number of options to consider. These are discussed below:

Infiltration – When designing soakaways, or other infiltration systems, it is necessary to take a number of other factors into consideration. These are listed below:

- Soakaways shall not be constructed through contaminated material.
- The depth of any soakaway should normally not exceed 2.0 metres and under no circumstances shall be permitted to intersect the water table.
- A minimum of a 1.0 metre unsaturated zone shall be maintained between the base of any soakaway and the maximum seasonal water table for that site.
- Soakaways within an Inner Source Protection Zone for a Public Water Supply shall only be permitted for the sole use of clean roof water drainage.
- Soakaways intended to drain highway or parking areas will usually require additional safeguards such as seal-trapped gullies or a suitably sized oil/grit separator.
- Soakaways designed to receive clean roof water should be kept separate from those receiving surface water runoff from highway or parking areas.

- The use of borehole soakaways will only be acceptable subject to written agreement from the Agency.

If soakaways are used to discharge surface water from the site it will be necessary to demonstrate that the design rainfall event (1% AEP plus climate change) can be managed on site. It may not, however, be practical to design the soakaways to accommodate the design event, in which case the surface water management scheme that is adopted will need to ensure that if the capacity of the infiltration system is exceeded, then the impact of any overland flow will need to be considered. Ideally these flows should be contained within the site at designated temporary storage locations. If this is not possible it will be necessary to demonstrate that flooding within the site or any floodwater leaving the site can be shown to have no material impact in terms of nuisance or damage, or increase river flows during periods of river flooding.

Groundwater levels onsite have not been quantified at this early planning stage; however, given the sites proximity to the Ravensbourne River it is apparent that groundwater levels at the site could be elevated. Analysis of BGS borehole records reveals that groundwater levels on the lower land to the east of the subject site (approximately 80m from the site) are around 2m below ground level. Another borehole located 150m north of the site recorded groundwater at 3m below the level of the site.

Taking the above into consideration and the potential for high groundwater at the site, it is recommended that more detailed investigation be undertaken before adopting traditional soakaway techniques.

This location is shown by the Environment Agency's groundwater source protection zone maps to be an area where infiltration is restricted. Whilst this does not preclude the use of infiltration, in order for water to be discharged to the ground, it must be demonstrated that an unsaturated zone will be available between the discharge point and the groundwater table at all times of the year. If this is not possible then infiltration will not be appropriate.

Inspection of the site topography, soil and geology information shows that it is unlikely that the above conditions will be satisfied, and therefore a direct discharge to groundwater may result. This would not be acceptable and therefore discharge of surface water via traditional soakaways is unlikely to be appropriate on this site. Notwithstanding this, the potentially good soakage rate at the site does identify that shallow infiltration techniques such as permeable paving may still be available for hardstanding areas.

Discharge to Watercourses – Given the proximity of the site to the Ravensbourne River, it is likely that a direct connection to the watercourse will be the most appropriate method of discharging surface water. The proposals have been shown to provide a decrease to the volume of surface water runoff from the site, and therefore measures to attenuate and restrict flows from the development are unlikely to be required. Nevertheless, there is potential onsite to incorporate SuDS features in order to better replicate the Greenfield conditions.

Discharge to Public Surface Water Sewer & Existing Connections – The topographic survey of the site identifies the location of existing surface water and foul sewers at the site. Discharge from the surface water sewer at this location is believed to be directly into the Ravensbourne River, and includes runoff from some neighbouring properties.

Therefore, it is probable that the proposed development will discharge via the existing surface water sewer connection into the river. However, because the proposals do not result in an increase in either the peak rate or runoff or the total volume of surface water discharge from the site, this is likely to be acceptable to both the sewerage undertaker and the Environment Agency.

7.4 Constraints

Although there is likely to be a reasonable degree of infiltration at the, infiltration testing is likely to be required at the detailed design stage in order to refine the outline designs put forward as part of this SWMS.

In addition, given the close proximity of the site to the Ravensbourne River it is likely that high groundwater could prohibit the effective use of infiltration. Consequently, it is recommended that site investigations are undertaken at the detailed design phase in order to confirm the depth below the ground level of the groundwater table.

Inspection of the site and scheme layout shows that whilst there are opportunities for the inclusion of sustainable drainage techniques, 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.

7.5 Sustainable Drainage Systems (SuDS)

Appropriately designed Sustainable Drainage Systems (SuDS) can be utilised such that they not only attenuate flows 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.

Policy 4C.8 of the London Plan highlights the importance of using SuDS in new developments wherever possible:

> *"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 runoff 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 7.4 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	✓	✓	Potential for relatively high groundwater due to proximity to river	?
Underground storage	X	X	✓	X	✓	Consider high groundwater due to proximity to river	?
Swales	✓	✓	✓	✓	X	Insufficient space	No
Filter strips	✓	✓	✓	✓	X	Insufficient space	No
Rainwater harvesting	X	✓	✓	✓	✓	None	Yes
Permeable paving	X	✓	✓	✓	✓	None	Yes
Green roofs	✓	✓	✓	X	✓	Dependent on proposed roof construction	?

Table 7.4 – Suitability of SuDS

Part H of the Building Regulations recommends that wherever practicable, appropriate SuDS elements should be incorporated into the drainage system. From Table 7.4 it can be seen that there are a number of SuDs elements that are potentially suitable for this site, however, further site investigations may be required at the detailed design stage to confirm which are the most appropriate for incorporation into the scheme.

One option worth investigating could be to incorporate rainwater harvesting into the scheme. This will not only reduce the amount of water discharged into the Ravensbourne River but will also help to reduce the burden on the already stretched potable water supplies.

8 Offsite Impacts

8.1 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 adjacent to the Ravensbourne River, however inspection of the scheme drawings identifies that all buildings and permanent structures are to be located at least 8m from the top of the bank of the watercourse. Consequently, the proposed development will not compromise any of the Environment Agency's maintenance or access requirements.

8.2 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 affect 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.

The proposed development is, however, located outside of the 1 in 100 year fluvial floodplain and consequently will not have an adverse impact on flood risk as a result of displaced floodwater.

8.3 Impact on Fluvial Morphology & Impedance of Flood Flows

The development site is not within the functional floodplain. Furthermore, as a result of the recommended surface water management measures, the peak hydraulic loading on the receiving watercourse will not be increased. As such it is considered that the development will not affect the morphology of the river.

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. The site has, however, been shown to be located entirely outside of the predicted flood extents and therefore development in this area does not have the potential to impede or change flood flow regimes.

9 Residual Risk

When considering residual risk it is necessary to make predictions as to the impacts of a flood event that exceeds the design event, or in the case of areas that are already defended to an adequate standard, the impact of a failure of these defences.

The mitigation measures discussed within this report will significantly reduce the risk of the development being affected by flooding; however, they do not completely remove the risk. This section of the report is therefore associated with the way the residual risk is managed and the safety of the occupants of the proposed development.

9.1 Flood Resistance and Resilience

It is has been shown that the proposed development will have ground floor levels that are raised well above the 1 in 100 year (plus climate change) flood level. However there is always the risk that this event could be exceeded, in which case, 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.

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. 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.

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.

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

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.

9.2 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 located outside of the predicted design flood extents and consequently safe access and escape from the dwellings can be achieved.

The road leading to the site is also above the design flood level and inspection of the wider flood mapping shows that there would be safe dry vehicular access to the site under an extreme flood event.

9.3 Flood Warning

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 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.

The site is located within the flood warning area referred to as 'Ravensbourne at Bromley'. For further details call Floodline on 0845 988 1188, select Option 1 and enter the Quickdial number 173901.

10 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 at Riverpark Gardens are sustainable in terms of flood risk and compliant with the NPPF and its Planning Practice Guidance, all of the above have been taken into consideration as part of this FRA.

From Table 2.2 it can be seen that the proposed development is situated within a Zone 2 flood risk area and is a development type that is classified as being ‘more vulnerable’. For such a combination of risk and vulnerability, the NPPF does not require the Exception Test to be applied; however, it is necessary to examine the impact of all sources of flood risk on the development, which has been the focus of this site-specific FRA.

The risk of flooding has therefore been considered across a wide range of sources and it is only the risk of fluvial flooding that has been shown to have any bearing on the development. However, when this risk is examined in detail, it has been shown that the development is not likely to be affected by the 1 in 100 year flood and will remain outside of this floodplain throughout the anticipated lifetime of the development, which has been conservatively estimated at 100 years.

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 runoff.

It is also necessary for the planning authority to demonstrate that the development can pass the Sequential Test. As discussed in Section 2.3, without having comprehensive knowledge of the land that is available for development in the district it is not possible for this FRA to comment in detail on the test.

However, from the evidence that has been put forward in this FRA it is clear that the site is located within a lower flood risk zone (Zone 2), and furthermore the detailed evidence shows that the risk of flooding is significantly less than is depicted by the Environment Agency's flood zone map. Consequently, this should be borne in mind when comparing this site with others that are within the same flood risk zone.

10.1 Recommendations

The findings of this report are such that it is recommended that the development is suitable for its location within the flood risk area. There are, however, a number of mitigation measures and considerations that are required to reduce the risk to the development and other areas within the floodplain.

- 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 7.1.

- The use of appropriate SuDS techniques as discussed in Section 7.5 should be considered for incorporation into the scheme design.

- If additional surface water is to be discharged into the Ravensbourne River then consent may be required from the Environment Agency.

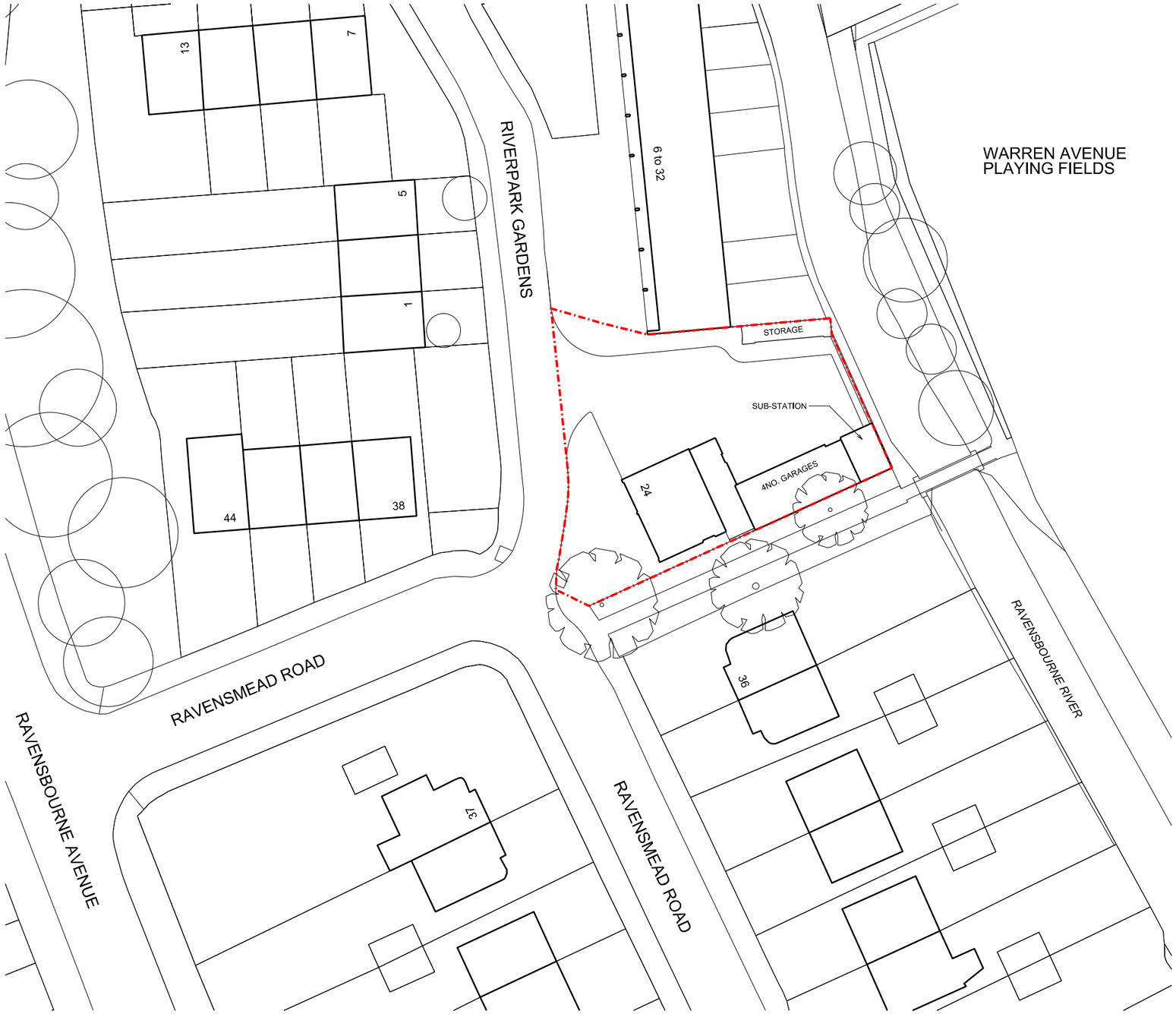
With the above mitigation measures incorporated into the design of the development the proposals will meet the requirements of the NPPF and its Planning Practice Guidance and will therefore be acceptable and sustainable in terms of flood risk.

A Appendices

A.1 Appendix A.1 – Drawings

A.2 Appendix A.2 – Environment Agency Flood Report

Appendix A.1 – Drawings



Status

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KEY:

Site Boundary

No.	Revisions	Date

N

0 2.5m 12.5m

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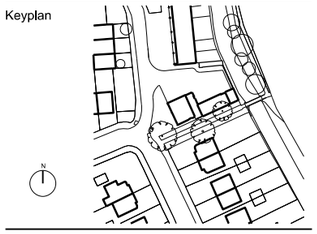
Keyplan



Title
EXISTING SITE PLAN

Job	Drawing No.		Rev.
0354	SK 001		-
Drawn	Scales at A1	Scales at A3	Date
JC	1:250	1:500	08/14

Status

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EDI Topographical survey notes and key (for further details refer to full EDI topographical survey drawings)

NOTES:–
The accuracy and content of this drawing are dependent on the original specification and EDI should be consulted before use at other scales.

Where underground services are shown, all reasonable care has been taken within the spirit of the original specification and requirement. Before use of this information the user should consult EDI and satisfy themselves of the completeness and accuracy of such detail before undertaking any works. Due to the nature of this work and limitations imposed by ground conditions and the detection equipment no guarantee can be given that all services have been recorded. Trial holes should be dug at critical locations.

All reasonable care has been taken in the survey detail represented on this drawing but any discrepancies must be reported to EDI immediately.

Our aim is to produce the best possible results within the specification and cost constraints of our clients. Any comments are most welcome.

Levels shown at kerbs are channel level unless stated.

LEGEND%%U

Features:%%U
AV Air Valve
AB Air Brick
BD Bollard
BH Borehole
BM Benchmark
BP Boundary Post
BS Bus Stop
BT British Telecom
CL Cover Level
COL Column
CTV Cable TV Cover
DCH Drainage Channel
DF Drinking Fountain
DIS Disused
DK Drop Kerb
DPC Damp proof Course
EIC Electricity IC
EJ Expansion Joint
ER Earth Rod
FH Fire Hydrant
FHR Fire Hose Reel
FS Flagstaff
G Gas
GV Gas Valve
IC Inspection Cover
IL Invert Level
JBX Junction Box
KO Kerb Outlet
LB Letter Box
LBN Litter Bin
LLP Low Level LP
LP Lamp Post
MP Marker Post
MS Mile Stone
MT Mercury Telecom
OHL Overhead Line
OP Overflow Pipe
PM Parking Meter
PP Power Pole
RAD Radiator
RE Rodding Eye
RNP Road Name Plate
RS Road Sign
RSD Roller Shutter Door
RWP Rain Water Pipe
SD Service Duct
SV Stop Valve
TCB Telephone Call Box
TP Telegraph Pole
TS Traffic Signal
UB Universal Beam
UNK Unknown
UR Urinal
UTL Unable to lift
V Vent
VP Vent Pipe
WM Water Meter
WO Wash Out
WP Waste Pipe

Building Level Details:
D Door
EL Eave Level
FFL Floor Level
FRL Flat Roof Level
HL Head Level
PPL Parapet Level
RL Ridge Level
SL Sill Level
SP Springer of Arch
TA Top of Arch
W Window
CL Ceiling/Beam Soffit

Boundary Types:%%U
BW Barbed Wire
CB Close Boarded
CH Chainlink
CI Corrugated Iron
CP Chestnut Paling
IR Iron Railing
IW Interwoven
LL Larch Lap
PAL Palisade
PR Post & Rail
PW Post & Wire
TNR Timber Knee Rail
RTW Retaining Wall
VSF Vehicle Safety Fence
WMF Wire Mesh Fence

Surfaces & Finishes:
B Brickwork
BB Breeze Block
C Concrete
CLT Ceiling Tiles
CO Cobbles
CPS Concrete Paving Slabs
CPT Carpet Tiles
CR Concrete Render
CT Ceramic Tiles
FT Floor Tiles
HBD Hardboard
L Linoleum
P Plaster
PAV Brick Paviors
S Steel work
T Tarmac
TSP Textured Safety Paving
VT Vinyl Tiles

Services:
CATV cables
CCTV cables
Data cables
Electric cables
Foul water
Gas pipes
Heating duct
Service ducts
Storm water
Telecom cab.
Unidentified
Water pipes
Pipe Diameter/Flow
Overhead Lines

Survey Station
Fence
Gate
Painted Road Markings
Edge of Vegetation
Kerb/Drop Kerb
Tree
Top
Bottom
Banks
Building
Overhead Building Detail
Wall

Control: All levels and co-ordinates are related to the datums described.
The horizontal control of this survey is based on Ordnance Survey grid as translated from GPS coordinates using Leica's SmartNet service. We have applied a reverse scale factor to maintain true ground distances, based on station ST3. The vertical control of this survey is based on OS datum as translated from GPS coordinates using the OSGM02 transformation as supplied by the OS. This may differ from the existing OS benchmarks in the area which should be disregarded; all levels should be taken from EDI survey stations.

No.	Revisions	Date

N

0 1m 5m

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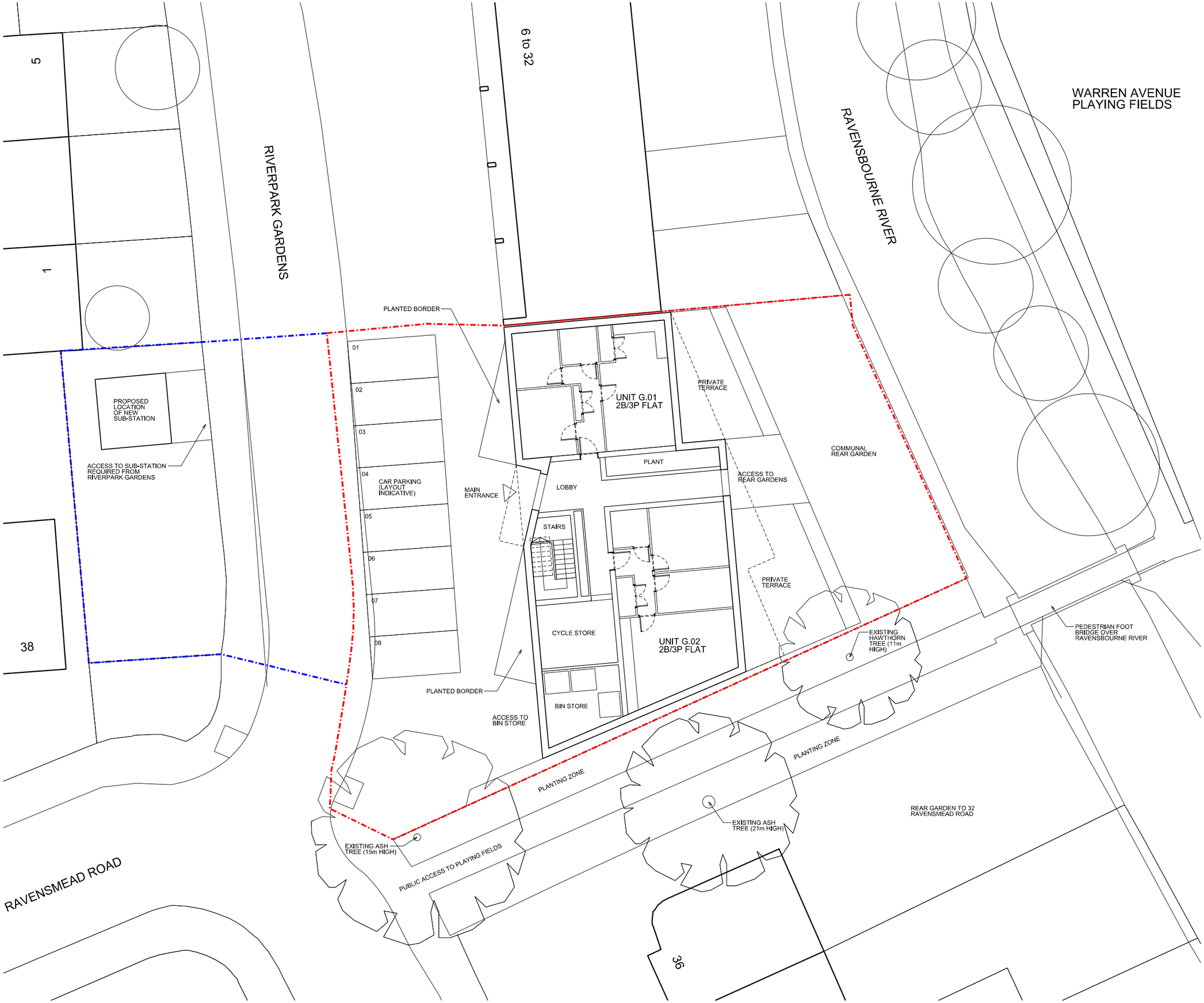
Keyplan

Title
TOPOGRAPHIC SURVEY

Job	Drawing No.		Rev.
0354	SK 002		-
Drawn	Scales at A1	Scales at A3	Date
JC	1:100	1:50	08/14



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KEY:

SITE BOUNDARY

EXTENT OF WORKS

No.	Revisions	Date

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0 1m 5m

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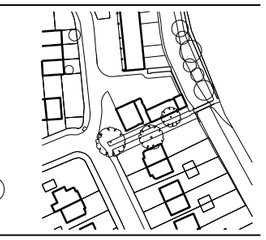
BROMLEY, BR2 0BQ

Keyplan



Title PROPOSED SITE PLAN

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Drawn	Scales at A1	Scales at A3	Date
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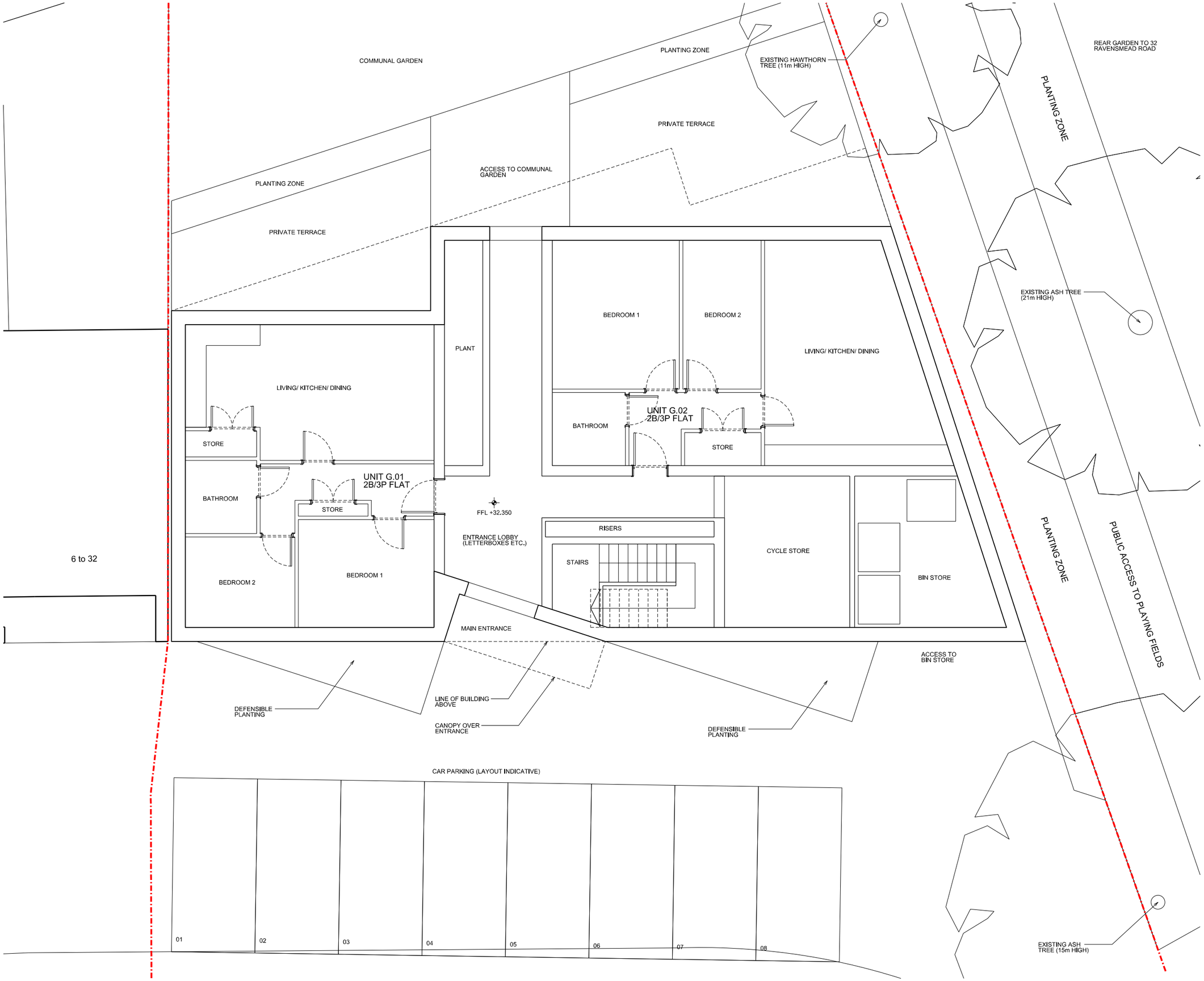

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No.	Revisions	Date

N

0 0.5m 2.5m

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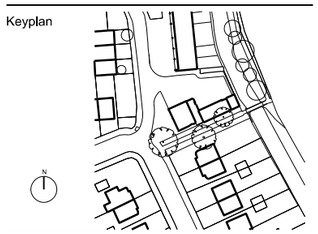
BROMLEY, BR2 0BQ

Keyplan



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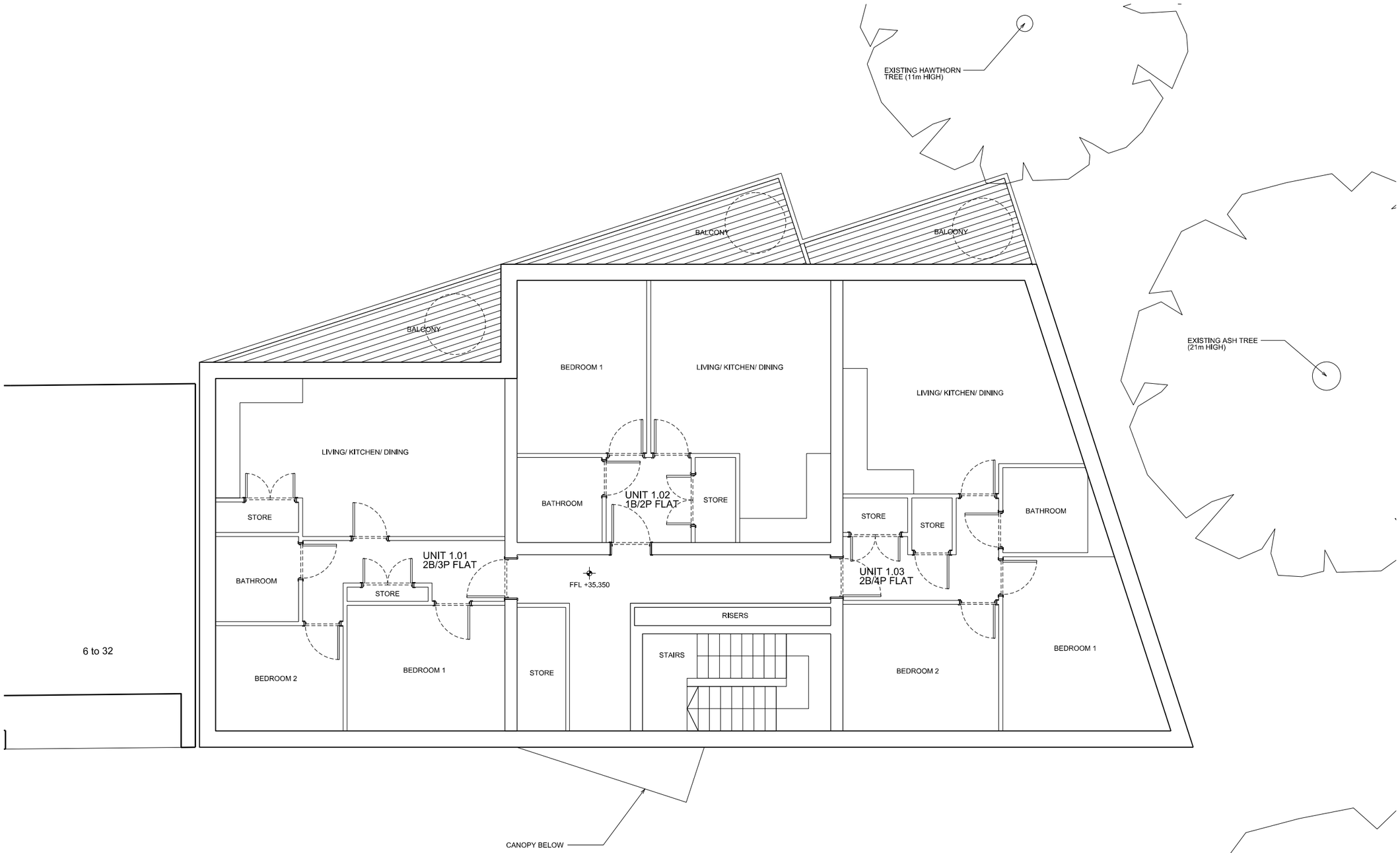

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No.	Revisions	Date

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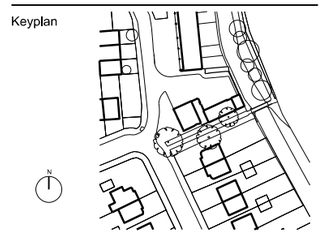

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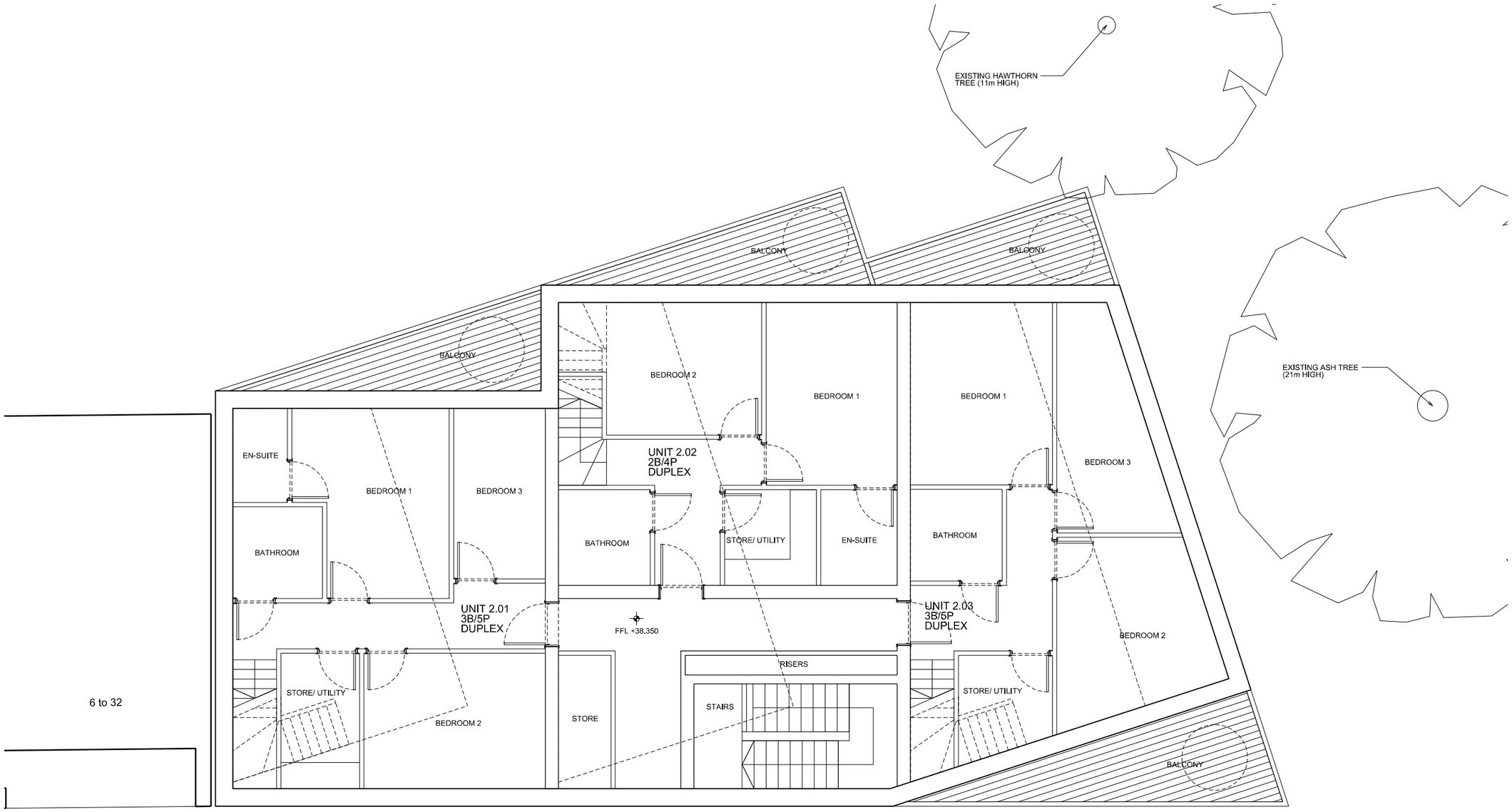

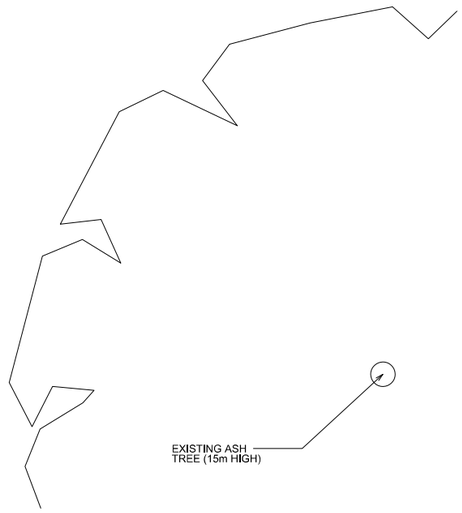

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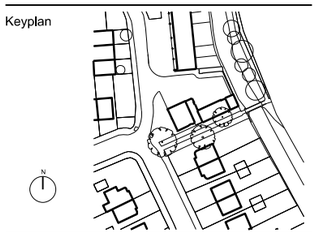

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PROPOSED SECOND FLOOR PLAN

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Drawn	Scales at A1	Scales at A3	Date
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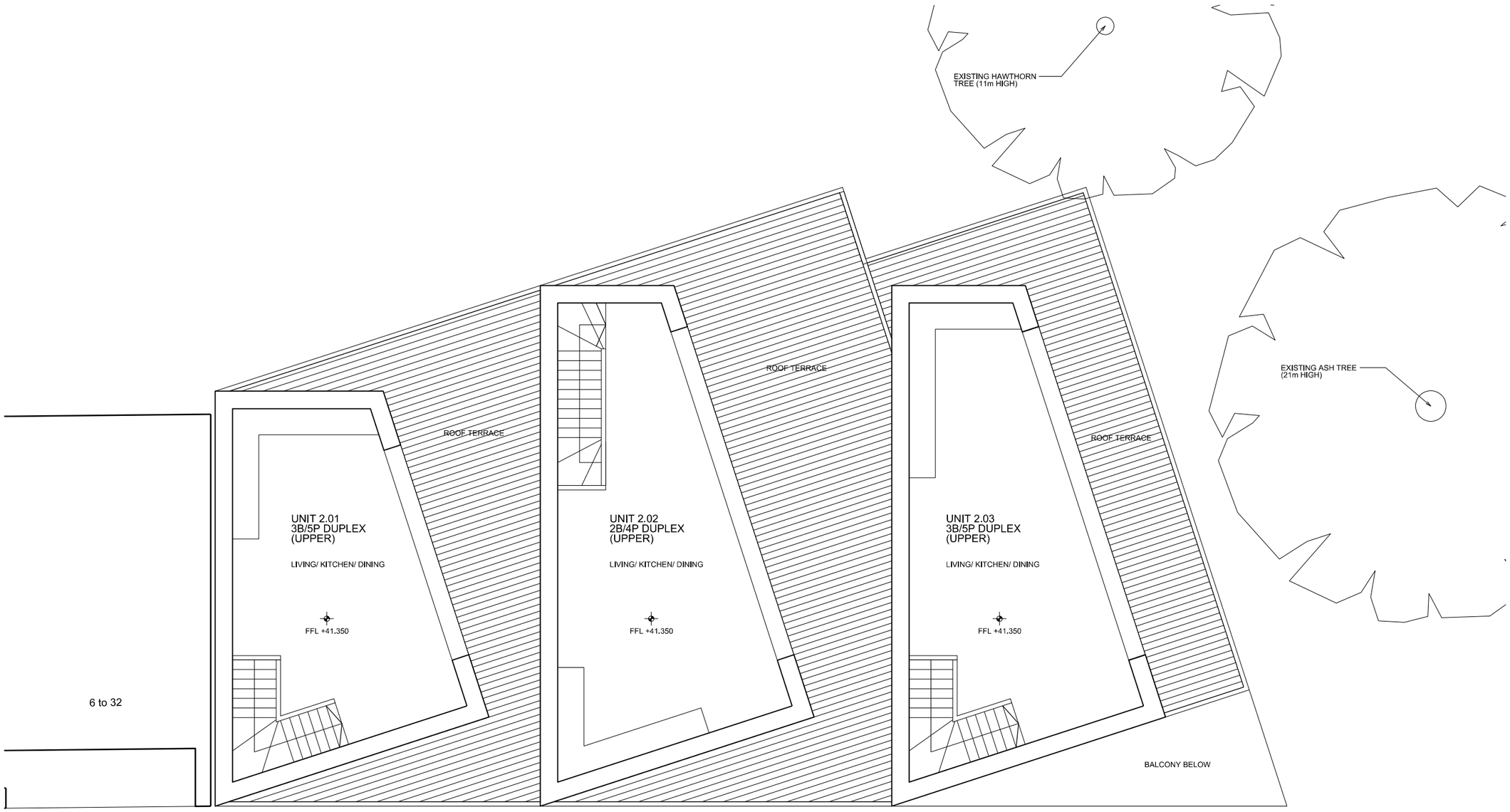

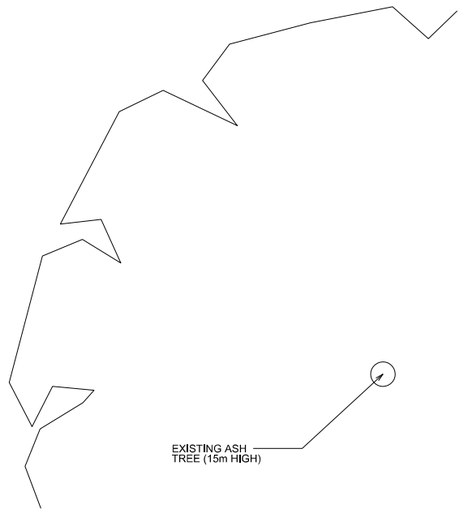

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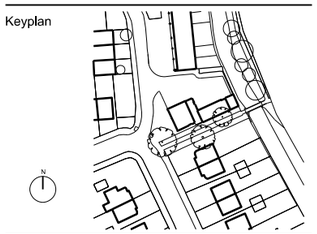

Title PROPOSED THIRD FLOOR PLAN

Job	Drawing No.		Rev.
0354	SK 007		-
Drawn	Scales at A1	Scales at A3	Date
JC	1:50	1:25	08/14

Appendix A.2 – Environment Agency Flood Report

Product 4 (Detailed Flood Risk) for: Land adjacent to Riverpark Gardens, Bromley, BR2 0BQ
Requested by: Stephen Hayward, Herrington Consulting Ltd
Reference: KSL140722JB178
Date: 24 July 2014

Contents

The information provided is based on the best data available as of the date of this letter.

You may feel it is appropriate to contact our office at regular intervals, to check whether any amendments/ improvements have been made to the data for this location. Should you re-contact us after a period of time, please quote the above reference in order to help us deal with your query.

This information is provided subject to the enclosed notice which you should read.

Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH.
Email: kslenquiries@environment-agency.gov.uk

Flood Map Confirmation

The Flood Map:

Our Flood Map shows the natural floodplain for areas at risk from river and tidal flooding. The floodplain is specifically mapped ignoring the presence and effect of defences. Although flood defences reduce the risk of flooding they cannot completely remove that risk as they may be over topped or breached during a flood event.

The Flood Map indicates areas with a 1% (0.5% in tidal areas), Annual Exceedance Probability (AEP) - the probability of a flood of a particular magnitude, or greater, occurring in any given year, and a 0.1% AEP of flooding from rivers and/or the sea in any given year. In addition, the map also shows the location of some flood defences and the areas that benefit from them.

The Flood Map is intended to act as a guide to indicate the potential risk of flooding. When producing it we use the best data available to us at the time and also take into account historic flooding and local knowledge. The Flood Map is updated on a quarterly basis to account for any amendments required. These amendments are then displayed on the internet at https://www.gov.uk/government/organisations/environment-agency.

At this Site:

The Flood Map shows that this site lies within the outline of Flood Zone 2. This zone comprises land assessed as having between a 1 in 100 (1%) and 1 in 1000 (0.1%) annual probability of fluvial flooding.

Enclosed is an extract of our Flood Map which shows this information for your area.

Method of production

The Flood Map at this location has been derived using detailed modelling of the River Ravensbourne completed in 2010 by Halcrow Group Ltd.

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Model Output Data

You have requested flood levels for various return periods at this location.

The modelled flood levels for the closest most appropriate model grid cells, any additional information you may need to know about the modelling from which they are derived and/or any specific use or health warning for their use are set out below.

Using a 2D TuFLOW model the floodplain has been represented as a grid. The flood water levels have been calculated for each grid cell.

A map showing the location of the points from which the data is taken is enclosed. Please note you should read the notice enclosed for your specific use rights.

Table 1: Modelled **defended** levels in metres above Ordnance Datum Newlyn (m AODN), for various Annual Exceedance Probabilities (AEP).

Node	Easting	Northing	20% AEP	5% AEP	2% AEP	1.4% AEP	1% AEP	1% AEP + CC	0.1% AEP
1	538810	170228	No flood	No flood	No flood	No flood	No flood	No flood	No flood
2	538809	170250	No flood	No flood	No flood	No flood	No flood	No flood	No flood
3	538830	170253	No flood	No flood	No flood	No flood	No flood	No flood	No flood
4	538837	170240	No flood	No flood	No flood	No flood	No flood	No flood	31.76
5	538823	170244	No flood	No flood	No flood	No flood	No flood	No flood	No flood
6	538832	170243	No flood	No flood	No flood	No flood	No flood	No flood	31.55
7	538849	170238	No flood	No flood	No flood	No flood	No flood	31.61	32.02
8	538841	170256	No flood	No flood	No flood	No flood	No flood	31.34	31.83
9	538847	170272	No flood	No flood	No flood	No flood	30.81	31.83	31.87
10	538835	170277	No flood	No flood	No flood	No flood	30.57	30.78	31.78
11	538867	170204	No flood	No flood	No flood	No flood	31.68	32.11	32.13

Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH.
Email: kslenquiries@environment-agency.gov.uk

Table 2: Modelled **undefended** levels in metres above Ordnance Datum Newlyn (m AODN), for various Annual Exceedance Probabilities (AEP).

Node	Easting	Northing	5% AEP	2% AEP	1.4% AEP	1% AEP	0.1% AEP
1	538810	170228	No flood	No flood	No flood	No flood	No flood
2	538809	170250	No flood	No flood	No flood	No flood	No flood
3	538830	170253	No flood	No flood	No flood	No flood	No flood
4	538837	170240	No flood	No flood	No flood	No flood	31.71
5	538823	170244	No flood	No flood	No flood	No flood	No flood
6	538832	170243	No flood	No flood	No flood	No flood	31.50
7	538849	170238	No flood	No flood	No flood	No flood	No flood
8	538841	170256	No flood	No flood	No flood	No flood	No flood
9	538847	170272	No flood	No flood	No flood	No flood	31.87
10	538835	170277	No flood	No flood	No flood	No flood	31.78
11	538867	170204	No flood	No flood	No flood	No flood	No flood

Data taken from Ravensbourne Mapping Study, completed by Halcrow Group Ltd., in 2010.

Due to the extreme nature of the 0.1% AEP event and the changes as a result of removing the defences for the undefended scenario several measures were put in place to stabilise the model. The link has been severed between ISIS and TUFLOW in a handful of locations to prevent rapid changes in water levels between 1D and 2D domains.

For the 0.1% AEP some cells away from the 1D/2D boundary were also nulled due to this instability. These individual cells which did not represent the only flow route.

For the 0.1% AEP the roughness was increased by 0.1 for the Quaggy model to avoid large fluctuations in water level. This means there may be minor differences between the defended and undefended runs. However it is expected that with the defences removed the roughness of the surrounding cells might be increased by a large spill for water to get out of the channel as opposed to the thin crest posed by many flood defences.

The undefended and defended extents are shown as identical in the raw data but when transferred to GIS show subtle differences. They are different by up to 3m but do not seem to affect the ABD. This issue is being investigated further by TUFLOW.

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It has been identified that there is a culvert missing in the model underneath Beckenham High Street. JBA have been asked to re run the model with this included. This highlighted a number of other errors with the modelling. This issue is being further investigated.

It is also noted that the modelled extents have not reached the historic outline of the September 1968 event.

Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH.
Email: kslenquiries@environment-agency.gov.uk

Defence Details

Defence

Asset type – Maintained channel

Description – Bank protection

Location – Footbridge in Beckenham Place Park to Farnaby Road

Maintainer – Local authority

Standard of Protection – 1 in 70 years

Asset protection type – Fluvial

Condition – 3

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Email: kslenquiries@environment-agency.gov.uk

Historic Flood Data

We hold records of historic flood events from rivers and the sea. Information on the floods that may have affected the area local to your site is provided below and in the enclosed map (if relevant).

Flood Event Data

Dates of historic flood events in this area:

- November 1965 – The site was subject to fluvial flooding that occurred at this time.
- September 1968 – The site was subject to fluvial flooding that occurred at this time.

Due to the fact that our records are not comprehensive, we would advise that you make further enquiries locally with specific reference to flooding at this location. You should consider contacting the relevant Local Planning Authority and/or water/sewerage undertaker for the area.

We map flooding to land, not individual properties. Our historic flood event record outlines are an indication of the geographical extent of an observed flood event. Our historic flood event outlines do not give any indication of flood levels for individual properties. They also do not imply that any property within the outline has flooded internally.

Please be aware that flooding can come from different sources. Examples of these are:
- from rivers or the sea;
- surface water (i.e. rainwater flowing over or accumulating on the ground before it is able to enter rivers or the drainage system);
- overflowing or backing up of sewer or drainage systems which have been overwhelmed,
- groundwater rising up from underground aquifers

Currently the Environment Agency can only supply flood risk data relating to the chance of flooding from rivers or the sea. However you should be aware that in recent years, there has been an increase in flood damage caused by surface water flooding or drainage systems that have been overwhelmed.

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Email: kslenquiries@environment-agency.gov.uk

Additional Information

Use of Environment Agency Information for Flood Risk / Flood Consequence Assessments

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

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

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

In **England**, you should refer to the Environment Agency's Flood Risk Standing Advice, the technical guidance to the National Planning Policy Framework and the existing PPS25 Practice Guide for information about what flood risk assessment is needed for new development in the different Flood Zones. These documents can be accessed via:

https://www.gov.uk/flood-risk-standing-advice-frsa-for-local-planning-authorities
https://www.gov.uk/government/publications/national-planning-policy-framework-technical-guidance
https://www.gov.uk/government/publications/development-and-flood-risk-practice-guide-planning-policy-statement-25

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

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk / Consequence Assessment (FRA / FCA) where one is required, but does not constitute such an assessment on its own.

2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or overland runoff. The information produced by the local planning authority referred to above may assist here.

3. Where a planning application requires a FRA / FCA and this is not submitted or deficient, the Environment Agency may well raise an objection.

4. For more significant proposals in higher flood risk areas, we would be pleased to discuss details with you ahead of making any planning application, and you should also discuss the matter with your local planning authority.

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Email: kslenquiries@environment-agency.gov.uk

Surface Water

We have provided two national Surface Water maps, under our Strategic Overview for flooding, to your Lead Local Flood Authority – London Borough of Bromley – who are responsible for local flood risk (i.e. surface runoff, ground water and ordinary watercourse), which alongside their existing local information will help them in determining what best represents surface water flood risk in your area.

London Borough of Bromley have reviewed these and determined what it believes best represents surface water flood risk. You should therefore contact this authority so they can provide you with the most up to date information about surface water flood risk in your area.

You may also wish to consider contacting the appropriate relevant Local Planning Authority and/or water/sewerage undertaker for the area. They may be able to provide some knowledge on the risk of flooding from other sources. We are working with these organisations to improve knowledge and understanding of surface water flooding.

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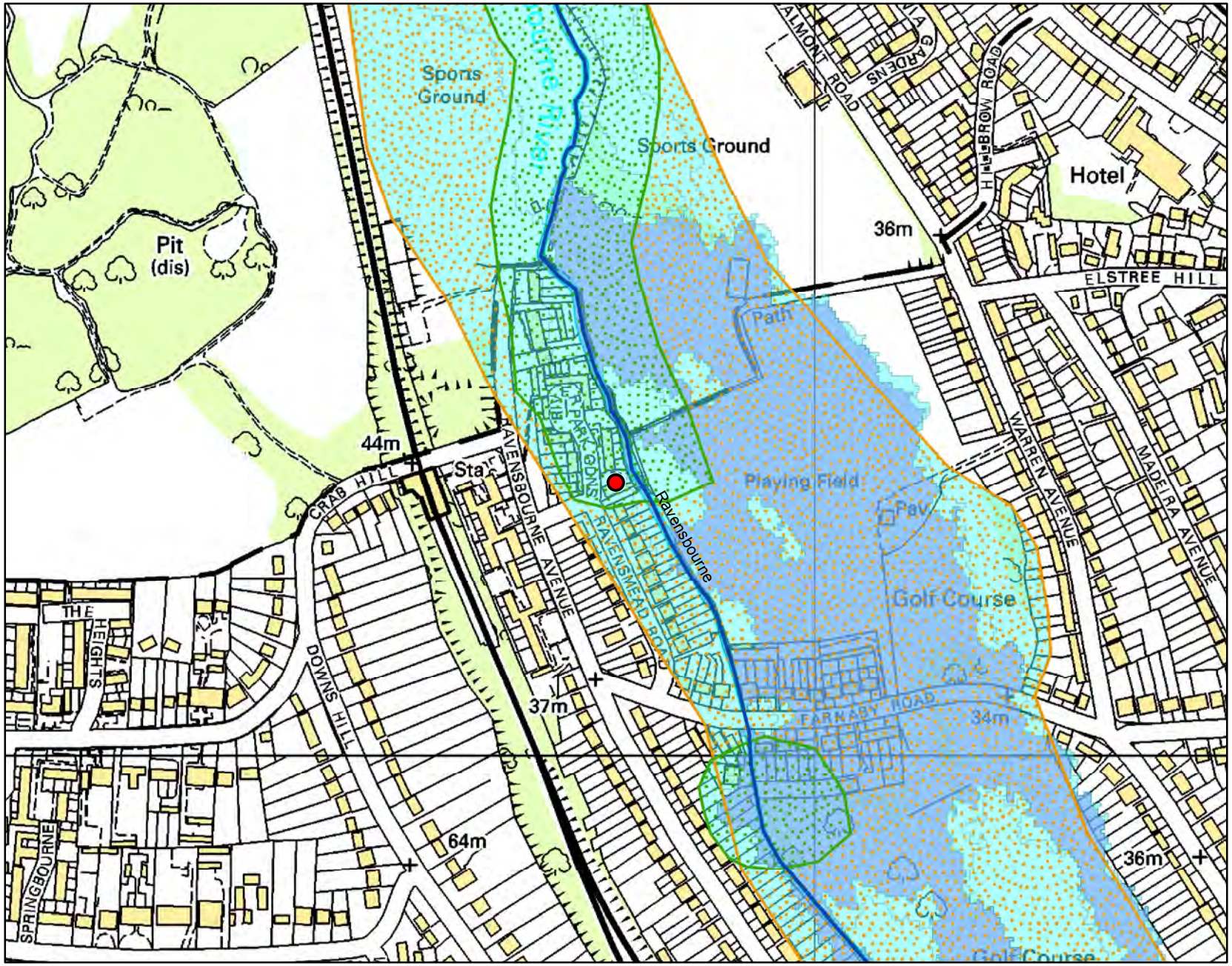
Email: kslenquiries@environment-agency.gov.uk

Flood Zone Map centred on NGR TQ3882270243 [Ref: KSL140722JB178]



Environment Agency

Scale 1: 5,000

Date of production: July 24, 2014

N W E S

LEGEND

- Site Location
- Main Rivers
- Nov 1965 Flood Outline
- Sep 1968 Flood Outline
- Flood Zone 3
- Flood Zone 2

Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

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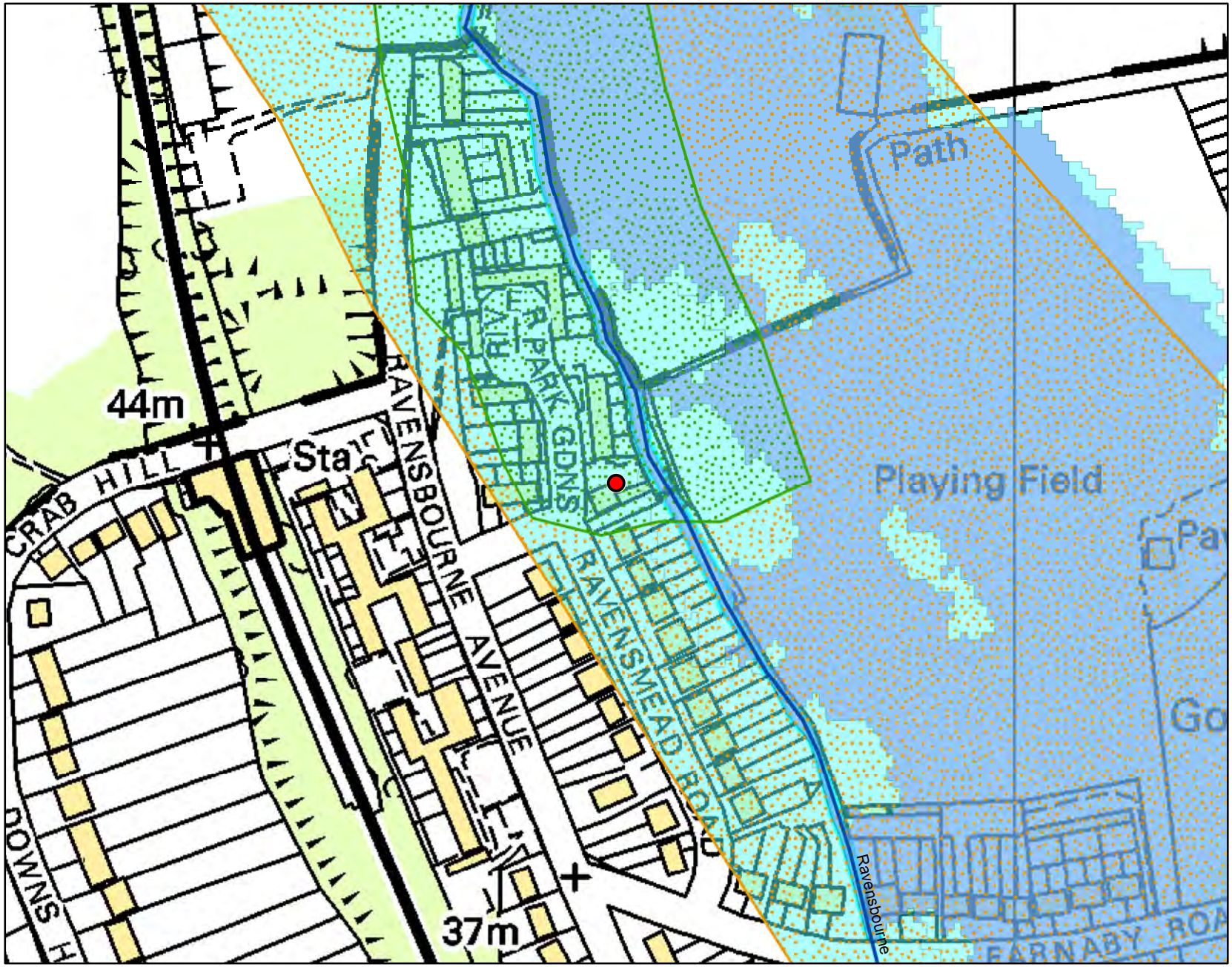
Flood Zone Map centred on NGR TQ3882270243 [Ref: KSL140722JB178]



Environment Agency

Scale 1: 2,500

Date of production: July 24, 2014

N W E S

LEGEND

- Site Location
- Main Rivers
- Nov 1965 Flood Outline
- Sep 1968 Flood Outline
- Flood Zone 3
- Flood Zone 2

Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

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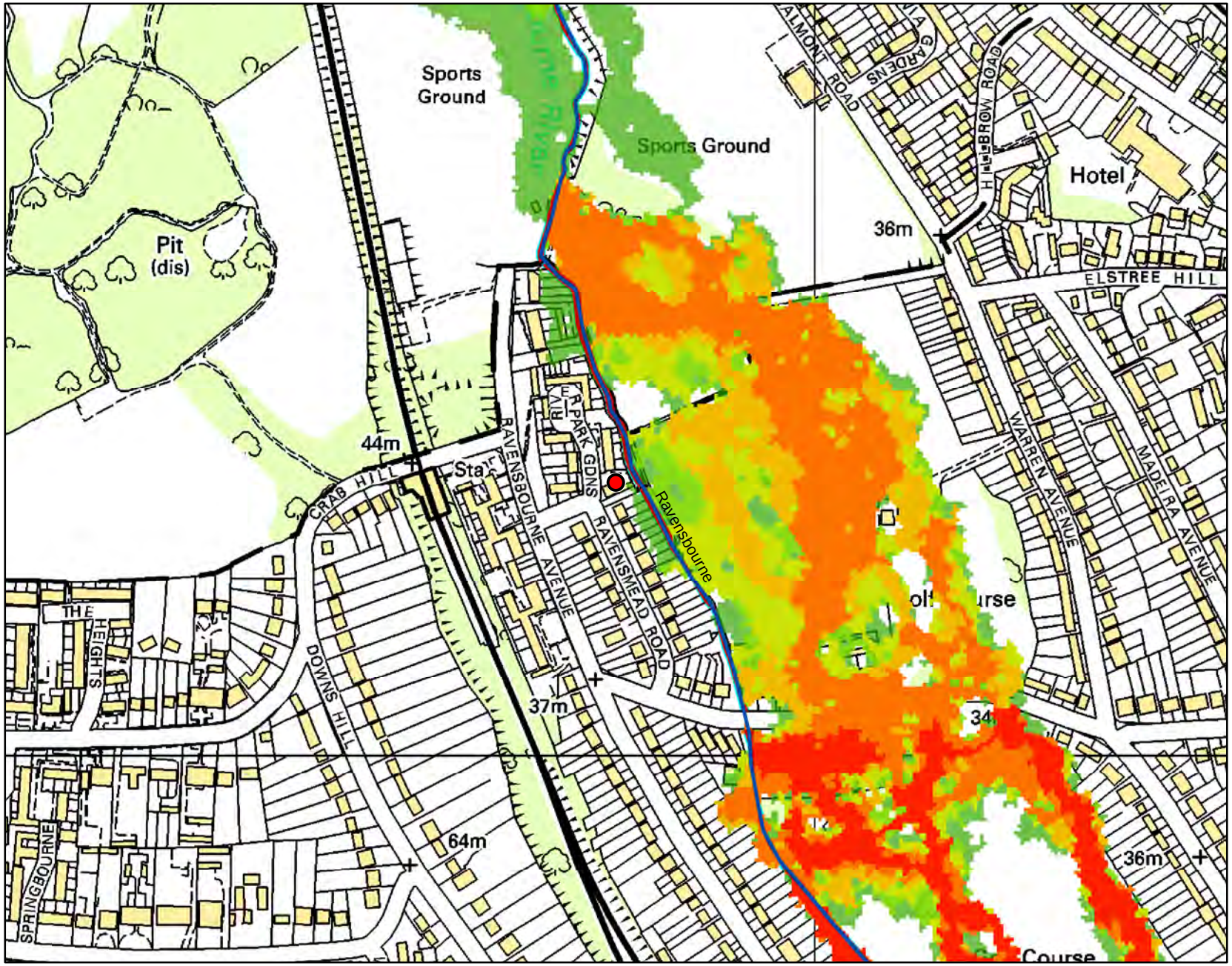
Fluvial Model Map centred on NGR TQ3882270243 [Ref: KSL140722JB178]



Environment Agency

Scale 1: 5,000

Date of production: July 24, 2014

N W E S

LEGEND

- Site Location
- Main Rivers
- 20% AEP extent
- 5% AEP extent
- 2% AEP extent
- 1.4% AEP extent
- 1% AEP extent
- 1% AEP + CC extent
- 0.1% AEP extent

AEP = Annual Exceedance Probability
The probability of a flood of a particular magnitude, or greater, occuring in any given year.

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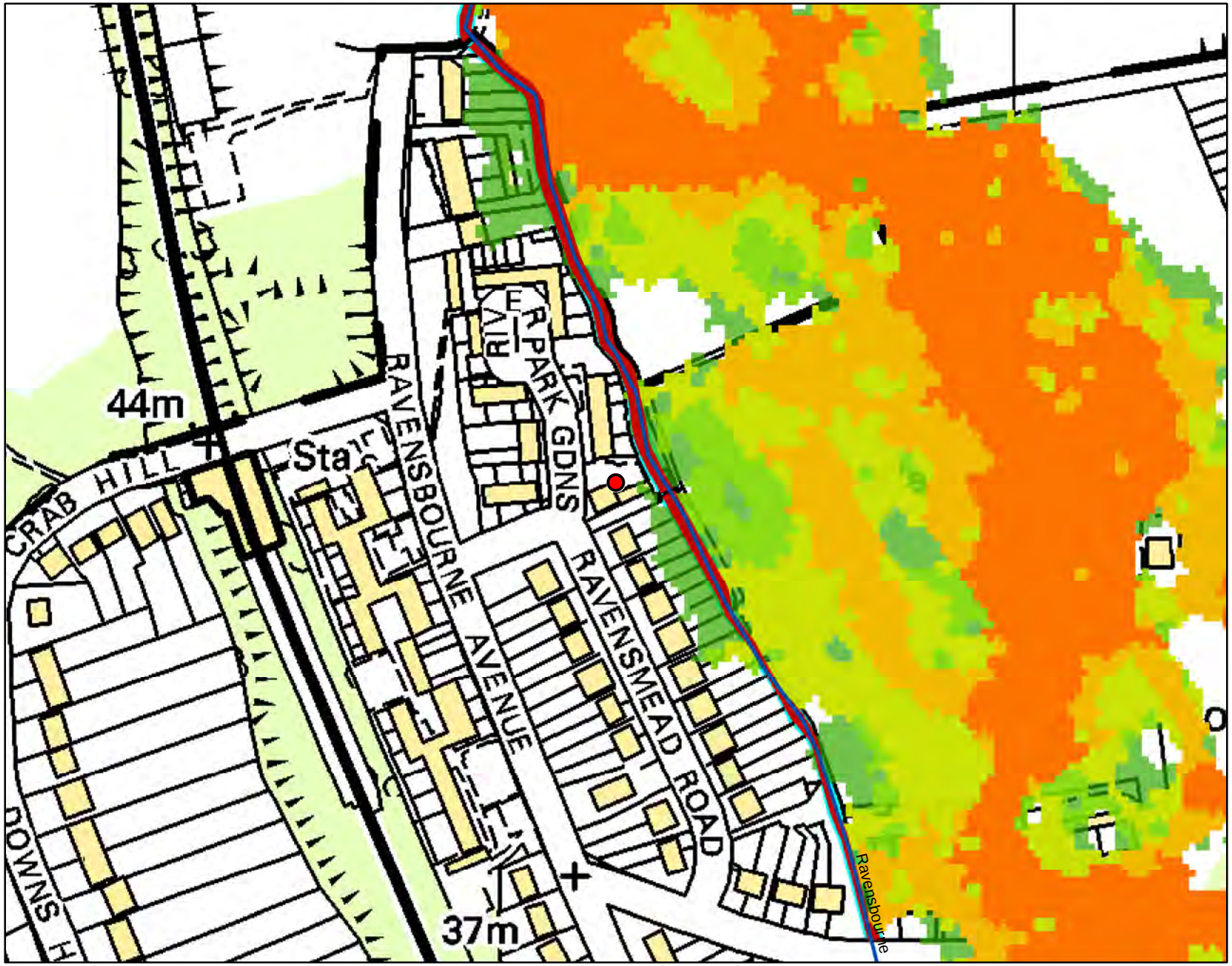
Fluvial Model Map centred on NGR TQ3882270243 [Ref: KSL140722JB178]



Environment Agency

Scale 1: 2,500

Date of production: July 24, 2014

N W E S

LEGEND

- Site Location
- Main Rivers
- 20% AEP extent
- 5% AEP extent
- 2% AEP extent
- 1.4% AEP extent
- 1% AEP extent
- 1% AEP + CC extent
- 0.1% AEP extent

AEP = Annual Exceedance Probability
The probability of a flood of a particular magnitude, or greater, occuring in any given year.

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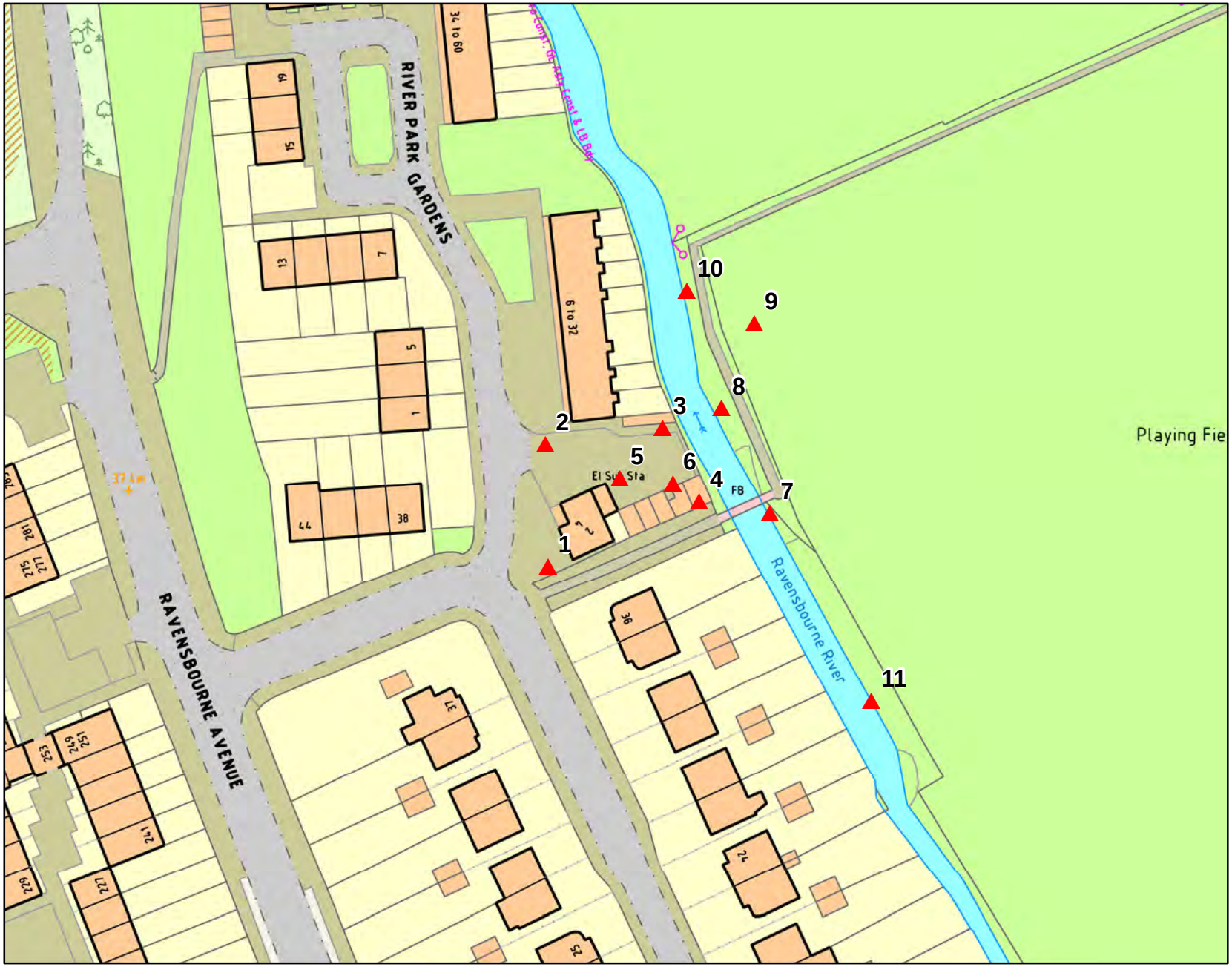
Site Node Locations Map centred on NGR TQ3882270243 [Ref: KSL140722JB178]



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Scale 1: 1,000

Date of production: July 24, 2014

N W E S

Legend

▲ Node Point Locations

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