# Yardley Primary School - 1FE Expansion

PEREGA

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## Contents



## Appendices



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| | | | | | |

# 1. Introduction

1.1 This flood risk assessment (FRA) has been prepared by Perega Ltd on behalf of their client, Evolve Norse for the development at Yardley Primary School, comprising a part single, part double storey building on site of the current dining/kitchen block, plus associated car parking areas.

1.2 The application boundary covers an area of approximately 0.10 hectare (ha) and is a brownfield site.

1.3 This FRA has been prepared in accordance with the requirements set out in the National Planning Policy Framework (NPPF) 2023 and the associated Technical Guidance.

1.4 The key site details are presented in Table 1, below.

***Table 1 – Site Summary***

| | |
|---|---|
| **Site Name** | Yardley Primary School |
| **Location** | Yardley Primary School, Hawkwood Cresent, London, E4 7PH |
| **Grid Reference** | TQ 37966 95505 |
| **Development Site Area** | 0.10 Hectare Approx. |
| **Development Type** | Education |
| **Flood Zone** | Flood Zone 1 (Low Probability Risk) |
| **Surface Water Flood Risk** | Medium Probability Risk |
| **Local Water Authority** | Thames Water |
| **Local Planning Authority** | London Borough of Waltham Forest |
| **Lead Local Flood Authority** | London Borough of Waltham Forest |

1.5 The development area is located in Flood Zone 1 and is less than one hectare; however, an independent FRA is required to support the Building Research Establishment Environmental Assessment Method (BREEAM) evaluation of the proposed development.

1.6 This report has been prepared solely as a Flood Risk Assessment (FRA). It therefore only addresses any environmental issues to the extent they are impacted by flooding. The findings are based on information evaluated at the time of preparation.

1.7 The report is the property of Perega and is produced for the exclusive use of our client and is confidential to that client. The contents may not be made use of by any third party without the express written consent of Perega. Any liability to any third party is expressly excluded.

1.8 This report is made on behalf of Perega. By receiving this report and acting on it, the client, or any third party relying on it, accepts that no individual is personally liable in contract, tort, or breach of statutory duty (including negligence).

## 2. Methodology

2.1 This is a desk-based study that utilises existing, publicly held information in the form of mapping and previously undertaken work. Conclusions made about flooding have been made using our expert judgement and knowledge of similar events.

2.2 In preparing this report, information has been gathered and referenced from several sources. These are as follows:

i. The Environment Agency's Flood Map for Planning.
ii. The Long-Term Flood Risk Map for England.
iii. The National Planning Policy Framework, and.
iv. The Planning Practice Guidance.

## 3. Site Details

### Site Setting

3.1 The site is a roughly trapezoid shaped parcel and currently contains a dining/kitchen block, part of Yardley Primary School, and associated car parking/hardstanding areas.

3.2 The site is bound by an access road along the south boundary, the school sport yard to the east, woods to the north and a residence to the west.

3.3 The site is accessed via Hawkwood Cresent using a gated vehicular crossover into the site from the south.

3.4 A site location plan is provided in **Appendix A**.

### Surface Water Features

3.5 There are no surface water bodies within the development boundary.

3.6 Hawkwood Nature Reserve is located south-east of site, at a distance of approximately 220m. There is also a tributary of the River Thames – the River Lee – which is located around 370m to the west of school with King George's Reservoir just slightly beyond it towards the west at a distance of approximately 450m to the site. The Ching Brook can be found approximately 1.6km east of the site.

3.7 There is an unnamed watercourse or ditch on map data to the east of the site at a distance of 140m from the building and is downhill of the site and on some flood risk mapping it is shown to extend to the north of the new proposed building within a nature area. This ditch is likely to be culverted along parts of its length and there is no recorded flooding of this unnamed watercourse.

### Geology

3.8 BGS Geology Viewer indicates that site is situated on the London Clay Formation, which is noted to be mainly clay, with silt and sand.

3.9 A ground investigation report was carried out by Listers Geo in January 2025.

3.10 Their investigations included trial pits and boreholes of maximum 19.55m deep. The ground generally consisted of a top layer of tarmacadam underlain by made ground of mainly slightly sandy brick and concrete cobbles, all of which are underlain by a deep layer of London clay with varying properties.

3.11 The ground investigation report also highlights that the near surface soils have been impacted by asbestos fibres, Asbestos Containing Materials and Polycyclic Aromatic Hydrocarbons. The report goes on to suggest that control measures are therefore required to protect groundworks and surrounding land users during the development; and remedial measures are necessary to reduce the long-term exposure risk to the future staff and pupils to an acceptable level.

3.12 An Excerpt ground investigation report can be seen in **Appendix I**. See DRAFT Report 24.09.031-dr01 Chingford for the full report.

3.13 A set of borehole logs from BGS GeoIndex (ref: TQ39NE1_A) located within the site boundary dated in 1935 shows approximately 0.15m of top soil underlain by 2.0m of alluvium of sand, ballast and clay. The borehole logs are provided in **Appendix I**.

3.14 From the same BGS Source a series of trial pit record were examined, these trial pits do not record standing surface water but do note some minor seepage which may be perched groundwater. Sides were reported as stable in all records.

3.15 The site lies outside a Coal Mining Reporting Area and therefore the risk associated with coal mine workings is considered to be negligible.

**Hydrogeology**

3.16 The ground investigation report shows that groundwater strike occurred at greater than 8.8m depth below ground level in borehole BH 01a and rose to within 0.8m of the surface standing water level. This report is provided in **Appendix I**.

3.17 Defra's Magic Maps indicates that the site is located in an area of unproductive Groundwater vulnerability. The map is shown in **Appendix C**.

**Existing Drainage**

3.18 The incumbent sewage undertaker is Thames Water.

3.19 There is an existing drainage network consisting of mixed usage of Ø100/150 surface and foul water pipes running along the access road to the school and connecting to a Ø225 surface water sewer and a Ø225 foul water sewer in Hawkwood crescent located south of the site.

3.20 The services records can be seen on the Topographical & Buried Utilities survey in **Appendix D.**

3.21 There are private sewers located within the site. A series of rainwater pipes and gullies collect surface water from the existing building and hardstanding/parking area. Sewers convey the runoff to the south of the site through the school access road where they discharge into the public surface water sewer in Hawkwood Crescent. These can be seen on the Topographical & Buried Utilities survey in **Appendix D**.

3.22 There is a foul water system running through the site from north-east to south-west that serves the existing building and discharges into the public foul sewer in Hawkwood Crescent through the school access road. These can also be seen on the Topographical & Buried Utilities survey in **Appendix D.**

**Source Protection Zones**

3.23 Groundwater Source Protection Zones (SPZ's) are defined around groundwater abstraction sources such as wells, boreholes and springs that are used for public drinking water supply.

3.24 SPZ's show the risk of contamination to groundwater from any activities that might cause pollution in the area. The closer the activity to the source of abstraction, the greater the risk. The maps show three main zones; inner – Zone 1; outer – Zone 2 and total catchment – Zone 3.

3.25 Zone 1 is defined as the 50-day travel time from any point below the water table to the source of abstraction. This zone has a minimum radius of 50 metres.

3.26 Zone 2 is defined by a 400-day travel time from a point below the water table to the source of abstraction. This zone has a minimum radius of 250 or 500 metres around the source, depending on the size of the abstraction.

3.27 Zone 3 is defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source of abstraction but is thought to be greater than 400 days travel time.

3.28 **Appendix C** shows Defra's Magic Map which identifies the site is within the outer protection zone (Zone 2). The drainage strategy should ensure that surface water runoff both from the building and the car park are adequately drained into the public surface water sewer system where it will be properly treated.

**Topography**

3.29 The site is generally quite flat with small variation in levels across the car park and grass field, although the existing building area is raised up from the immediate surroundings. The external areas around the building are at around 22.00m AOD. The car park ranges from around 22.00m AOD to 22.50m AOD with an approximate fall of 500mm.

3.30 The topographic survey can be seen in **Appendix D.**

**Existing Discharge Rate**

3.31 The existing site is brownfield.

3.32 The HR Wallingford tool has been used to calculate the following Greenfield discharge rate per hectare for the site which can be seen in **Appendix E**. This is summarised in Table 1.

***Table 1: Greenfield Runoff Rates per ha***

| Storm Event | Greenfield Rate (l/s/ha) |
|---|---|
| QBar | 0.55 |
| 1-year | 0.47 |
| 30-year | 1.27 |
| 100-year | 1.77 |

## 4. The Proposed Development

4.1 The proposed development consists of a part single, part double storey building, replacing the existing dining/kitchen block infrastructure, and associated parking and hardstanding area..

4.2 The proposed development can be seen in **Appendix F.**

4.3 The impermeable and permeable areas for the site are summarised in Table 2.

***Table 2: Impermeable and permeable areas***

| | Impermeable Area ($m^2$) | Permeable Area ($m^2$) |
|---|---|---|
| Car Park | | 100 |
| Footpaths | 240 | |
| Buildings | 500 | |
| Soft Landscaping | | 220 |
| Total Area | 740 | 220 |

## 5. Strategic Flood Risk Assessments, Surface Water Management Plans and Local Flood Risk Management Strategies

5.1 Strategic Flood Risk Assessments (SFRA's) and Surface Water Management Plans (SWMP's) provide a high-level overview of flood risk and are prepared by the Lead Local Flood Authorities (LLFA), which in this case is the London Borough of Waltham Forest. SFRA's consider flooding from surface water runoff, groundwater and ordinary watercourses. They also reference historical flooding that has occurred in the local area as well as the potential for future flooding. SWMP's aim to identify areas that are vulnerable to surface water flooding and establish a plan to managing surface water in those areas.

5.2 AECOM produced a Level 1 SFRA report in October 2018 and a Level 2 SFRA report in October 2021. It refers to the Environment Agency Historic Flood Map data showing records of flooding from the River Lee and the Dagenham Brook including extensive flooding in the south east of the borough.

5.3 There were also records of flooding along the Ching Brook which extends into the areas of South Chingford. The reports noted that there are flood defences in place on these watercourses, with varying levels of protection and recommends that any proposed development within areas shown to have a flood history should investigate this risk further as part of a site specific flood risk assessment.

5.4 The Surface Water Map (**Appendix B)** for flood risk shows the proposed site has Medium chance of surface water flooding, which will be adequately addressed by raising the proposed building FFL and introducing SuDS on site Rain Gardens and permeable grasscrete to catch and direct the excess of the existing flow route off-site. Additionally, the proposed site is within Flood Zone 1 and is considerably less than 1 hectare and will therefore not require a flood risk assessment. The SFRA reports can be seen in **Appendix G**.

5.5 The river Lee is approximately 370m to the west and therefore is unlikely to affect the site. The Ching Brook is 1.6km to the east and therefore is unlikely to affect the site.

5.6 The SWMP for Waltham Forest was published in September 2021. It identified thirteen Critical Drainage Areas (CDAs) in the borough council; however, the site does not lie within one of these. The SWMP can be seen in **Appendix H**.

5.7 The London Plan is the overall strategic plan for London and includes policies concerning flood risk and sustainable development. Policy SI13 states that the drainage proposals should look to incorporate green SuDS features over grey where possible in line with the following drainage hierarchy:

"1) rainwater use as a resource (for example rainwater harvesting, blue roofs for irrigation)
2) rainwater infiltration to ground at or close to source
3) rainwater attenuation in green infrastructure features for gradual release (for example green roofs, rain gardens)
4) rainwater discharge direct to a watercourse (unless not appropriate)
5) controlled rainwater discharge to a surface water sewer or drain
6) controlled rainwater discharge to a combined sewer."

**The Environment Agency Flood Map for Planning**

5.8 The Environment Agency's Flood Map for Planning gives an indicative prediction of areas at risk of fluvial and tidal flooding. The mapping is an amalgamation modelled flood levels and historical flood event outlines.

5.9 The Flood Map is split into 'Flood Zones', which demarcate the extent of flooding from rivers or the sea for different return periods. The Flood Map for Planning shows the extent of the natural floodplain if there were no defences or other man-made structures. They do not provide a definitive picture of where flooding would occur; rather, they provide an indicative prediction of areas at risk.

5.10 Table 4 lists the flood zone categories and explains the flood risk probabilities they represent.

**Table 4 – Flood Zone Categories**

| Flood Zone | Definition |
|---|---|
| Zone 1 Low Probability | Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3) |
| Zone 2 Medium Probability | Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map) |
| Zone 3a High Probability | Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map) |
| Zone 3b The Functional Floodplain | This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their SFRAs areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map) |

**The National Planning Policy Framework**

5.11 The NPPF sets out the Government's national policies on different aspects of land use planning in England in relation to flood risk. The Technical Guidance to the NPPF provides further information on the policies set out in the NPPF. It encourages development to take place in areas of lower flood risk wherever possible and stresses the importance of preventing increases in flood risk off site to the wider catchment area.

5.12 Within each Flood Zone, a key factor in determining planning applications for development is the flood risk vulnerability of a development. Table 2 of the Technical Guidance to the NPPF categorises different development types according to their vulnerability to flooding. These categories are:

- Essential infrastructure.
- Highly vulnerable development.
- More vulnerable development.
- Less vulnerable development, and.
- Water-compatible development.

5.13 Within the different Flood Zones each of the above development categories are considered appropriate or not permissible. The PPG lists these as:

**Flood Zone 1:**

All the development categories listed above are appropriate.

**Flood Zone 2:**

Water-compatible, less vulnerable development, more vulnerable development and essential infrastructure is appropriate in this zone. An exception test is required for highly vulnerable infrastructure in this zone.

**Flood Zone 3a:**

Water-compatible and less vulnerable development is appropriate in this zone. Highly vulnerable development should not be permitted in this zone. An exception test is required for more vulnerable and essential infrastructure in this zone.

**Flood Zone 3b:**

Only water-compatible development and essential infrastructure that must be there should be permitted in this zone. An exception test is required for essential infrastructure.

5.14 The above information sets out the basis by which developments must be assessed in terms of flood risk. In Section 7 the vulnerability of the proposed development will be reviewed against the Flood Zone in which it is located. This will inform the suitability of the development as per the advice within the PPG.

## 6. Historical Flooding

6.1 A number of historical flood events are discussed in the Waltham Forest SFRA. Flooding from the river Lee and its tributaries the Ching Brook and Dagenham Brook have occurred on a number of occasions within the borough, although flood defences should now provide protection from events up to and including the 1 in 200 year event.

6.2 Flooding from surface water has been reported to us as occurring across the borough, with a map showing the modelled risk of flood for surface water from the SFRA indicating that the site is at Medium risk from this.

## 7. Current and Future Flood Risk

7.1 Flooding can arise from a variety or combination of sources. These may be natural or artificial and may be affected by climate change. These are discussed below detail and summarised in Table 8.

**Fluvial Flooding**

7.2 **Appendix B** shows the Environment Agency's Flood Map for Planning at the development location. It lies within Flood Zone 1. Therefore, flooding from rivers and the Sea is considered to be **Low**.

**Flood Risk Vulnerability and Appropriateness of Development**

7.3 Educational developments are listed in Annex 3 of the NPPF as being 'more vulnerable' to flooding. Table 2 in the Flood risk and coastal change section of the PPG (replicated below in Table 5) states that 'more vulnerable' development is appropriate in Flood Zone 1. **Therefore, the development is considered as appropriate in this location.**

***Table 5: replicated from Table 2 NPPF: Flood Risk Vulnerability and Flood Zone 'compatibility'.***

| Flood Zones | Flood Risk Vulnerability Classification | | | | |
|---|---|---|---|---|---|
| | Essential Infrastructure | Highly Vulnerable | More Vulnerable | Less Vulnerable | Water Compatible |
| Zone 1 | ✓ | ✓ | ✓ | ✓ | ✓ |
| Zone 2 | ✓ | Exception Test required | ✓ | ✓ | ✓ |
| Zone 3a † | Exception Test required † | × | Exception Test required | ✓ | ✓ |
| Zone 3b * | Exception Test required * | × | × | × | ✓ * |

**Notes**

✓ Development is appropriate

× Development should not be permitted.

† In Flood Zone 3a, essential infrastructure should be designed and constructed to remain operational and safe in times of flood

* In Flood Zone 3b (function floodplain) essential infrastructure that has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- Remain operational and safe for users in times of flood;
- Result in no net loss of floodplain storage;
- Not impede water flows and not increase flood risk elsewhere

**Tidal Flood Risk**

7.4 The Environment Agency's Flood Map for Planning does not differentiate between fluvial and tidal flooding. However, the site is not located near to the sea therefore the site is not in an area at risk of tidal flooding.

**Surface Water Flood Risk**

7.5 Pluvial flooding results from rainfall-generated overland flow, where rainwater has not yet reached a watercourse or sewer and where the local drainage systems become overwhelmed. Pluvial flooding often occurs during short, very intense storms, but can also occur during longer periods of rainfall when the ground is already saturated, or where land has low permeability due to development.

Although pluvial flood events are usually short-term, they can be devastating with fast flows and deep waters occurring quickly.

7.6 In these conditions surface water can build up where the topography allows it to converge or pond. Where it gathers it will travel down prevailing gradients. Pluvial flooding then occurs at locations where significant surface water flow paths converge, at localised low points and/or due to overland obstructions. In urban areas pluvial flooding often occurs where the built environment channels overland flow routes (down roads that are bounded by kerbs, for example) or where there are obstacles to the natural overland flow routes. Boundary walls and buildings are often the main causes and, hence, affect the likelihood of pluvial flooding to impact property and gardens.

7.7 Pluvial flooding is exacerbated in many cases by the mistreatment or failure of the below ground infrastructure (including partial or full blockages of gullies and/or within the combined sewers and the accumulation of fats, oils and greases within the sewer networks).

7.8 The Long-Term Flood Map for England (LTFMfE) attempts to model the areas where pluvial flooding is likely to occur. The LTFMfE is a national scale modelled output. It shows the flooding that could take place from the 'surface runoff' generated by rainwater (including snow and other precipitation) which:

i. is on the surface of the ground (whether it is moving), and
ii. has not yet entered a watercourse, drainage system or public sewer.

7.9 The LTFMfE predominantly follows topographical flow paths of existing watercourses, or dry valleys with some isolated ponding located in low lying areas.

7.10 The LTFMfE shows that part of the development site has a **medium** risk of surface water flooding as it is within Flood Zone 1. This can be seen in **Appendix B**. This risk is managed by raising the FFL levels and introducing suitable SuDS on site Rain Garden and permeable grasscrete surfacing to capture part of the runoff and redirect excess flow offsite.

**Groundwater Flood Risk**

7.11 The risk of groundwater flooding is dependent on local geological and hydrogeological conditions at any given time. Groundwater levels rise during wet winter months and fall again in the summer when rainfall is low, and extractions are higher. In very wet winters, rising groundwater levels can reactivate flow in ephemeral streams that only flow for part of the year or even lead to the flooding of normally dry land.

7.12 The site is not in an area vulnerable to groundwater flooding, although the clayey silty soils underlaying the site may be waterlogged, may contain pockets of perched water, the groundwater strikes recorded on BGS records suggest that historically the water levels are not within the superficial soils or close to the surface.

7.13 The site investigation has recorded the strikes of groundwater at around 8.8m depth which rose during their monitoring but did not reach the surface. This is believed by Listers Geo that this may represent perched groundwater within the made ground as it is unlikely that groundwater would move through London Clay.

7.14 This does not represent a threat to buildings on site unless substantial impermeable surfaces uphill are discharging surface water into the made ground.

**Flood Risk from Canals**

7.15 There are no purpose-built canals or navigable waterways in the vicinity therefore, there is no risk from canals.

### Flood Risk from Reservoirs and Large Water Bodies

7.16 Flooding can occur from reservoirs or large water bodies that are impounded above the surrounding ground levels or are used to retain water in times of flood. Although unlikely, reservoirs and large waterbodies can overtop or breach their impounding structures leading to rapid inundation of the downstream floodplain.

7.17 The Environment Agency is the enforcement authority for the Reservoirs Act 1975 in England and Wales. All large reservoirs must be regularly inspected and supervised by reservoir panel engineers. Local Authorities are responsible for coordinating Emergency Plans for reservoir flooding and ensuring communities are well prepared. Local Authorities should work with other members of the Local Resilience Forum (LRF) to develop these plans.

7.18 There are no recorded reservoirs in the immediate surrounding areas therefore there is no risk from this source.

### Flood Risk from Sewers

7.19 Sewer flooding can occur when the capacity of the infrastructure is exceeded by excessive flows, or because of a reduction in capacity due to collapse or blockage, or if the downstream system becomes surcharged. This can lead to the sewers flooding onto the surrounding ground via manholes and gullies, which can generate overland flows.

7.20 Typically, sewer systems are constructed to accommodate rainstorms with a 30-year return period or less, depending on their age. Consequently, rainstorm events greater than 1 in 30-years would be expected to result in surcharging of some parts of the sewer system. In fact, due to most gullies being poorly maintained and often partially blocked with silt, leaves and other debris, their capacity is often estimated to be closer to the 1 in 10-year storm.

7.21 English and Welsh water companies are required to maintain a register of flooding incidences due to hydraulic capacity problems on the sewage network. This database identifies properties where flooding has occurred on a frequency of 1 in 5 years and 1 in 10 years. The database is known as the DG5 and DG10 registers.

7.22 Waltham Forest SFRA notes that the borough is served by a combined public sewer system managed by Thames Water. The report notes that sewer systems are typically designed for events up to and including 1-in-30 years or greater. “Therefore, rainfall events with an annual probability less than 1-in-30 years would be expected to result in surcharging of some of the sewer system.”

### Climate Change

7.23 The NPPF and the supporting Technical Guidance document sets out how flood risk should be considered over the lifetime of a development. This requires an increase in flood risk due to climate change to be considered. Both peak river flows and rainfall intensity should be assessed.

#### *Peak River Flows*

7.24 A range of climate change allowances have been provided by the NPPF for peak river flow increases - a ‘central’ allowance, a ‘higher central’ allowance, an ‘upper end’ allowance and a ‘H++’ allowance. The flood zone and risk vulnerability classification of the development decide which allowance to consider.

7.25 The NPPF groups England's individual river and rainfall catchments into wider catchment areas that are considered to have similar hydrogeological conditions, physical characteristics, rainfall inputs and responses to storm events.

7.26 The development is identified within the *'London Management Catchment'*.

7.27 The NPPF states that all uses of land are appropriate in Flood Zone 1.

***Peak Rainfall Intensity***

7.28 With climate change it is becoming more common to see rainfall events of higher intensity. Increased rainfall intensity affects river levels and drainage systems, with the result being an increase in surface water flooding and sewerage surcharge.

7.29 The NPPF states that for flood risk assessments for developments with a lifetime beyond 2100, the upper end allowances should be used. Table 6 and 7 summarises the data attributed the London Management Catchment.

**Table 6 – Catchment Peak River Flow Allowances**

| 3.3% annual exceedance rainfall event | | |
|---|---|---|
| **Epoch** | **Central Allowance** | **Upper End Allowance** |
| 2050s | 20% | 35% |
| 2070s | 20% | 35% |

**Table 7 – Catchment Peak River Flow Allowances**

| 1% annual exceedance rainfall event | | |
|---|---|---|
| **Epoch** | **Central Allowance** | **Upper End Allowance** |
| 2050s | 20% | 40% |
| 2070s | 25% | 40% |

**Residual Flood Risk**

7.30 It is important to recognise that flood risk can never be fully mitigated and there will always be a residual risk of flooding. The residual risk is associated with several potential risk factors, including (but not limited to):

- A flood event that exceeds that for which the local flood defences or local drainage system has been designed to withstand.
- A residual danger posed to property and life because of flood defence failure through overtopping or structural collapse.
- General uncertainties inherent in the prediction of flooding.

7.31 Modelling of flood events is not an exact science. Therefore, there is an inherent uncertainty in the prediction of flood levels and extents used in the assessment of flood risk. The Environment Agency's Flood Map for Planning is largely based upon detailed modelling within the area. The LTFMfE and

Ground Water Flooding mapping are based on broader-scale models that require numerous assumptions to be made.

7.32 Whilst they all provide a good depiction of flood risk for specific modelled conditions, all modelling requires the making of core assumptions and these might not occur in the open and dynamic environment of a flood event. Also, the Environment Agency's Flood Map for Planning and other flood modelling is updated regularly. Interested parties are recommended to keep abreast of this so that a significant change or increase in flood risk can be determined.

Summary of Flood Risk

***Table 8: Summary of Flood Risk on Site***

| Flood Source | Risk Level | | | | Comment |
|---|---|---|---|---|---|
| | High | Medium | Low | Very Low | |
| Fluvial | | | | X | Fluvial Flood Zone 1, no rivers in vicinity however flood risk may increase due to tidal locking |
| Tidal | | | | X | Tidal Flood Zone 1, however site is far inland. Local watercourses and the River Lea and the reservoir are protected by flood defences. |
| Groundwater | | | | X | EA Maps states that flooding from groundwater is unlikely in site area. |
| Surface Water | | | | X | EA Maps show a medium risk of surface water flooding |
| Canals | | | | X | There are no canals or navigable waterways in the vicinity |
| Reservoirs | | | | X | No recorded reservoirs in the vicinity |
| Sewers | | | | X | There is no evidence to suggest that the site is at any risk of sewer flooding |
| Increase due to Climate Change | | | X | | Increased rainfall intensities are not expected to affect the flood risk on site. |

## 8. Flood Avoidance, Resistance and Resilience

8.1 Flood risk can be mitigated through taking measures to avoid, resist and be resilient to flooding. Avoidance is carrying out development in line with the sequential test and relocating development to areas of lower flood risk. There is a range of construction methods that can be incorporated into the design of new development to reduce the risk of flooding at a site. These can either be categorised as resistance or resilience measures. Resistance measures are those used to try to prevent floodwaters from reaching or entering a property. Resilience measures are those that acknowledge that flooding is likely to occur and try to minimise the damage caused by floodwaters entering the building. The Environment Agency recommends consideration is given to the incorporation of flood resistance and resilience into the design and construction of a development in areas that are at risk of flooding.

### Avoidance

8.2 The best possible mitigation for properties at risk of flooding would be to relocate the building to an area of lower flood risk. This method is regarded as an avoidance measure. In the case of the new building, this is not applicable because the development is a new site. It is not possible to move the entire development to an area of lower flood risk.

### Resistance

8.3 Resistance measures can help to prevent water from entering a property. This is particularly effective for low depth flooding. It is recommended to raise the threshold of a building to above the predicted flood levels, nominally 100 – 150mm. Raising thresholds and floor levels beyond the minimum required or would provide an additional level of protection and would have the additional benefit of lowering the residual risk of flooding. However, on sites where accessible dwellings are integral to the development, this may not be appropriate as access must be optimised for those with a physical disability.

### Resilience

8.4 Resilience measures do not stop water from entering a property; they acknowledge that there will be floodwater ingress and aim to minimise the impact in terms of cost and disruption immediately after a flood event. They can be incorporated into the structure of the building or can be included in the finishes, services, and insulation on a building’s internals.

8.5 It is the conclusion of this report that the flood risk is not sufficient to require flood resilient construction methods in the proposed building and associated car park. It would represent unnecessary cost and complexity for the development.

8.6 The building FFL has been set 150mm above adjacent ground level at a minimum to prevent it being at a low-point and to ensure any overland flow bypasses the building along a route away.

## 9. Proposed Drainage Strategy

9.1 Based on the above flood risks and constraints, a proposed drainage strategy has been developed which can be seen in **Appendix F.**

### Surface Water

9.2 As the development is to be constructed on a brownfield site, replacing an existing building, the preferred method of surface water discharge would be to reuse the existing surface water connection offsite, which connects to the Thames Water surface water sewer in Hawkwood Cresent south of the development site.

9.3 A series of proposed ACO channels will collect the surface water from the hardstanding area before discharging to the surface water network. The carpark to the west of the building will be surfaced with reinforced grasscrete paving, including where vehicle parking bays are located.

9.4 There are reports that surface water runoff from the adjacent land to the east of the development site routes into the site from the south east of the development site. A Rain garden is proposed to the north-west of the proposed building. This will collect some of the overland flow which runs over it while the rest is routed north-westwards along its pre-development route towards the existing ditches there to receive it.

9.5 The local authority planning tree officer was consulted to evaluate the feasibility of the rain gardens and confirmed on an email received on 22/10/2025 that the proposed rain gardens are acceptable subject to an appropriate method statement.

*"The position of the rain garden on the western side is underneath the crowns of retained trees (T29 and T30). However, as I recall from our site visit, the land at this point is raised and the trees are situated in the adjacent caretaker's home, growing at a lower level beyond a boundary wall. Therefore, it is unlikely that installation of the rain garden would affect the trees' RPAs or the existing hydrological conditions for the tree roots and, provided an appropriate method statement is drawn up for the installation, this would be acceptable.*

*Installation of new sewer connections and removal of existing pipes is proposed within the RPA of trees on the grassed area. This requires a method statement that demonstrates how this work can be carried out without damaging the trees' rooting systems. There are specialist techniques that can be employed when installing service runs in proximity to trees and the project arboriculturist would need to select the most suitable option for use in this instance."*

9.6 Vac-Ex could be used to excavate the rain garden with minimal risk of damage to the tree roots in this area.

9.7 The runoff from the roofs of the new building will be collected by rainwater pipes which connect into the surface water drainage system. This discharge rate will match the 4.2 l/s discharge rate agreed with Thames Water subject to S106 approval.

*9.8* Different areas of hardstanding pose different risks of pollution.

9.9 Table 9 is replicated from CIRIA's C753: The SuDS Manual.

***Table 9: Pollution hazard indices for different land use classifications - reproduced from Table 26.2 CIRIA C753: The SuDS Manual***

| **Land use** | **Pollution hazard level** | **Total suspended solids (TSS)** | **Metals** | **Hydrocarbons** |
|---|---|---|---|---|
| Residential roofs | Very Low | 0.2 | 0.2 | 0.05 |
| Other roofs (typically commercial/industrial roofs) | Low | 0.3 | 0.2 (up to 0.8 where there is potential for metals to leach from the roof) | 0.05 |
| Individual property driveways, residential car parks, low traffic roads (e.g. cul-de-sacs, home zones and general access roads) and non-residential car parking with infrequent change (e.g. schools, offices) i.e. < 300 traffic movements/day | Low | 0.5 | 0.4 | 0.4 |
| Commercial yard and delivery areas, non-residential car parking with frequent change (e.g. hospitals, retail), all roads except low traffic roads and trunk roads/motorways[1] | Medium | 0.7 | 0.6 | 0.7 |
| Sites with heavy pollution (e.g. haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways[1] | High | 0.8[2] | 0.8[2] | 0.9[2] |

**Notes**

1 Motorways and trunk roads should follow the guidance and risk assessment process set out in Highways Agency (2009)

2 These should only be used if considered appropriate as part of a detailed risk assessment – required for all these land use types (Table 4.3). When dealing with high hazard sites, the environmental regulator should first be consulted for pre-permitting advice. This will help determine the most appropriate approach to the development of a design solution.

Based on Table 9, both the building roof and hardstanding onsite will have a Low pollution hazard level associated with them.

The roofs are thought to have a suitably low risk as to not require treatment before discharge into the surface water sewer. The two no. parking bays will have a permeable surface with gravel beneath at the sub-base which will provide a level of treatment. Although parking bays have a low pollution hazard level from table 9 above there can be a reduction in all values of around 0.2 by utilising permeable surfaces.

### Foul Water

9.10 There is an existing foul water sewer which runs north east to south west across the school site. It is proposed to divert the existing foul sewer to the north of the proposed new building and connect back into the existing pipeline near the proposed access to the site. It is assumed that this pipeline is not adopted, however, prior to the works progressing, this is to be confirmed and if needed, a S185 diversion application would need to be submitted to accommodate the diversion.

9.11 The proposed new foul water from the new building will be collected via a series of stub stacks, soil vent pipes and foul gullies. It will be conveyed to the west of the site and discharged into an existing foul water manhole which connects to the foul sewer in Hawkwood Cresent to the south of site.

## 10. Conclusion

10.1 This flood risk assessment (FRA) has been prepared by Perega Ltd on behalf of their client, Evolve Norse to support the detailed planning application for the development at Yardley Primary School, Hawkwood Cresent, London, E4 7PH comprising of part single, part double storey building, plus associated car parking area and landscaping over a site area of approximately 0.10 hectares.

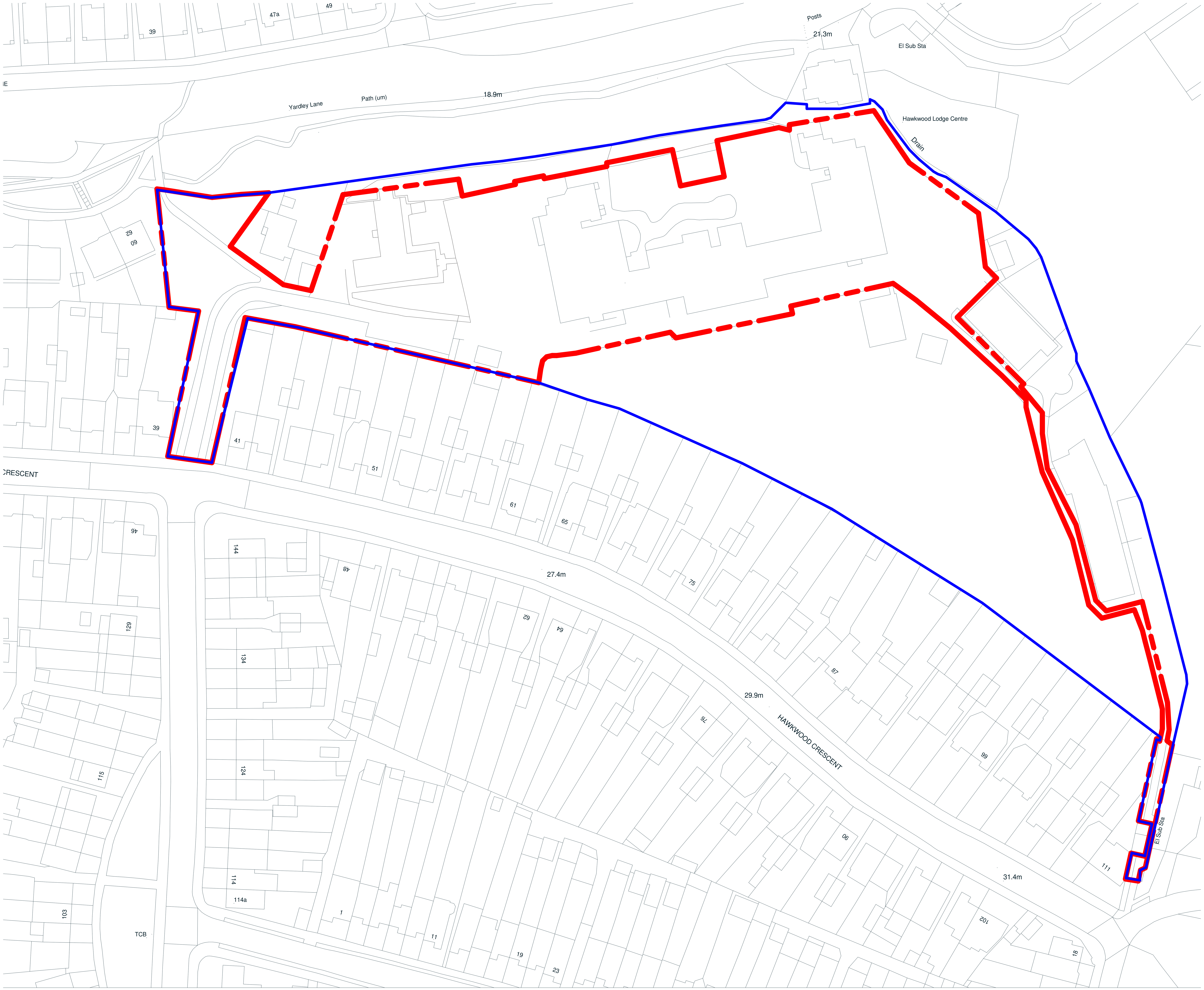
10.2 There are no surface water features onsite, and the existing topography is relatively flat across the site. A ground investigation found the existing hardstanding surfacing was underlaid with made ground. No ground water was struck within 8.8m of the surface, but the site is located in an area noted to be of very low Groundwater Vulnerability.

10.3 Existing private sewers convey both the surface water and foul water to the Thames Water surface water and foul sewers located in Hawkwood Cresent to the south of the site. It is proposed to utilised these connections for the new development.

10.4 To provide suitable SuDS on site Rain Gardens and permeable grasscrete surfacing will be provided. An existing flow route of surface water reported by the local authority will be maintained by raising FFL levels so any modelled overland flows from off-site can leave the development site without presenting a flood risk to buildings.

10.5 The site is located in Flood Zone 1, which has a low risk of flooding.

# Appendix A
Site Location Plan




00 Existing Location Plan
1 : 500

RESPONSIBILITY IS NOT ACCEPTED FOR OTHERS SCALING DIRECTLY FROM THIS DRAWING. DO NOT SCALE FROM THIS DRAWING, USE WRITTEN DIMENSIONS ONLY.

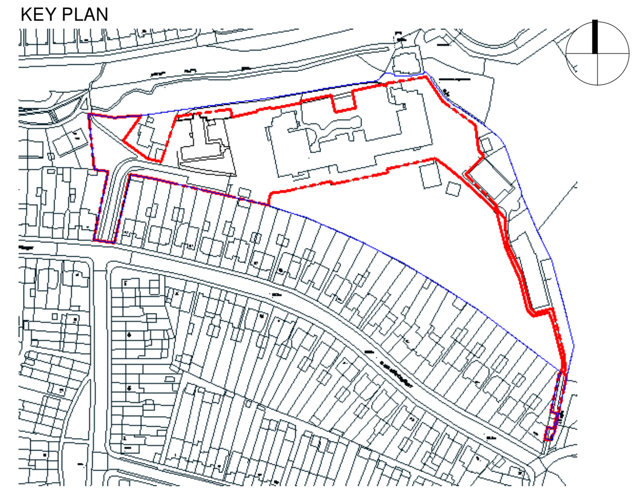
0m 5m 15m 30m
1:500

ORIGINAL SHEET SIZE A1

THIS DRAWING IS PRODUCED FOR USE IN THIS PROJECT ONLY AND MAY NOT BE USED FOR ANY OTHER PURPOSE. THE ORIGINATOR ACCEPT NO LIABILITY FOR THE USE OF THIS DRAWING OTHER THAN THE PURPOSE FOR WHICH IT WAS INTENDED IN CONNECTION WITH THIS PROJECT AS RECORDED IN THE 'PURPOSE FOR ISSUE' AND 'FILE STATUS CODE'.



KEY PLAN



NOTES

Key

Development Area
9878 m2

School Boundary
20349 m2

| Rev | Description | Date | Drawn | Chkd /Appd |
|---|---|---|---|---|
| P01 | Boundary amended; Layout amended following comments from planners and stakeholders; Landscaping amended | 7.1.25 | RA | TN/DA |

EVOLVE
A PARTNERSHIP BETWEEN WALTHAM FOREST COUNCIL AND NORSE CONSULTING

Evolve Norse Ltd.
280 Fifers Lane, Norwich, NR6 6EQ
**Tel**:01603 894100; **web:**www.nps.co.uk

CLIENT
LBWF

PROJECT
Yardley PS 1FE Expansion, Hawkwood Crescent, E4 7PH

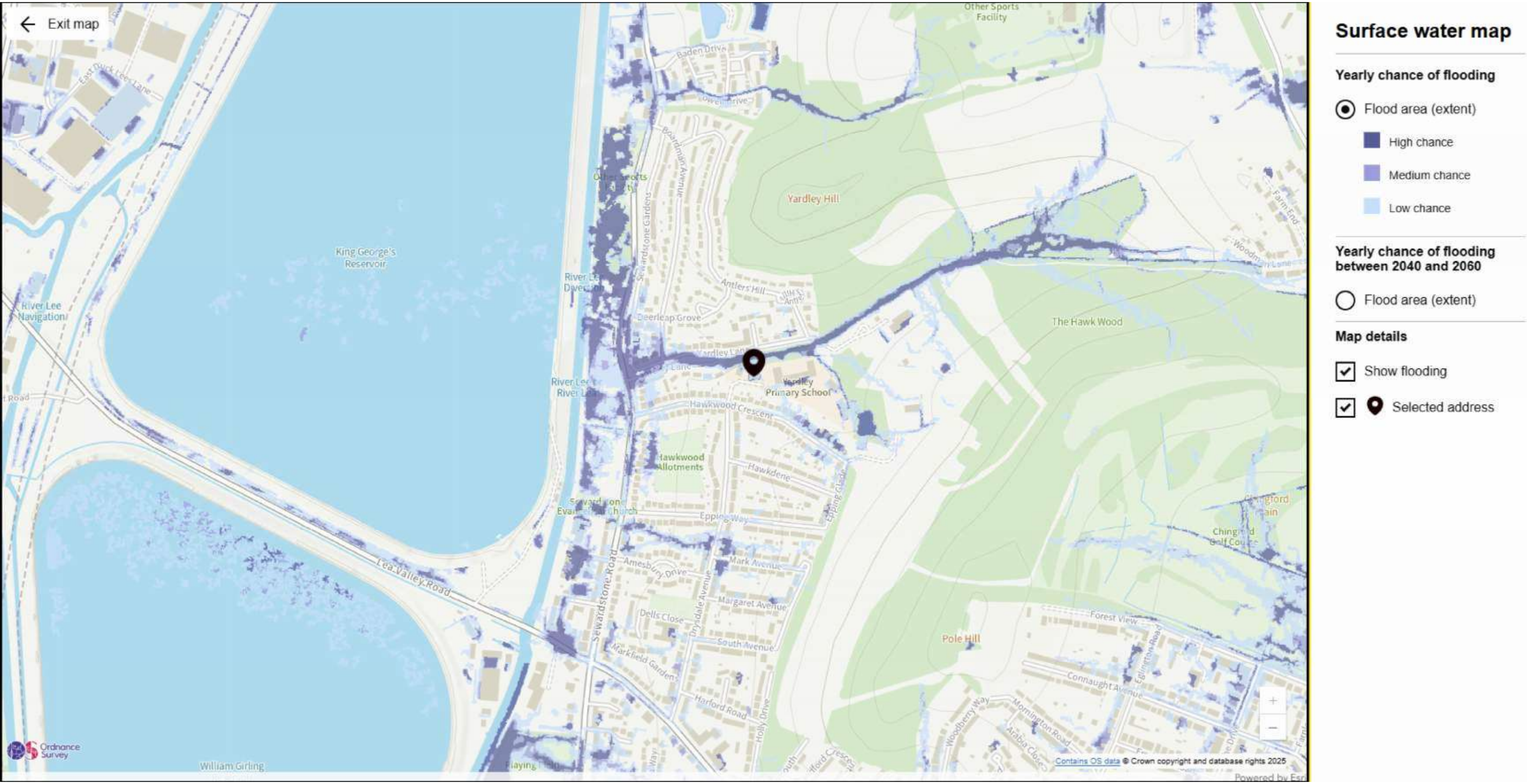
TITLE
Existing Site Location Plan

| SCALE | DISCIPLINE | PROJECT NUMBER |
|---|---|---|
| 1 : 500 | Architecture | 116612 |

| DRAWING NUMBER | REV CODE |
|---|---|
| EVO-XX-00-DR-A-000 | P01 |

| STATUS CODE | PURPOSE OF ISSUE | Drawn by | Approved by |
|---|---|---|---|
| S2 | For Information | RA | TN |
| | | Checked by STE | |

# Appendix B
Flood Risk Maps



Exit map
Surface water map
Yearly chance of flooding
Flood area (extent)
High chance
Medium chance
Low chance
Yearly chance of flooding between 2040 and 2060
Flood area (extent)
Map details
Show flooding
Selected address
King George's Reservoir
Yardley Hill
The Hawk Wood
Yardley Primary School
Hawkwood Crescent
Hawkwood Allotments
Sewardstone Road
Lea Valley Road
Pole Hill
Connaught Avenue
Forest View
Mark Avenue
Margaret Avenue
South Avenue
Dells Close
Epping Way
Antlers Hill
Deerleap Grove
Boardman Avenue
River Lee Navigation
Other Sports Facility
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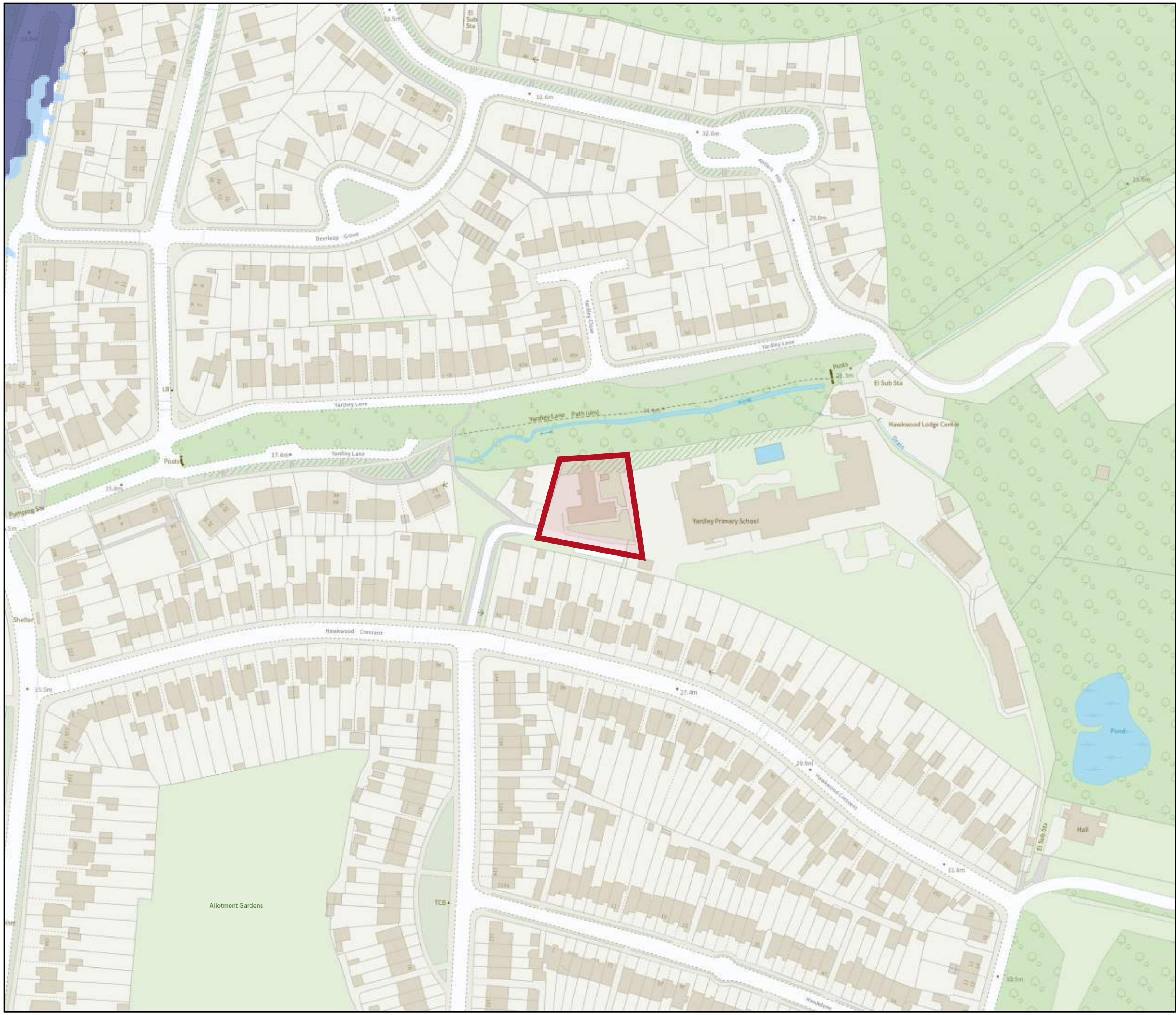



Environment Agency

**Flood map for planning**

Your reference
**C13942**

Location (easting/northing)
**537962/195504**

Scale
**1:2500**

Created
**5 Mar 2025 13:48**

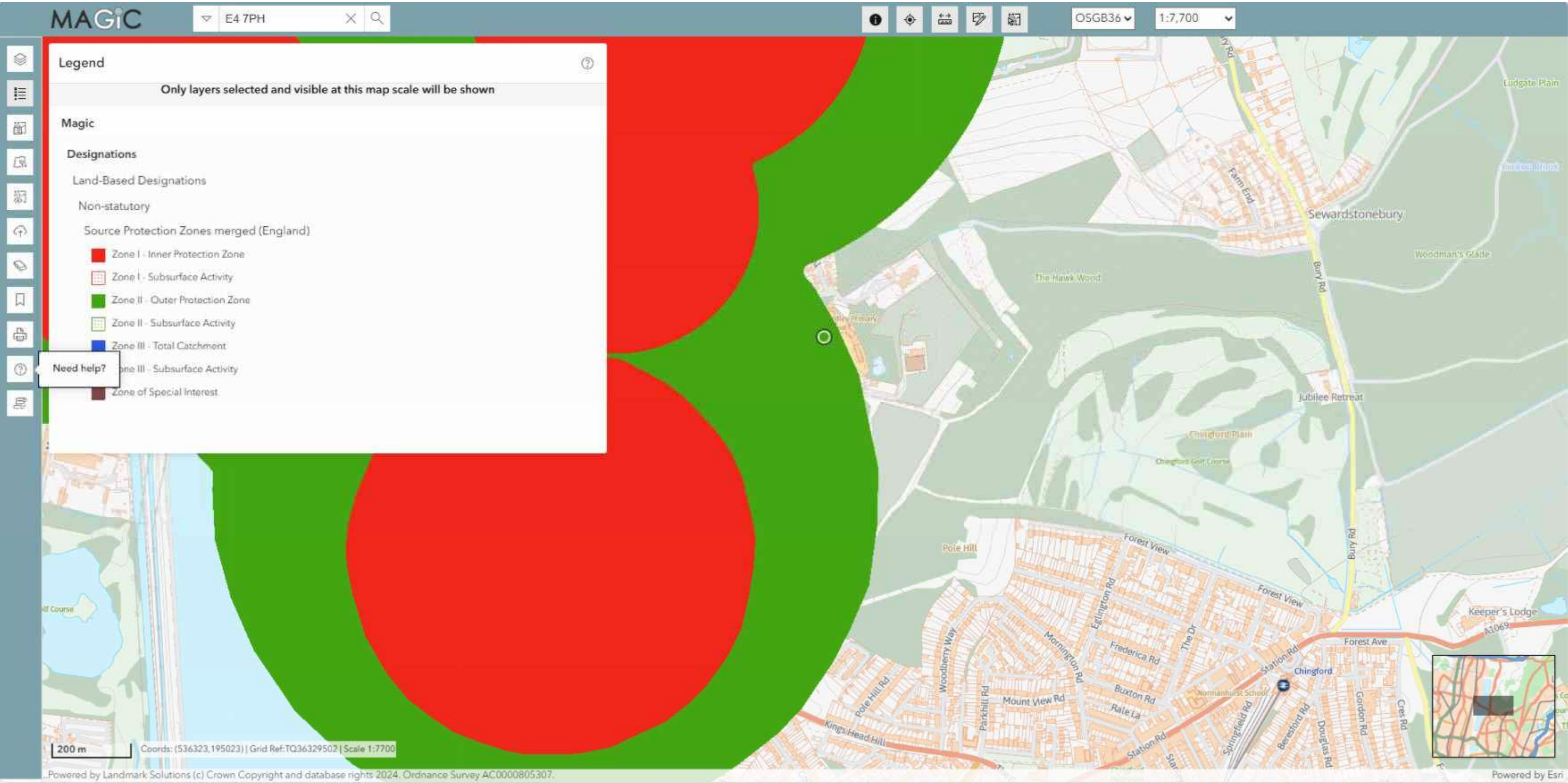
- Selected area
- Flood zone 3
- Flood zone 2
- Flood zone 1
- Flood defence
- Main river
- Water storage area

0 20 40 60m

# Appendix C

Magic Maps Drawings

MAGiC
E4 7PH
OSGB36
1:21,388
Legend
Only layers selected and visible at this map scale will be shown
Magic
Landscape
Geology and Soils
Groundwater Vulnerability Map (England)
Local Information
Soluble Rock Risk
High
Medium - High
Medium
Medium - Low
Low
Unproductive
500 m
Coords: (532596,193673) | Grid Ref:TQ32599367 | Scale 1:21388
Powered by Landmark Solutions (c) Crown Copyright and database rights 2024. Ordnance Survey AC0000805307.
Powered by Esri
Cheshunt


MAGIC
E4 7PH
OSGB36
1:7,700
Legend
Only layers selected and visible at this map scale will be shown
Magic
Designations
Land-Based Designations
Non-statutory
Source Protection Zones merged (England)
Zone I - Inner Protection Zone
Zone I - Subsurface Activity
Zone II - Outer Protection Zone
Zone II - Subsurface Activity
Zone III - Total Catchment
Zone III - Subsurface Activity
Zone of Special Interest
Need help?
Sewardstonebury
Ludgate Plain
Woodman's Glade
The Hawk Wood
Farm End
Bury Rd
Jubilee Retreat
Chingford Plain
Pole Hill
Forest View
Keeper's Lodge
A1069
Forest Ave
Chingford
Station Rd
Frederica Rd
Buxton Rd
Rale La
Mount View Rd
Mornington Rd
Ellington Rd
The Dr
Woodberry Way
Parkhill Rd
Pole Hill Rd
Kings Head Hill
Springfield Rd
Beresford Rd
Douglas Rd
Gordon Rd
Cres Rd
200 m
Coords: (536323,195023) | Grid Ref:TQ36329502 | Scale 1:7700
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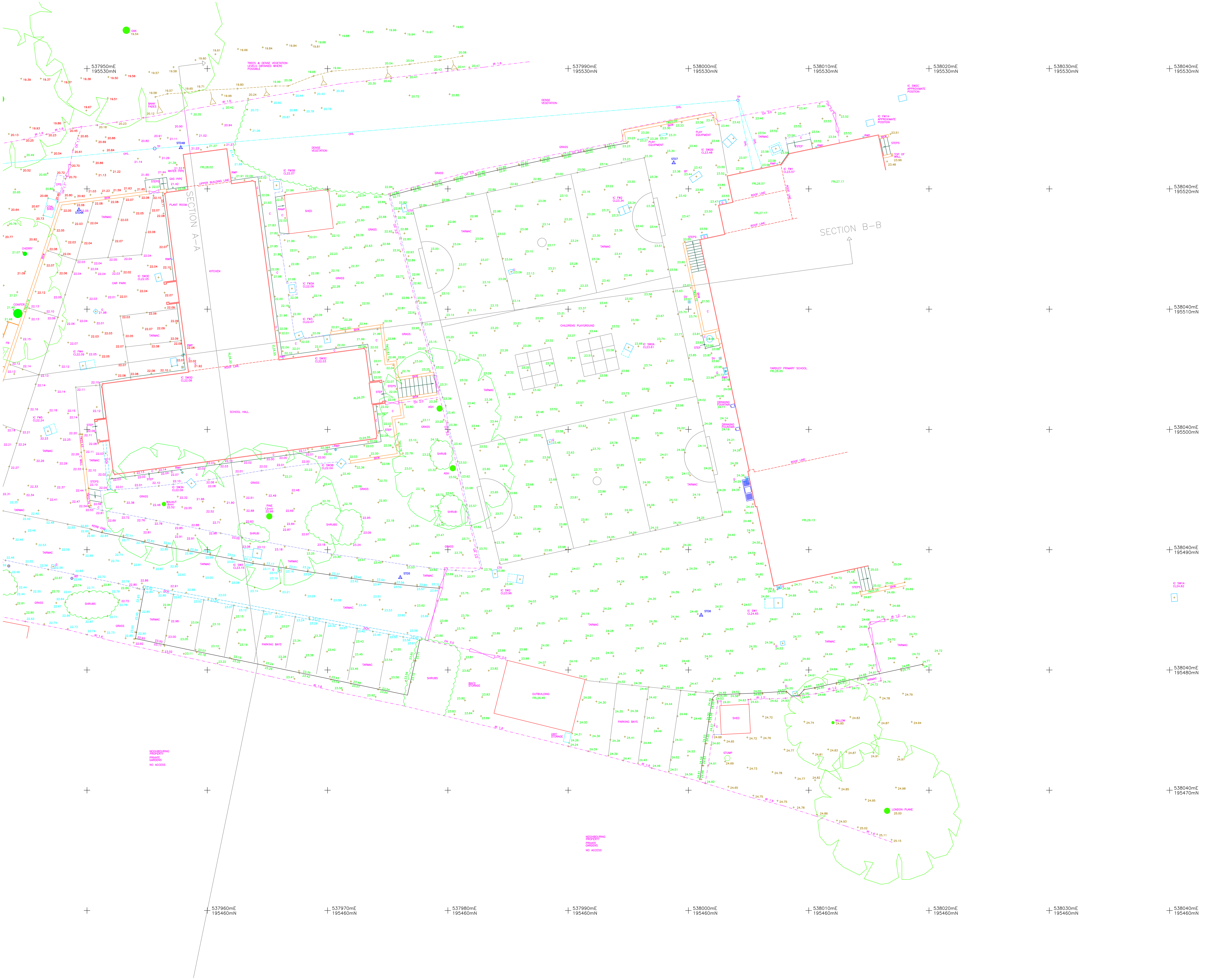
Powered by Esri

# Appendix D
Topo and Services


537890mE 195530mN
537910mE 195530mN
537930mE 195530mN
537940mE 195530mN
537950mE 195530mN
537890mE 195520mN
537890mE 195510mN
537890mE 195500mN
537890mE 195490mN
537890mE 195480mN
537890mE 195470mN
537890mE 195460mN
537960mE 195460mN
537960mE 195450mN
537960mE 195440mN
537890mE 195430mN
537920mE 195430mN
537930mE 195430mN
537940mE 195430mN
537950mE 195430mN
537960mE 195430mN
SECTION B–B
SECTION A–A
SECTION A–A
CARETAKERS HOUSE
SCHOOL HALL
KITCHEN
PLANT ROOM
CAR PARK
OUTBUILDING
OUTBUILDING
SHRUBS
GRASS
TARMAC
PARKING BAYS
NEIGHBOURING PROPERTY PRIVATE GARDENS NO ACCESS
NEIGHBOURING PROPERTY PRIVATE GARDENS NO ACCESS
TREES & DENSE VEGETATION LEVELS OBTAINED WHERE POSSIBLE
SCHOOL KEEP CLEAR
HAWKWOOD CRESCENT
DRYSDALE ROAD
20



SECTION A-A
SECTION B-B
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538030mE 195530mN
538040mE 195530mN
538040mE 195520mN
538040mE 195510mN
538040mE 195500mN
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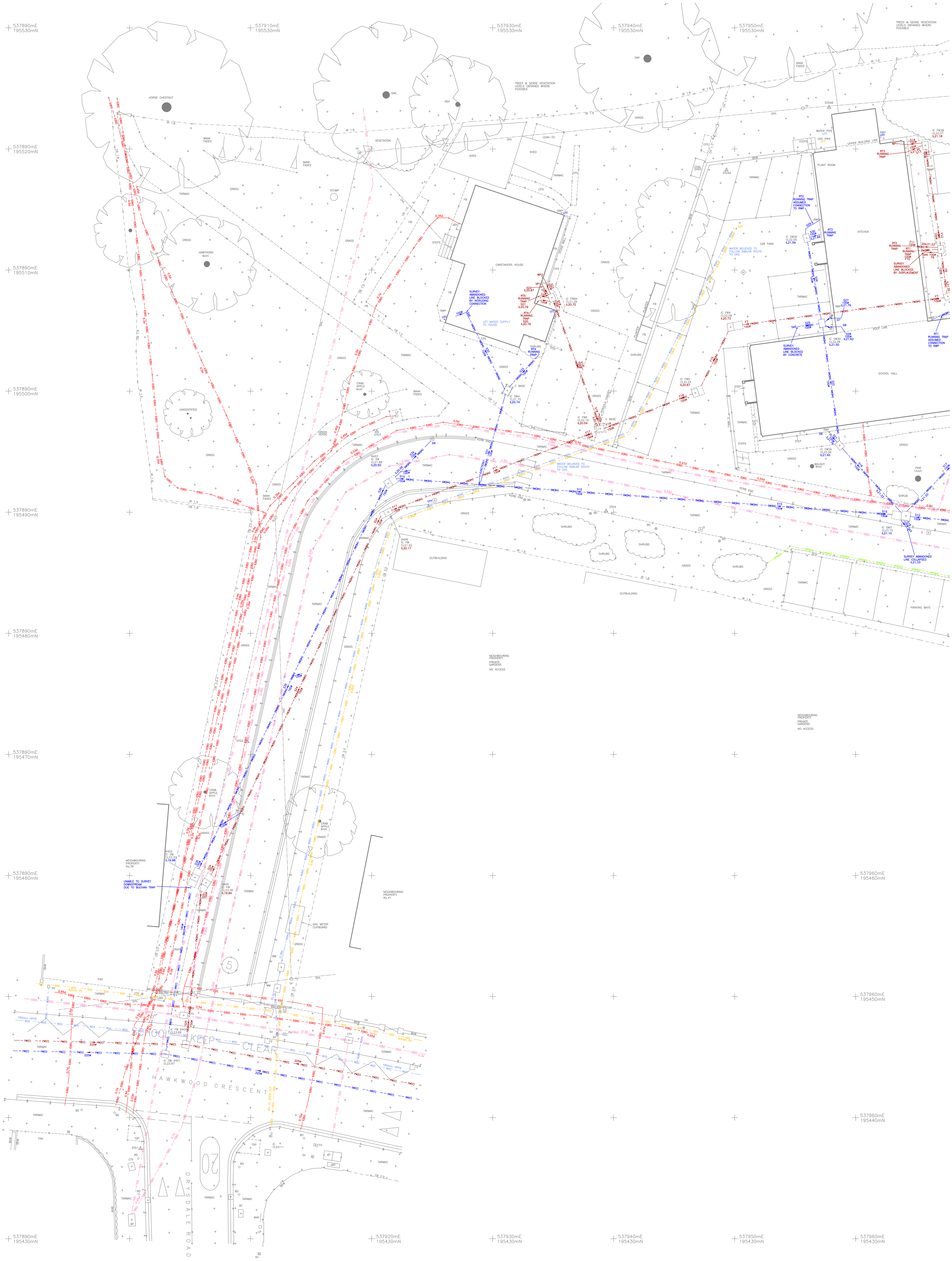

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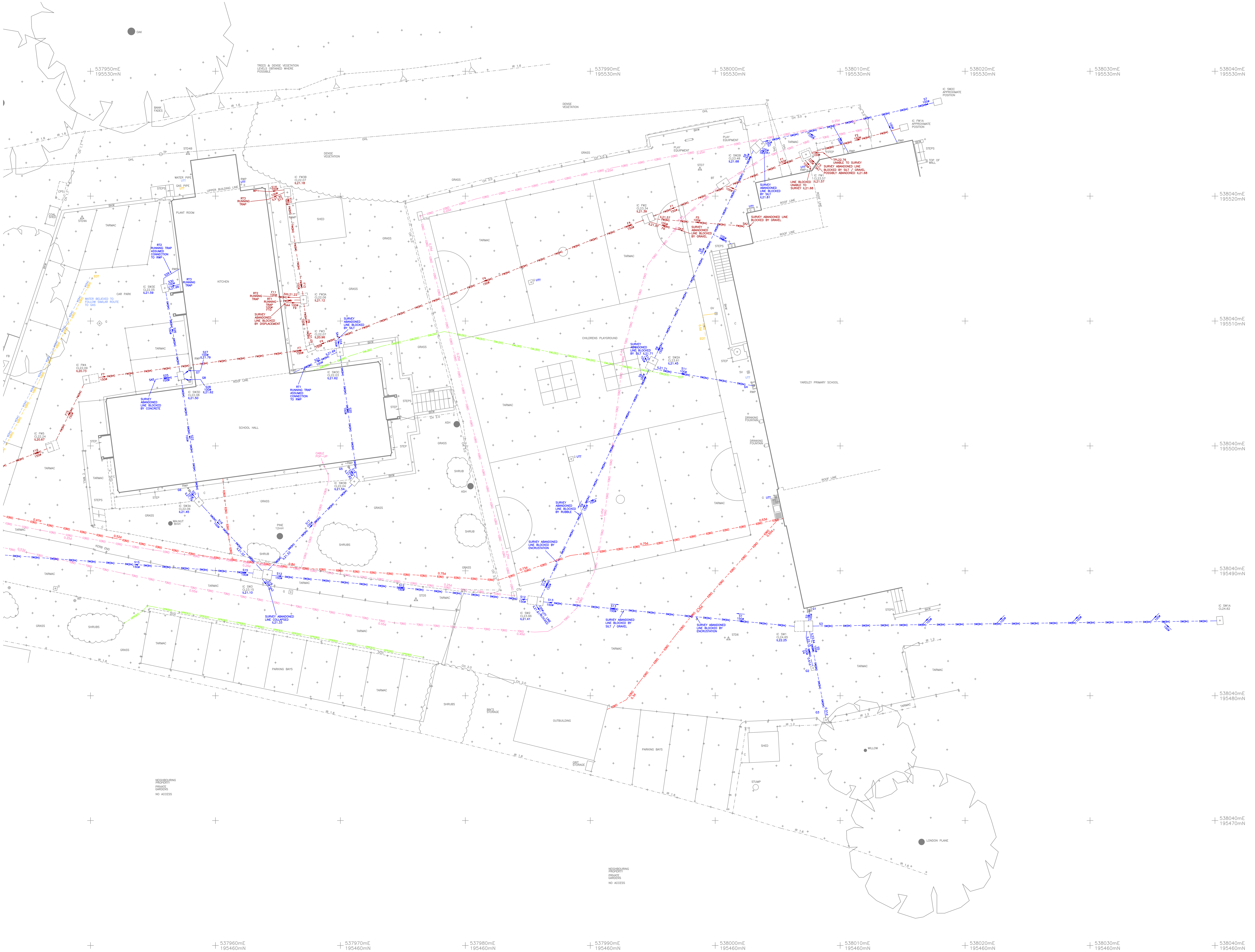
537960mE 195460mN
537960mE 195450mN
537960mE 195440mN
537890mE 195430mN
537920mE 195430mN
537930mE 195430mN
537940mE 195430mN
537950mE 195430mN
537960mE 195430mN
TREES & DENSE VEGETATION LEVELS OBTAINED WHERE POSSIBLE
HORSE CHESTNUT
OAK
ASH
HAWTHORN
CRAB APPLE
UNIDENTIFIED
GRASS
TARMAC
SHED
LEAN-TO
CARETAKERS HOUSE
CAR PARK
PLANT ROOM
KITCHEN
SCHOOL HALL
SHRUBS
OUTBUILDING
PARKING BAYS
NEIGHBOURING PROPERTY PRIVATE GARDENS NO ACCESS
GAS METER CUPBOARD
UNABLE TO SURVEY DOWNSTREAM DUE TO BUCHAN TRAP
WATER BELIEVED TO FOLLOW SIMILAR ROUTE TO GAS
SURVEY ABANDONED LINE COLLAPSED
KEEP CLEAR
HAWKWOOD CRESCENT
DRYSDALE ROAD



537950mE 195530mN
537990mE 195530mN
538000mE 195530mN
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538020mE 195530mN
538030mE 195530mN
538040mE 195530mN
538040mE 195520mN
538040mE 195510mN
538040mE 195500mN
538040mE 195490mN
538040mE 195480mN
538040mE 195470mN
538040mE 195460mN
537960mE 195460mN
537970mE 195460mN
537980mE 195460mN
537990mE 195460mN
538000mE 195460mN
538010mE 195460mN
538020mE 195460mN
538030mE 195460mN
TREES & DENSE VEGETATION LEVELS OBTAINED WHERE POSSIBLE
DENSE VEGETATION
PLANT ROOM
KITCHEN
CAR PARK
SCHOOL HALL
SHED
GRASS
TARMAC
CHILDRENS PLAYGROUND
YARDLEY PRIMARY SCHOOL
PLAY EQUIPMENT
STEPS
SHRUBS
SHRUB
PARKING BAYS
OUTBUILDING
WILLOW
LONDON PLANE
STUMP
NEIGHBOURING PROPERTY PRIVATE GARDENS NO ACCESS

# Appendix E
UK SuDS Tool

hr wallingford

# Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

| | |
|---|---|
| **Calculated by:** | Eitel Tchapdeu |
| **Site name:** | Yardley Primary School |
| **Site location:** | Yardley Primary School, Hawkwood Cresent, London, E4 7PH |

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

## Site Details

| | |
|---|---|
| **Latitude:** | 51.64143° N |
| **Longitude:** | 0.00762° W |
| **Reference:** | 3395724112 |
| **Date:** | Mar 05 2025 16:01 |

## Runoff estimation approach

IH124

## Site characteristics

**Total site area (ha):** 0.102

## Methodology

| | |
|---|---|
| **$Q_{BAR}$ estimation method:** | Calculate from SPR and SAAR |
| **SPR estimation method:** | Calculate from SOIL type |

## Soil characteristics

| | Default | Edited |
|---|---|---|
| **SOIL type:** | 4 | 5 |
| **HOST class:** | N/A | N/A |
| **SPR/SPRHOST:** | 0.47 | 0.53 |

## Hydrological characteristics

| | Default | Edited |
|---|---|---|
| **SAAR (mm):** | 619 | 619 |
| **Hydrological region:** | 6 | 6 |
| **Growth curve factor 1 year:** | 0.85 | 0.85 |
| **Growth curve factor 30 years:** | 2.3 | 2.3 |
| **Growth curve factor 100 years:** | 3.19 | 3.19 |
| **Growth curve factor 200 years:** | 3.74 | 3.74 |

## Notes

### (1) Is $Q_{BAR}$ < 2.0 l/s/ha?

When $Q_{BAR}$ is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

### (2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

### (3) Is SPR/SPRHOST ≤ 0.3?

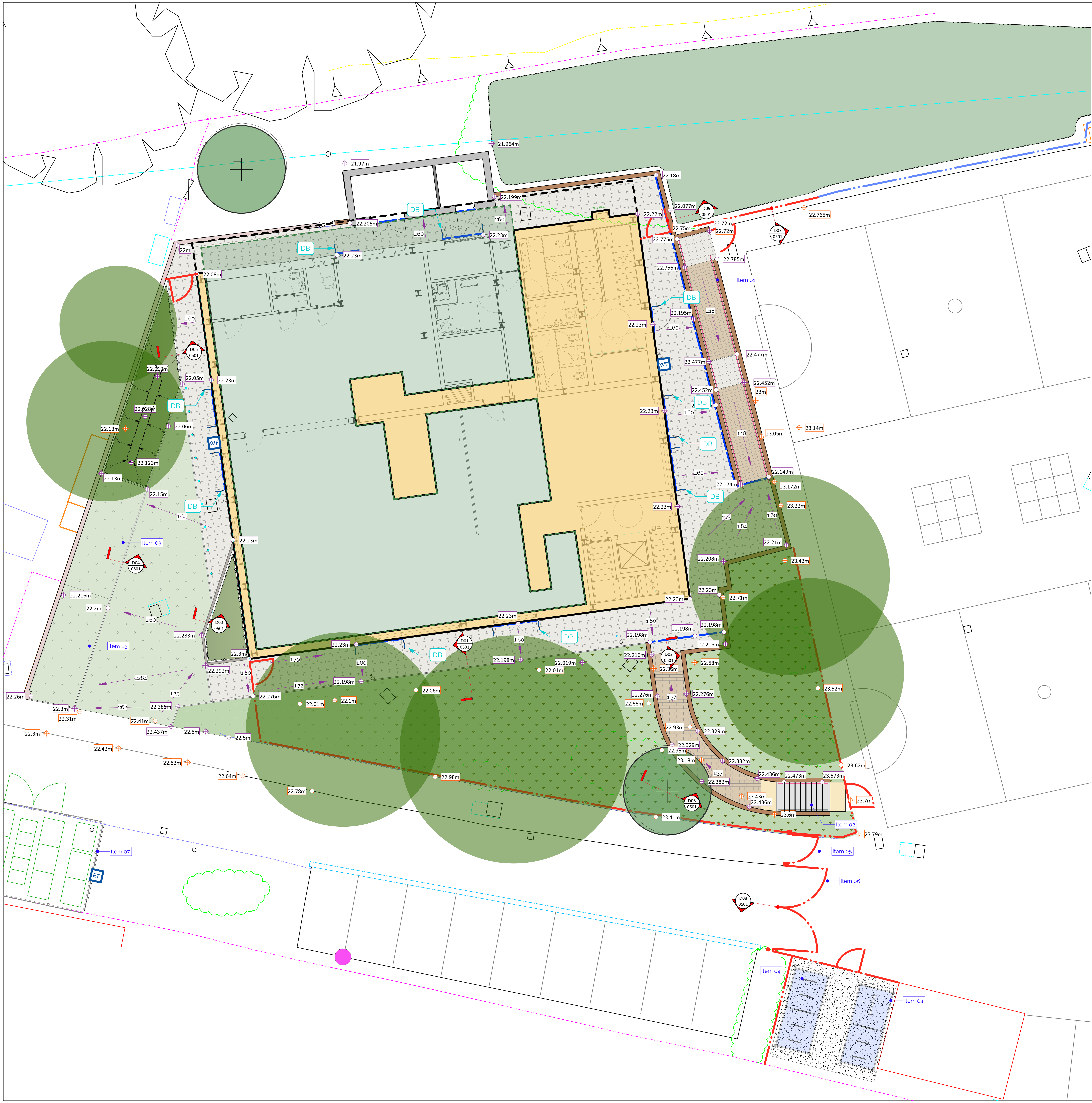
Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

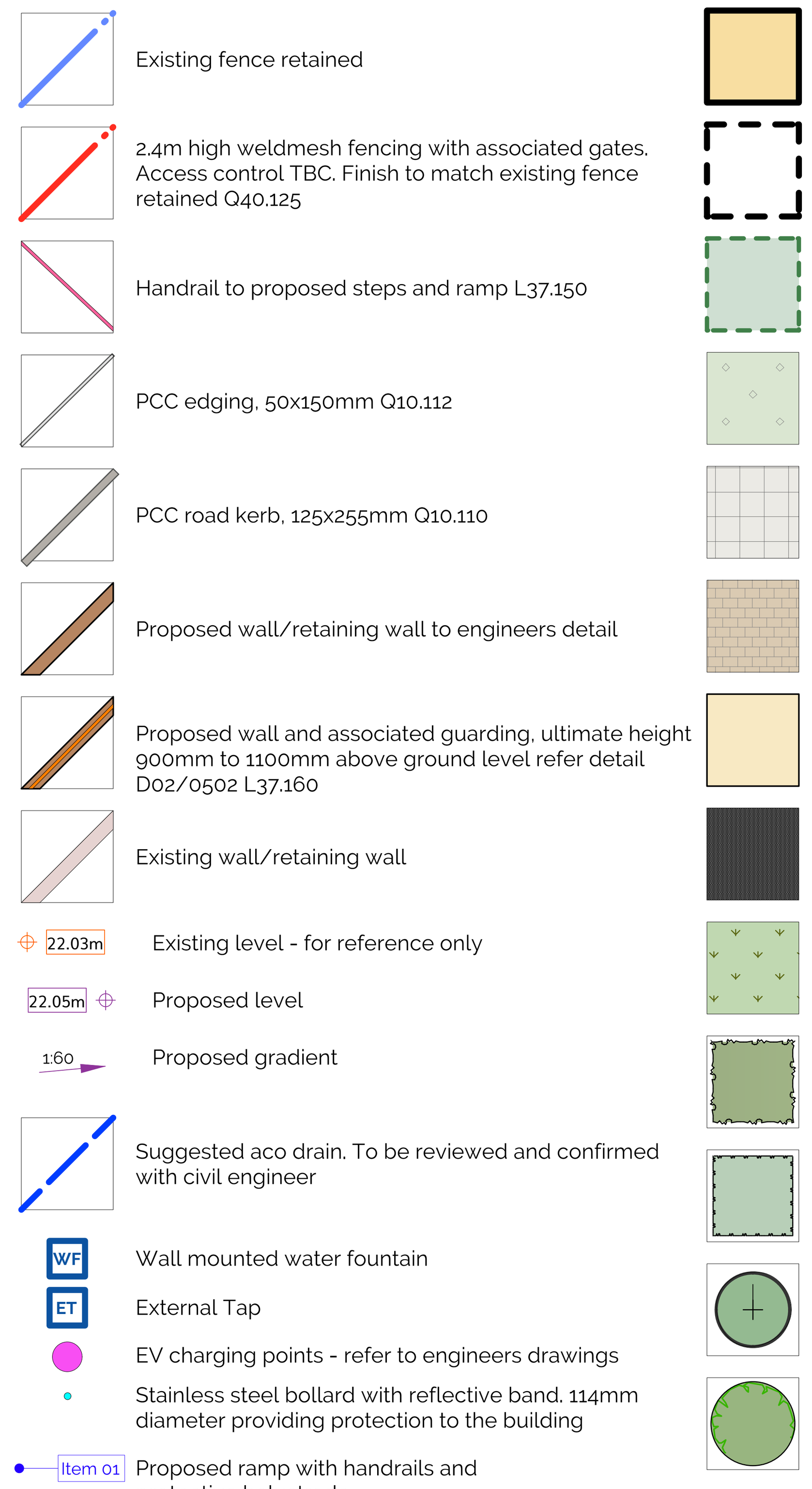
## Greenfield runoff rates

| | Default | Edited |
|---|---|---|
| $Q_{BAR}$ (l/s): | 0.43 | 0.55 |
| **1 in 1 year (l/s):** | 0.36 | 0.47 |
| **1 in 30 years (l/s):** | 0.98 | 1.27 |
| **1 in 100 year (l/s):** | 1.36 | 1.77 |
| **1 in 200 years (l/s):** | 1.59 | 2.07 |

# Appendix F

Proposed Site Layout and Drainage Strategy



Existing fence retained

2.4m high weldmesh fencing with associated gates. Access control TBC. Finish to match existing fence retained Q40.125

Handrail to proposed steps and ramp L37.150

PCC edging, 50x150mm Q10.112

PCC road kerb, 125x255mm Q10.110

Proposed wall/retaining wall to engineers detail

Proposed wall and associated guarding, ultimate height 900mm to 1100mm above ground level refer detail D02/0502 L37.160

Existing wall/retaining wall

22.03m Existing level - for reference only

22.05m Proposed level

1:60 Proposed gradient

Suggested aco drain. To be reviewed and confirmed with civil engineer

WF Wall mounted water fountain

ET External Tap

EV charging points - refer to engineers drawings

Stainless steel bollard with reflective band. 114mm diameter providing protection to the building

Item 01 Proposed ramp with handrails and protective balustrade

Item 02 Stepped access down to the new building. 8 steps at 150mm risers. Steps to have hazard warning paving located at the top and bottom of the steps. Steps to have hazard warning inlays.

Item 03 Reinforced grass parking bay

Item 04 2 no. BROXAP - Sheffield Junior Cycle Stores. Shelter 1: 5 hoops/10 cycle spaces Q50.210 Shelter 2: 3 hoops/6 cycle spaces and 1 scooter rack providing 10 spaces Q50.216 Total: 16 cycle spaces in total and 10 scooter spaces B91.340

Item 05 New pedestrian gate

Item 06 New double leaf vehicle gates

Item 07 Proposed bin store. Refer to architects information

DB Door barrier. BROXAP or similar Q50.210A

Proposed building

Roof overhang

Extent of green roof - refer to architect plan

Reinforced grass paving Q23.170 Q30.310

Tobermore Mayfair PCC flag paving 450x450x50mm. Colour: Silver Q25.315

Tobermore Tegula Trio block paving. 197x173x50mm,173x173x50mm, 130x173x50mm. Colour: Golden Q24.119

Corduroy hazard warning paving 400x400x50mm. Colour: Buff Q25.320B

Cast in situ concrete paving to new cycle stores to engineers specification

Wildflower meadow planting. Refer to drawing 2530-WWA-ZZ-ZZ-D-L-0301

Ornamental planting. Refer to drawing 2530-WWA-ZZ-ZZ-D-L-0301 Q31

Existing vegetation retained

Proposed tree planting. Refer to drawing 2530-WWA-ZZ-ZZ-D-L-0301 D06/0501 Q30.500

Existing tree retained and protected during works

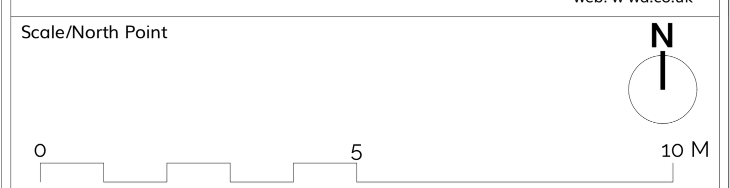
| No. | Date | Appr | Revision Notes |
|---|---|---|---|
| P 10 | 11/11/25 | BB | Steps omitted |
| P 09 | 04/11/25 | | FFL lifted and levels and layout amended to suit |
| P 08 | 09/09/25 | AH | Tender issue - spec references added |
| P 07 | 05/09/25 | AH | Tender issue |
| P 06 | 26/06/25 | AH | One tree omitted following ecologist advice for overall BNG enhancement |
| P 05 | 23/05/25 | BB | Aco drains shown at door thresholds |

Note: All Dimensions must be checked on site and not scaled from this drawing.
All cross references are to the latest revision of the relevant drawing or specification being referenced



wynne-williams associates
landscape architects & arboricultural consultants
tel: 01376 573050
web: wwa.co.uk

Scale/North Point




Client
Norse Group

Job Title
Yardley Primary School

Drawing Title
Landscape Masterplan

Issue
TENDER

Scale
1:100@A1

Drawn
AH

Checked
LD

Project ID
2530

Date
03/12/2024

Drg
2530-WWA-ZZ-ZZ-D-L-0101

Status
S4

Rev
P10

**Storm Design Details**

| | |
|---|---|
| Blue Roof | = 480m² |
| Patio Area | = 185m² |
| Private Highway | = 127m² |
| Private Parking | = 28m² |
| Total | = 820m² |

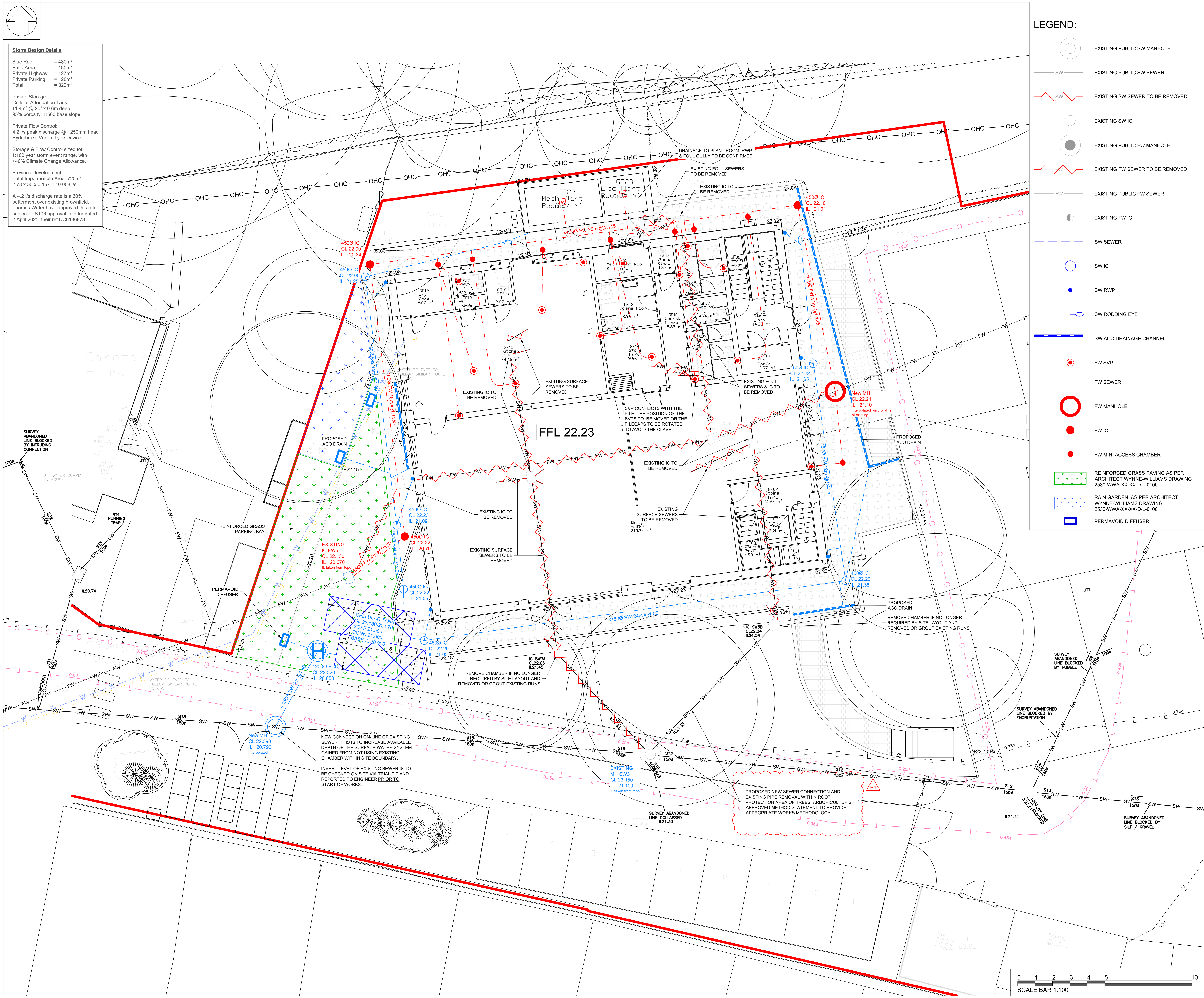
Private Storage:
Cellular Attenuation Tank,
11.4m³ @ 20² x 0.6m deep
95% porosity, 1:500 base slope.

Private Flow Control:
4.2 l/s peak discharge @ 1250mm head
Hydrobrake Vortex Type Device.

Storage & Flow Control sized for:
1:100 year storm event range, with
+40% Climate Change Allowance.

Previous Development:
Total Impermeable Area: 720m²
2.78 x 50 x 0.157 = 10.008 l/s

A 4.2 l/s discharge rate is a 60% betterment over existing brownfield. Thames Water have approved this rate subject to S106 approval in letter dated 2 April 2025, their ref DC6136878






## SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

IN ADDITION TO THE HAZARDS/RISKS NORMALLY ASSOCIATED WITH THE TYPES OF WORK DETAILED ON THIS DRAWING, NOTE THE FOLLOWING

CONSTRUCTION

1. UNKNOWN UTILITIES ONSITE
2. EXISTING DRAINAGE ONSITE IS RELATIVELY UNKNOWN - THERE MAY BE UNKNOWN EXISTING DRAINAGE IN THE GROUND
3. EXISTING FOUNDATIONS MAY BE IN THE GROUND

MAINTENANCE

-

DEMOLITION

1. UNKNOWN UTILITIES ONSITE
2. EXISTING DRAINAGE ONSITE IS RELATIVELY UNKNOWN - THERE MAY BE UNKNOWN EXISTING DRAINAGE IN THE GROUND
3. EXISTING FOUNDATIONS MAY BE IN THE GROUND

ALL WORKS TO BE CARRIED OUT BY A COMPETENT CONTRACTOR, WORKING (WHERE APPROPRIATE) TO AN APPROVED METHOD STATEMENT

## GENERAL NOTES:

1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL THE RELEVANT ARCHITECTS, ENGINEERS' AND SERVICE ENGINEERS DRAWINGS & SPECIFICATIONS.
2. ALL UNITS IN MILLIMETERS U.N.O. ON THE DRAWING.
3. DO NOT SCALE OFF THE DRAWING.
4. THE WORKS DESCRIBED AND SPECIFIED ON THIS DRAWING AND ASSOCIATED DRGS SHALL BE UNDERTAKEN IN ACCORDANCE WITH ALL CURRENT HEALTH AND SAFETY LEGISLATION AND THE PROJECT HEALTH & SAFETY PLAN, PREPARED BY THE PLANNING SUPERVISOR FOR THE PROJECT.
5. WHERE NOTES AND INFORMATION ON THIS DRG DIFFER FROM THE SPECIFICATION, CLARIFICATION SHOULD BE SOUGHT FROM THE ENGINEER.
6. ALL PIPES, MANHOLES, GULLIES, ACCESS FITTINGS ETC, ARE TO BE MATERIALS COMPLYING WITH THE BUILDING REGULATIONS. WHERE DRAINAGE IS TO BE ADOPTED, THESE SHALL ALSO COMPLY WITH SEWERAGE SECTOR GUIDANCE APPENDIX C.
7. PIPE BEDDING TO BE IN ACCORDANCE WITH THE MANUFACTURES RECOMMENDATIONS, TAKING ACCOUNT OF THE DEPTH AND LOADINGS IN RELATION TO THE PIPE STRENGTH AND MODIFIED IF NECESSARY. WHERE BELOW GROUND WATER LEVEL IS ABOVE THE PIPE THE MAIN CONTRACTOR IS TO ISSUE BEDDING PROPOSALS TO THE ENGINEER FOR CONSIDERATION.
8. PIPES ENTERING AND EXITING MANHOLES ARE TO HAVE LEVEL SOFFITS U.N.O.
9. DETAILS OF EXISTING SEWERS SHALL BE CONFIRMED BY THE CONTRACTOR ON SITE PRIOR TO THE COMMENCEMENT OF WORKS. THE CONTRACTOR SHOULD CHECK THE LEVELS OF ALL NEW OUTFALLS IN RELATION TO EXISTING SEWERS PRIOR TO CONSTRUCTION OF ANY DRAINAGE TO ENSURE THE PROPOSED DESIGN MAY BE ACHIEVED. ANY DISCREPANCIES TO REPORTED TO THE ENGINEER.
10. BEFORE EXCAVATION COMMENCES, THE CONTRACTOR SHALL ASCERTAIN THE DEPTHS, SIZES AND LOCATIONS OF ALL SERVICES TO BE CROSSED. ANY CONFLICT IN LEVELS BETWEEN NEW AND EXISTING SEWERS TO BE NOTIFIED TO THE ENGINEER.
11. REFER TO ARCHITECTS DRAWINGS FOR POSITIONS OF SOIL VENT PIPES, STUB STACKS , RAINWATER PIPES AND INTERNAL GULLIES.
12. ALL ROAD GULLY CONNECTIONS TO BE Ø150, LAID NO FLATTER THAN 1:80 U.N.O. ALL ROOF DRAINAGE CONNECTIONS TO BE Ø100, LAID NO FLATTER THAN 1:40 U.N.O.
13. ADOPTABLE DRAINAGE:
    - 13.1. NO WORKS ARE TO BE UNDERTAKEN TO THE PUBLIC SEWER UNTIL THE APPROPRIATE S106 CONNECTION APPLICATIONS HAVE BEEN MADE AND ISSUED BY THE STATUTORY AUTHORITY FOR THE WORKS.
    - 13.2. ADOPTED DRAINAGE PIPEWORK TO BE HEPWORTH SUPERSLEEVE VITRIFIED CLAY DRAINAGE SYSTEM TO BS EN 295 OR SIMILAR. ALL JOINTS TO BE FLEXIBLE, PIPES TO BE LAID IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS.
14. PRIVATE DRAINAGE PIPEWORK TO BE EITHER HEPWORTH SUPERSLEEVE VITRIFIED CLAY DRAINAGE SYSTEM TO BS EN 295 (OR SIMILAR) OR HEPWORTH UPVC DRAINAGE SYSTEM TO BS EN 1401 (OR SIMILAR). ALL JOINTS TO BE FLEXIBLE, PIPES TO BE LAID IN ACCORDANCE WITH MANUFACTURERS RECOMMENDATIONS. UPVC PIPES TO BE LAID IN SHORT LENGTH MAXIMUM 3.0 m DUE TO HEAVE POTENTIAL.
15. ONLY EXISTING DRAINAGE INFRASTRUCTURE TO BE MAINTAINED AS PART OF THE WORKS IS INDICATED ON THIS DRAWING. ALL EXISTING DRAINAGE INFRASTRUCTURE TO BE MADE REDUNDANT TO BE CONFIRMED AS SUCH PRIOR TO COMMENCING THE WORKS. REFER TO THE SITE CLEARANCE DRAWING FOR DETAILS OF DRAINAGE INFRASTRUCTURE TO BE TAKE UP AND REMOVED TO TIP OFF SITE.
16. ALL FLOWS FROM EXISTING BUILDINGS SHALL BE MAINTAINED DURING CONSTRUCTION U.N.O ON THE DRAWING.
17. EXTERNAL CHANNEL DRAINS TO BE TRAPPED AND RODDABLE WITH LEAF/GRIT BASKET.

| Rev | Description | By | Date | Chkd |
|---|---|---|---|---|
| P4 | LEVELS AROUND SITE UPDATED TO SUIT SURVEY. NOTE FROM LOCAL AUTHORITY PLANNING TREE OFFICER ADDED. | ET | 27/09/2025 | RGM |
| P3 | DRAWING UPDATED TO LLFA COMMENTS. BUILDING FFL RAISED, FLOOD ROUTE AND RAIN GARDENS INTRODUCED. | ET | 26/09/2025 | RGM |
| P2 | DRAINAGE UPDATED TO AVOID CLASHES WITH FOUNDATION. | AS | 10/09/2025 | RGM |
| P1 | ISSUED FOR INFORMATION | ET | 30/04/2025 | RGM |

PEREGA

Quarry Court, Lime Quarry Mews, Guildford, GU1 2RD 01483 565 886

Client
EVOLVE NORSE

Project
YARDLEY PRIMARY SCHOOL
1FE EXPANSION

Title
OUTLINE PROPOSED DRAINAGE STRATEGY

| Perega Project No. | Checked | Passed | Size | Scale |
|---|---|---|---|---|
| C13942 | RGM | GS | A1 | 1:100 |

| Project Code | Originator | Zone | Level | Type | Role | Drawing No. |
|---|---|---|---|---|---|---|
| C13942 | PER | XX | XX | DR | C | 02001 |

| Suitability Code | Status | Revision |
|---|---|---|
| S2 | INFORMATION | P4 |

PEREGA

# Appendix G

Strategic Flood Risk Assessment

AECOM Imagine it. Delivered.

# Level 2 Strategic Flood Risk Assessment

London Borough of Waltham Forest

Final Report

Project number: 60633725

October 2021

## Quality information

| Prepared by | Checked by | Verified by | Approved by |
|---|---|---|---|
| Lauren Lewis<br>Water Consulting Apprentice<br><br>Miguel Headley<br>Graduate Engineer | Sarah Littlewood<br>Principal Consultant | Emily Craven<br>Associate | Sarah Littlewood<br>Principal Consultant |

## Revision History

| Revision | Revision date | Details | Authorized | Name | Position |
|---|---|---|---|---|---|
| 1 | 4th November 2020 | Draft Report | EC | Emily Craven | Associate |
| 2 | 13th October 2021 | Final Report | EC | Emily Craven | Associate |
| | | | | | |
| | | | | | |

## Distribution List

| # Hard Copies | PDF Required | Association / Company Name |
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| | | |

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# Table of Contents



# Tables

# 1. Introduction

## 1.1 Terms of reference

1.1.1 AECOM has been commissioned by the London Borough of Waltham Forest to prepare a Level 2 Strategic Flood Risk Assessment (SFRA).

## 1.2 Project Background

1.2.1 The National Planning Policy Framework[1] (NPPF) and associated Planning Practice Guidance for Flood Risk and Coastal Change (PPG)[2] set out the active role Local Planning Authorities (LPAs) should take to ensure that flood risk is understood and managed effectively and sustainably throughout all stages of the planning process. The NPPF outlines that Local Plans should be supported by a Strategic Flood Risk Assessment (SFRA) and LPAs should use the findings to inform strategic land use planning. The overall approach of the NPPF to flood risk is broadly summarised Paragraph 103:

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

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

## 1.3 Level 1 SFRA

1.3.1 A Level 1 SFRA report has been prepared for London Borough of Waltham Forest[3]. The purpose of the Level 1 SFRA is to collate and analyse the most up to date readily available flood risk information for all sources of flooding and provide an overview of flood risk issues across the study area.

1.3.2 The Level 1 SFRA provides guidance on:

- The application of the Sequential Test by the LPA when allocating future development sites to inform their Local Plan, as well as by developers promoting development on windfall sites.
- Managing and mitigating flood risk, the application of sustainable drainage systems (SuDS), and the preparation of site-specific Flood Risk Assessments (FRAs).
- Potential flood risk management objectives and policy considerations which may be developed and adopted by the London Borough of Waltham Forest as formal policies within their developing Local Plans.

1.3.3 Using the strategic flood risk information presented within the Level 1 SFRA, London Borough of Waltham Forest were provided with guidance on how to undertake the Sequential Test and document the process whereby future development is steered towards areas of lowest flood risk.

[1] Department for Communities and Local Government. 2012. *National Planning Policy Framework*. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2
[2] Department for Communities and Local Government. 2014. *Planning Practice Guidance: Flood Risk and Coastal Change.* Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/
[3] AECOM, October 2018, London Borough of Waltham Forest Level 1 Strategic Flood Risk Assessment.

## 1.4 Exception Test

1.4.1 Where it is not possible to accommodate potential development sites outside those areas identified to be at risk of flooding, the Exception Test may be required, as set out in Table 1-1. The purpose of the Exception Test is to ensure that where it may be necessary to locate development in areas at risk of flooding, new development is only permitted in Flood Zone 2 and Flood Zone 3 where the flood risk is clearly outweighed by other sustainability factors and where the development will be safe during its lifetime, considering climate change.

1.4.2 The NPPF states that for the Exception Test to be passed:

- *Part 1 - "It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by the SFRA where one has been prepared; and*
- *Part 2 - A site-specific Flood Risk Assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall."*

1.4.3 Both elements of the test will have to be passed for development to be allocated or permitted.

1.4.4 In order to determine Part 1 of the Exception Test, applicants should assess their scheme against the objectives set out in the LPA's Sustainability Appraisal[4]. In order to demonstrate satisfaction of Part 2 of the Exception Test, relevant flood risk management and mitigation measures should be applied and demonstrated within a site-specific flood risk assessment (FRA). Chapter 5 'Managing and Mitigating Flood Risk through Spatial Planning and Development Control' and Chapter 6 'Guidance for Developers' within the Level 1 SFRA should be referred to in order to support Part 2 of the Exception Test.

**Table 1-1 Flood risk vulnerability and Flood Zone 'compatibility' (PPG, 2014)**

| Flood Risk Vulnerability Classification | | Essential Infrastructure | Water Compatible | Highly Vulnerable | More Vulnerable | Less Vulnerable |
|---|---|---|---|---|---|---|
| Flood Zone | 1 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 2 | ✓ | ✓ | Exception Test Required | ✓ | ✓ |
| | 3a | Exception Test Required | ✓ | × | Exception Test Required | ✓ |
| | 3b | Exception Test Required | ✓ | × | × | × |

✓ - Development is appropriate × - Development should not be permitted

[4] London Borough of Waltham Forest, March 2020, Sustainability Appraisal Scoping Report. https://www.walthamforest.gov.uk/sites/default/files/C0232_Waltham%20Forest%20Site%20Allocations%20SA%20Scoping%20Report_2_0.pdf

# 2. Level 2 SFRA

## 2.1 Datasets

2.1.1 This report comprises the Level 2 SFRA for the London Borough of Waltham Forest. The scope of the Level 2 SFRA is to consider the detailed nature of the flood characteristics within a flood zone including, where appropriate and the data is available:

- flood probability
- flood depth
- flood velocity
- rate of onset of flooding, and
- duration of flood.

2.1.2 For the Waltham Forest study area, the following sources of information have been obtained.

### River Lee Modelling

2.1.3 Modelling of the River Lee was supplied by the Environment Agency from the River Lee 2D Modelling and Mapping Study, August 2014[5]. Outputs from the study included flood extents, maximum flood depths and hazard rating information for a range of annual exceedance probability (AEP) events. Within this study, climate change was considered for the 1% AEP event by increasing peak flows in the hydrological boundaries by 20% in accordance with the Environment Agency guidance 2011 and UKCIP09.

2.1.4 In February 2016, (after completion of the River Lee modelling in 2014), climate change guidance was published[6], which outlined that within the Thames river basin district, climate change allowances of +25%, +35% and +70% should be considered when planning for future development.

2.1.5 As part of an Environment Agency led project (WEM Lot 3 HNL Dagenham Brook Flood Alleviation Scheme), the modelling of the River Lee was updated. Models M03 and M04 from the original River Lee modelling were combined and re-run for the project, including model simulations for the 1% AEP event including +25%, +35% and +70% allowances for climate change[7]. The baseline model outputs from this project have been used to inform this Level 2 SFRA.

2.1.6 **Since the preparation of the draft version of this Level 2 SFRA, the climate change allowances that should be used in flood risk assessments were revised again, in July 2021[8]. The Waltham Forest study area is within the London Management Catchment, within which the climate change allowances have been reduced and are as follows:**

- **2080s 'Central' allowance +17% (previously +25%)**
- **2080s 'Higher central' allowance +27% (previously +35%)**
- **2080s 'Upper End' allowance +54% (previously +70%)**

2.1.7 **The guidance states that the central (+17%) and higher central (+27%) allowances should be used in SFRAs. The assessments provided in this SFRA for the River Lee are therefore conservative in their assessment of the future risk of river flooding (as they refer to the former higher central +35% and upper end +70%). Site specific FRAs for individual development sites should make reference to the most up to date climate change allowances (available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances) depending on the Flood Zone in which the site is located and vulnerability classification of the proposed development.**

[5] CH2MHill for the Environment Agency, August 2014, River Lee 2D Modelling and Mapping Technical Report.
[6] Flood risk assessments: climate change allowances, February 2016 https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[7] AECOM, March 2017, WEM Lot 3 HNL Dagenham Brook Flood Alleviation Scheme. Technical Note: Update of Environment Agency Dagenham Brook Hydraulic Model.
[8] Flood risk assessments: climate change allowances, July 2021 https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

2.1.8 Maps showing the maximum flood depths and hazard ratings for the 1% AEP including +35% allowance for climate change are included in the site proformas where required. The 1% AEP flood extent including +70% allowance for climate change has also been reviewed during the preparation of the site proformas, to determine where sites may be at particular increased risk during this scenario. It is noted that information on the rate of onset of flooding and the duration of flooding has not been made available from this dataset.

2.1.9 Flood 'hazard' categorises the danger to people for different combinations of flood water depth and velocity. The derivation of these categories is based on the methodology set out by Defra in Flood Risks Assessment Guidance for New Development FD2320/TR2[9] using the following equation:

*Flood Hazard Rating = ((v+0.5)*D) + DF Where v = velocity (m/s), D = depth (m), DF = debris factor*

| Flood Hazard | | Description |
|---|---|---|
| **Low** | HR < 0.75 | Caution – Flood zone with shallow flowing water or deep standing water |
| **Moderate** | 0.75 ≥ HR ≤ 1.25 | Dangerous for some (i.e. children) – Danger: flood zone with deep or fast flowing water |
| **Significant** | 1.25 > HR ≤ 2.0 | Dangerous for most people – Danger: flood zone with deep fast flowing water |
| **Extreme** | HR > 2.0 | Dangerous for all – Extreme danger: flood zone with deep fast flowing water |

## Ching Brook Modelling

2.1.10 Modelling of the Ching Brook was included within the modelling of the River Lee that was supplied by the Environment Agency from the River Lee 2D Modelling and Mapping Study, August 2014[5]. The Ching Brook is model reference M13. The model only included one climate change scenario, which was the 1% AEP event including 20% increase in peak river flow.

2.1.11 AECOM, on behalf of London Borough of Waltham Forest, re-ran the Ching Brook model for additional climate change allowances. As the work was initiated prior to the release of the 2021 climate change allowances, the +25%, +35% and +70% allowances were applied to the 1% AEP event and re-run. The +35% CC scenario (referred to as the design flood at that time) is the primary output that has been mapped and referenced within the Level 2 SFRA site assessments.

2.1.12 Some alterations were required to the model build to run the +70% scenario. AECOM have prepared a short technical note detailing the steps undertaken to rerun the model which has been sent to the Environment Agency for reference. This is included in Appendix C.

2.1.13 **Consultation with the Environment Agency with respect to the Ching Brook model throughout the preparation of this Level 2 SFRA has identified that in order for the Ching Brook model to better represent flood risk in the catchment, updated hydrology is required for the model as well as updated channel survey and LiDAR topographic survey of the floodplain. The Ching Brook modelling is scheduled to be updated as part of the Environment Agency's Lee 2100 modelling project, however outputs are not expected until mid/late 2022 and the modelling is only intended to be used at a strategy-level, rather than for site specific flood risk assessments.**

2.1.14 **In order to progress the SFRA, it has been agreed with the Environment Agency that the existing Ching Brook modelling can be considered acceptable for use provided it overestimates the flood risk during the 1% AEP, plus an allowance for climate change, flood event, but it is also noted that a more site-specific and detailed assessment of flood risk from the Ching Brook may be required for future individual planning applications.**

2.1.15 **Since the preparation of the draft version of this Level 2 SFRA, the climate change allowances that should be used in flood risk assessments were revised again, in July 2021[8]. The Waltham Forest study area is within the London Management Catchment, within which the climate change allowances have been reduced and are as follows:**

- **2080s 'Central' allowance +17% (previously +25%)**
- **2080s 'Higher central' allowance +27% (previously +35%)**
- **2080s 'Upper End' allowance +54% (previously +70%)**

[9] Defra and Environment Agency (2005) FD2320/TR2 Flood Risk Assessment Guidance for New Development.

2.1.16 **The guidance states that the central (+17%) and higher central (+27%) allowances should be used in SFRAs. The assessments made for the Ching Brook and provided in this SFRA are therefore conservative in their assessment of the future risk of river flooding (as they refer to the former higher central +35% and upper end +70%). Site specific FRAs for individual development sites should refer to the most up to date climate change allowances (available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances) depending on the Flood Zone in which the site is located and vulnerability classification of the proposed development.**

2.1.17 Maps showing the maximum flood depths and hazard ratings for the 1% AEP including +35% allowance for climate change are included in the site proformas where required. The 1% AEP flood extent including +70% allowance for climate change has also been reviewed during the preparation of the site proformas, to determine where sites may be at particular increased risk during this scenario.

2.1.18 It is noted that information on the rate of onset of flooding and the duration of flooding has not been made available from the Ching Brook dataset.

# Risk of Flooding from Surface Water

## Flood Extents

2.1.19 The outputs of the Environment Agency's Risk of Flooding from Surface Water (RoFSW) mapping include GIS layers showing the extent of flooding from surface water that could result from a flood with a 3.33%, 1% and 0.1% chance of happening in any given year.

2.1.20 It is noted that the Risk of Flooding from Surface Water is not to be used at property level. Because of the way they have been produced and the fact that they are indicative, the maps are not appropriate to act as the sole evidence for any specific planning or regulatory decision or assessment of risk in relation to flooding at any scale without further supporting studies or evidence. However, the mapping provides a useful source of information to identify the risk of surface water flooding to the wider area in which a site is located, and the general patterns of surface water flow and ponding.

## Critical Drainage Areas

2.1.21 Critical Drainage Areas (CDAs) are defined in the Waltham Forest Surface Water Management Plan[13] and Level 1 SFRA[3] as 'a discrete geographic area (usually within an urban setting) where there may be multiple and interlinked sources of flood risk and where severe weather is known to cause flooding of the area thereby affecting people, property or local infrastructure'. The CDAs for the London Borough of Waltham Forest are not restricted to Flood Zone 1.

# Groundwater Flooding

## Areas Susceptible to Groundwater Flooding

2.1.22 Areas Susceptible to Groundwater Flooding (AStGWF) is an Environment Agency dataset included within the Level 1 SFRA[3]. It is a strategic scale map showing where groundwater flooding could occur. It shows the proportion of each 1km grid square where geological and hydrogeological conditions show that groundwater flooding could occur.

2.1.23 The susceptible areas are represented by one of four categories showing the proportion of each 1km square that is susceptible to groundwater emergence. It does not show the likelihood of groundwater flooding occurring.

- <25%
- >=25%<50%
- >=50%<75%
- >=75%

2.1.24 The absence of values for any grid square means that no part of that square is identified as being susceptible to groundwater emergence.

2.1.25 The map identifies areas where further investigation is needed to assess whether groundwater flooding may affect property or infrastructure.

### Suitability for Infiltration SuDS

2.1.26 The Suitability for Infiltration SuDS dataset has been obtained from the British Geological Survey (BGS) [10]. This dataset gives a preliminary indication of the suitability of the ground for infiltration SuDS. These are drainage systems that allow surface water to infiltrate to the ground, such as soakaways, infiltration basins, infiltration trenches and permeable pavements. The selection and design of an appropriate system depends on the properties of the ground and in particular the following four factors:

- the presence of severe constraints that must be considered prior to planning infiltration
- the drainage potential of the ground
- the potential for ground instability when water is infiltrated
- the protection of groundwater quality

2.1.27 The BGS Infiltration SuDS map is based on 15 nationally derived subsurface property datasets, some of which are a result of direct observations, whilst others rely on modelled data.

## Reservoir Flooding

2.1.28 The Environment Agency Long Term Flood Risk Map[11] identifies those areas that could flood in the unlikely event that a reservoir failed.

2.1.29 The likelihood of reservoir flooding is much lower than other forms of flooding. Current reservoir regulation, which has been further enhanced by the Flood and Water Management Act, aims to make sure that all reservoirs are properly maintained and monitored in order to detect and repair any problem[12].

[10] https://www.bgs.ac.uk/datasets/infiltration-suds-map/
[11] https://flood-warning-information.service.gov.uk/long-term-flood-risk/map
[12] https://www.gov.uk/government/news/reservoir-flood-maps-published

## 2.2 Site Proformas

2.2.1 The Level 2 SFRA provides a detailed assessment of the following development sites. These sites have been identified by Waltham Forest Council for future redevelopment and have been identified as requiring further assessment in relation to the level of flood risk.

- GypsyPitch01 Peacocks Close/Folly Lane
- SA01 Low Hall Depot
- SA02 Lea Bridge Site 1, 2 and 3
- SA03 Lea Bridge Gasholders
- SA04 Hare and Hounds Football Ground/ Former Wingate Stadium Site, Lea Bridge Road
- SA05 Estate Way
- SA06 New Spitalfields Market
- SA07 Bywaters, Leyton
- SA10 Leyton Mills Retail Park (South and North)
- SA50 Dog Track Carpark and Sainsburys
- SA51 Morrisons Supermarket and Car Park
- SA52 Cork Tree Retail Park
- SA58 Motorpoint, Sewardstone Road
- WND03 Uplands
- WND04 Rigg Approach
- WND07 Bus station, Leyton (LLDC)
- WND15 Lammas Road (SIL)
- WND17 Golden Business Park (SIL7)
- WND18 Costco and Land at Harbet Road
- WND19 Waltham Park Way (BEA)
- WND20 Trinity Way and Avenue Business Park (BEA)
- WND21 Deacon Trading Estate (BEA)

2.2.2 A proforma has been prepared for each of the sites to assess the risk of flooding from all sources and provide recommendations for how development could be delivered on the site that would satisfy the requirements of the Exception Test. Table 2-1 provides an overview of the datasets that have been used to populate the proformas.

### Table 2-1 Datasets and information used for Level 2 Site Proformas

| Proforma Field | Dataset / information used |
|---|---|
| **Site Description** | |
| **Site Name** | As provided by London Borough of Waltham Forest (Excel sheet and GIS layer of sites). |
| **Site ID** | As provided by London Borough of Waltham Forest (Excel sheet and GIS layer of sites). |
| **Area (ha)** | The area of the site (hectares). |
| **Proposed use** | As provided by London Borough of Waltham Forest. **Where this was not specified, mixed-use including residential has been assumed to provide a conservative assessment of the site.** |
| **Vulnerability classification** | Defined in accordance with PPG Flood Risk and Coastal Change Table 1. |
| **Flood Zone and Historic Flooding** | |
| **Proportion within each Flood Zone and Areas Benefitting from Defences** | Flood Map for Planning (Rivers and Sea) Flood Zone 2; Flood Map for Planning (Rivers and Sea) Flood Zone 3; Flood Map for Planning (Rivers and Sea) Areas Benefitting from Defences; Level 1 SFRA Flood Zone 3b Functional Floodplain outline. |
| **Flood Warning Area** | Environment Agency Flood Warning Areas. |
| **Flood Records within 500m of the site** | As provided by London Borough of Waltham Forest. |
| **River Flooding** | |
| **Maximum Flood Depth Map for the River Lee or Ching Brook for the 1% AEP event including +35% climate change** | River Lee Modelling, (AECOM for the Environment Agency, March 2017, WEM Lot 3 HNL Dagenham Brook Flood Alleviation Scheme). Maximum flood depth mapping for the 1% AEP event including +35% allowance for climate change.<br>Ching Brook Climate Change Modelling, (AECOM on behalf of London Borough of Waltham Forest, August 2020). Maximum flood depth mapping for the 1% AEP event including +35% allowance for climate change. |
| **Maximum Flood Hazard Map for the River Lee or Ching Brook for the 1% AEP event including +35% climate change** | River Lee Modelling, (AECOM for the Environment Agency, March 2017, WEM Lot 3 HNL Dagenham Brook Flood Alleviation Scheme). Maximum flood hazard mapping for the 1% AEP event including +35% allowance for climate change.<br>Ching Brook Climate Change Modelling, (AECOM on behalf of London Borough of Waltham Forest, August 2020). Maximum flood hazard mapping for the 1% AEP event including +35% allowance for climate change. |
| **Surface Water Flooding** | |
| **Risk of Flooding from Surface Water Map** | Environment Agency dataset. Obtained June 2020. |
| **Critical Drainage Area** | As defined in the Surface Water Management Plan[13] and Level 1 SFRA for London Borough of Waltham Forest[3]. Defined as 'a discrete geographic area (usually within an urban setting) where there may be multiple and interlinked sources of flood risk and where severe weather is known to cause flooding of the area thereby affecting people, property or local infrastructure'. The CDAs for the London Borough of Waltham Forest are not restricted to Flood Zone 1. |
| **Groundwater Flooding** | |
| **Bedrock Geology** | Bedrock geology underlying the site, based on BGS mapping. |
| **Superficial Geology** | Superficial geology underlying the site, based on BGS mapping. |
| **Areas Susceptible to Groundwater Flooding** | The susceptible areas are represented by one of four categories showing the proportion of each 1km square that is susceptible to groundwater emergence. It does not show the likelihood of groundwater flooding occurring. |
| **BGS Suitability for Infiltration SuDS** | A BGS dataset[10] which gives a preliminary indication of the suitability of the ground for infiltration SuDS. The selection and design of an appropriate system depends on the properties of the ground and in particular the following four factors:<br>• the presence of severe constraints that must be considered prior to planning infiltration<br>• the drainage potential of the ground<br>• the potential for ground instability when water is infiltrated<br>• the protection of groundwater quality |
| **Other sources** | |
| **Flooding from reservoirs** | As identified on the Environment Agency Long Term Flood Risk Map[11]. |
| **Summary** | |
| An overview of the risk of flooding to the site now and in the future (as a result of the impacts of climate change) based on the information within the proforma. | |

[13] Capita Symonds Scott Wilson, 2011, London Borough of Waltham Forest Surface Water Management Plan.

| Site Specific Recommendations |
| --- |
| Recommendations for how development could be delivered on the site to meet the requirements of part 2 of the Exception Test (where required) i.e. that it will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.<br>Recommendations are made in line with the development management measures presented within the Level 1 SFRA[3] (Chapter 5) and typically address the following:<br>- Applying **sequential approach** within development site<br>- **Setting back development** from the edge of watercourses<br>- **Finished floor levels**. Note: *The site assessments consider the flood level for the 1% AEP including 35% climate change allowance as an initial indication. The design flood levels should be selected as set out in the latest guidance (available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances) which are currently the central allowance (17%) or higher central (27%) depending upon the combination of Flood Zone and vulnerability classification of the proposed development.*<br>- **Floodplain compensation storage**. *Note: The site assessments consider the flood level for the 1% AEP including 35% climate change allowance as an initial indication. The latest guidance (available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances) states that the central allowance (17%) should be used for most cases and the higher central allowance (27%) when the affected area contains essential infrastructure.*<br>- **Access and egress arrangements**. *Note: The site assessments refer to the flood level for the 1% AEP including 35% climate change allowance as an initial indication. The design flood levels should be selected as set out in the latest guidance (available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances) which are currently the central allowance (17%) or higher central (27%) depending upon the combination of Flood Zone and vulnerability classification of the proposed development.*<br>- **Flood Warning and Evacuation** procedures<br>- **Surface water management**<br>- Further investigation of **groundwater** levels. |

2.2.3 The sites in **Appendix A** require application of the Exception Test in accordance with the NPPF (Table 1-1). For these sites, recommendations have been provided to indicate how development may meet the requirements of part 2) of the Exception Test, i.e. may be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, may reduce flood risk overall.

2.2.4 The sites in **Appendix B** are those sites where the combination of Flood Zone and development vulnerability do not trigger the need for the Exception Test in accordance with the NPPF (Table 1-1). However, these sites have been included for assessment as they may be at risk of river flooding in the future as a result of climate change. Where this is shown to be the case, recommendations have been provided to indicate how development may be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, may reduce flood risk overall.

## 2.3 Future Updates to the SFRA

2.3.1 SFRAs are intended to be living documents, that are kept up to date as information on flood risk management changes. The Environment Agency SFRA guidance available online[14] states that in order to remain up to date, it is necessary to update a SFRA to incorporate any changes to:

- the predicted impacts of climate change on flood risk
- detailed flood modelling - such as from the Environment Agency or lead local flood authority
- the local plan, spatial development strategy or relevant local development documents
- local flood management schemes
- flood risk management plans
- shoreline management plans
- local flood risk management strategies
- national planning policy or guidance.

[14] https://www.gov.uk/guidance/local-planning-authorities-strategic-flood-risk-assessment

# Appendix A Exception Test Sites

| | |
|---|---|
| GypsyPitch01 | Peacocks Close/Folly Lane |
| SA01 | Low Hall Depot |
| SA02 | Lea Bridge Site 1, 2 and 3 |
| SA03 | Lea Bridge Gasholders |
| SA04 | Hare and Hounds Football Ground/ Former Wingate Stadium Site, Lea Bridge Road |
| SA50 | Dog Track Carpark and Sainsburys |
| SA52 | Cork Tree Retail Park |
| WND07 | Bus station, Leyton (LLDC) |

# Appendix B Other Sites

| | |
|---|---|
| SA05 | Estate Way |
| SA06 | New Spitalfields Market |
| SA07 | Bywaters, Leyton |
| SA10 | Leyton Mills Retail Park (South and North) |
| SA51 | Morrisons Supermarket and Car Park |
| SA58 | Motorpoint, Sewardstone Road |
| WND03 | Uplands |
| WND04 | Rigg Approach |
| WND15 | Lammas Road (SIL) |
| WND17 | Golden Business Park (SIL7) |
| WND18 | Costco and Land at Harbet Road |
| WND19 | Waltham Park Way (BEA) |
| WND20 | Trinity Way and Avenue Business Park (BEA) |
| WND21 | Deacon Trading Estate (BEA) |

# Appendix C Ching Brook Climate Change Modelling Technical Note

aecom.com

# London Borough of Waltham Forest Level 1 SFRA

Final Report

Project number: 60577135

October 2018

## Quality information

| Prepared by | Checked by | Approved by |
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| Hannah Booth<br>Graduate Water Consultant<br><br>Sarah Waite<br>Hydrologist Consultant | Emily Craven<br>Associate Director, Water | Sarah Kelly<br>Regional Director, Water |

## Revision History

| Revision | Revision date | Details | Authorized | Name | Position |
| --- | --- | --- | --- | --- | --- |
| 01 | July 2018 | Draft Report for client comment | 26 July 2018 | Sarah Kelly | Regional Director, Water |
| 02 | August 2018 | Final report | 02 October 2018 | Sarah Kelly | Regional Director, Water |
| | | | | | |
| | | | | | |

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# Table of Contents

## Figures



## Tables

# Abbreviations

| ACRONYM | DEFINITION |
|---|---|
| AEP | Annual Exceedance Probability |
| AOD | Above Ordnance Datum |
| AIMS | Asset Information Management System |
| BGS | British Geological Survey |
| CFMP | Catchment Flood Management Plan |
| Defra | Department for Environment, Flood and Rural Affairs |
| FRA | Flood Risk Assessment |
| FWMA | Flood and Water Management Act 2010 |
| GIS | Geographical Information System |
| GLA | Greater London Authority |
| LB | London Borough |
| LiDAR | Light Detection and Ranging |
| LLFA | Lead Local Flood Authority |
| LPA | Local Planning Authority |
| LRF | Local Resilience Forum |
| MLWL | Maximum Likely Water Level |
| MHCLG | Ministry of Housing, communities & Local Government (formerly Department for Communities and Local Government). |
| PFRA | Preliminary Flood Risk Assessment |
| PPG | Planning Practice Guidance |
| NPPF | National Planning Policy Framework |
| SA | Sustainability Appraisal |
| SFRA | Strategic Flood Risk Assessment |
| SPD | Supplementary Planning Document |
| SPZ | Source Protection Zone |
| SuDS | Sustainable Drainage Systems |
| TWUL | Thames Water Utilities Limited |
| RoFSW | Risk of Flooding from Surface Water |

# Glossary of Terms

| GLOSSARY | DEFINITION |
|---|---|
| 1D Hydraulic Model | Hydraulic model which computes flow in a single dimension, suitable for representing systems with a defined flow direction such as river channels, pipes and culverts |
| 2D Hydraulic Model | Hydraulic model which computes flow in multiple dimensions, suitable for representing systems without a defined flow direction including topographic surfaces such as floodplains |
| Annual Exceedance Probability (AEP) | Annual Exceedance Probability (AEP) refers to the probability of a flood event occurring in any year. The probability is expressed as a percentage. For example, a large flood which may be calculated to have a 1% chance to occur in any one year is described as 1%AEP. |
| Asset Information Management System (AIMS) | Environment Agency database of assets associated with Main Rivers including defences, structures and channel types. Information regarding location, standard of service, dimensions and condition. |
| Aquifer | A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water. |
| Attenuation | In the context of this report - the storing of water to reduce peak discharge of water. |
| Catchment Flood Management Plan | A high-level plan through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk. |
| Climate Change | Long term variations in global temperature and weather patterns caused by natural and human actions. For fluvial events a 70% increase in river flow is applied and for rainfall events, a 30% increase. These climate change values are based upon information within the NPPF and Planning Practice Guidance as at 3rd February 2017. |
| Critical Drainage Area | Within the SWMP – A discrete geographic area (usually hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zone during severe weather thereby affecting people, property or local infrastructure.<br>By the Environment Agency - discrete geographical area where multiple and interlinked sources of flood risk cause flooding during severe weather. |
| Culvert | A structure, often a channel or pipe that carries water below the level of the ground |
| Design flood | This is a flood event of a given annual flood probability, which is generally taken as:<br>• fluvial (river) flooding likely to occur with a 1% annual probability (a 1 in 100 chance each year), or;<br>The suitability of a proposed development is assessed and mitigation measures, if any, are designed against the design flood. Both should contain a suitable allowance for climate change.<br>https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances . |
| DG5 Register | A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years. Refer to Map 9A and 9B included in Appendix A. |
| Evapotranspiration | The sum of evaporation and plant transpiration from the land and ocean surface to the atmosphere. Evaporation accounts for the movement of water to the air from |

| GLOSSARY | DEFINITION |
|---|---|
| | sources such as the soil, canopy interception, and waterbodies. |
| Exception Test | The exception test should be applied following the application of the sequential test. The exception test is a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available. Conditions need to be met before the exception test can be applied. |
| Flood Defence | Infrastructure used to protect an area against floods, such as floodwalls and embankments; they are designed to a specific standard of protection (design flood) which is the largest flood that a given project is designed to safely accommodate. |
| Flood Resilience | Measures that minimise water ingress (e.g. to buildings) and promotes fast drying and easy cleaning, to prevent permanent damage. |
| Flood Resistant | Measures that prevent flood water entering a building or damaging its fabric. This has the same meaning as flood proof. |
| Flood Risk | The level of flood risk is the product of the frequency or likelihood of the flood events and their consequences (such as loss, damage, harm, distress and disruption). |
| Flood Zone | Flood Zones refer to the probability of river and sea flooding ignoring the presence of existing flood defences (i.e. the natural floodplain). It should be noted that Flood Zones on the Environment Agency Flood Map for Planning do not take account of the potential impact of climate change.<br>See Section 2.5 for further information on Flood Zones https://flood-map-for-planning.service.gov.uk/ |
| Fluvial | Relating to the actions, processes and behaviour of a watercourse (river or stream). |
| Freeboard | A freeboard is used to account for residual uncertainty within design, often an extra 300mm or 600mm added to finished floor level above the design flood level to account for any uncertainty in flood levels. A safety factor. Refer to section 5.4 for further guidance. |
| Functional Floodplain | Land where water has to flow or be stored in times of flood. |
| Groundwater | Water that is in the ground, this is usually referring to water in the saturated zone below the water table. |
| Impounded Reservoir | A reservoir with outlets controlled by gates that release stored surface water as needed in dry months; may also store water for domestic or industrial use or for flood control. Also known as storage reservoir. |
| ISIS | A commonly-used 1D hydraulic modelling software package. |
| Lead Local Flood Authority (LLFA) | As defined by the Flood and Water Management Act, London Borough of Waltham Forest as LLFA are responsible for developing, maintaining and applying a strategy for local flood risk management (flooding from surface water, groundwater and ordinary watercourses) in their areas and for maintaining a register of flood risk assets. |
| Light Detection and Ranging (LiDAR) | Airborne ground survey mapping technique, which uses a laser to measure the distance between the aircraft and the ground. Within this report, LiDAR has been used to map topography across the borough as illustrated in Map 1. |
| Local Flood Risk Zone | Discrete areas of flooding that do not exceed the national criteria for a 'Flood Risk Area' but still affect houses, businesses or infrastructure. A LFRZ is defined as the actual spatial extent of predicted flooding in a single location. |
| Local Planning Authority | The public authority that is responsible for controlling planning and development |

| GLOSSARY | DEFINITION |
|---|---|
| (LPA) | through the planning system. |
| Main River | Watercourse defined on a 'Main River Map' designated by Defra. The Environment Agency has permissive powers to carry out flood defence works, maintenance and operational activities for Main Rivers only. |
| Mitigation measure | An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere. |
| National Planning Policy Framework (NPPF) | The revised National Planning Policy Framework sets out government's planning policies for England and how these are expected to be applied. |
| Ordnance Datum | In the British Isles, an ordnance datum is a vertical datum used by an ordnance survey as the basis for deriving altitudes on maps. A spot height may be expressed as AOD (Above Ordnance Datum), in this instance meaning above mean sea level at Newlyn in Cornwall. |
| Ordinary Watercourse | A watercourse that does not form part of a Main River. This includes "all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows" according to the Land Drainage Act 1991. |
| Planning Practice Guidance (PPG) | The PPG describes the planning approach to development including within areas at risk of flooding from all sources |
| Pluvial | Pluvial refers to flood events occurring through the direct action of rain – i.e. surface water flooding. Rather than water overflowing the banks of a river which is considered fluvial flooding. |
| Residual Flood Risk | The remaining flood risk after risk reduction measures have been taken into account. An example of residual flood risk includes the failure of flood management infrastructure, or a severe flood event that exceeds a flood management design standard, such as a flood that overtops a raised flood defences, or an intense rainfall event which the drainage system cannot cope with. |
| Return Period | Also known as a recurrence interval is an estimate of the likelihood of an event, such as a flood to occur. |
| Risk | Risk is a factor of the probability or likelihood of an event occurring multiplied by consequence: Risk = Probability x Consequence. It is also referred to in this report in a more general sense. |
| Sequential Test | Aims to steer vulnerable development to areas of lowest flood risk. |
| Sewer Flooding | Flooding caused by a blockage or overflowing in a sewer or urban drainage system. |
| Source Protection Zone (SPZ) | Defined areas in which certain types of development are restricted to ensure that groundwater sources remain free from contaminants. |
| Surface Water | Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water. |
| Sustainability Appraisal (SA) | A sustainability appraisal is a systematic process that must be carried out during the preparation of a Local Plan. Its role is to promote sustainable development by assessing the extent to which the emerging plan, when judged against reasonable alternatives, will help to achieve relevant environmental, economic and social objectives. |
| Sustainable drainage systems (SuDS) | Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques. |

| GLOSSARY | DEFINITION |
| --- | --- |
| Topographic survey | A survey of ground levels. |
| TUFLOW | A modelling package for simulating depth averaged 2D free-surface flows that is in widespread use in the UK and elsewhere for 2D inundation modelling. |

# Executive Summary

A considerable proportion of the London Borough of Waltham Forest (LB Waltham Forest) is at risk of flooding from rivers, surface water and groundwater sources. The River Lee and its tributaries the Ching Brook and Dagenham Brook are dominant features in the Borough and flooding from these watercourses has occurred a number of times in the last 100 years, during which many homes and businesses were affected.

As the Local Planning Authority (LPA) LB Waltham Forest Council has the responsibility, in accordance with the National Planning Policy Framework (NPPF) Chapter 14 ‘Meeting the Challenge of climate change, flooding and coastal change’, to ensure that flood risk is understood and managed effectively through all stages of the planning process. As such, LB Waltham Forest is required to undertake a Strategic Flood Risk Assessment (SFRA) to form part of the evidence base for the preparation of their Local Plan and AECOM has been commissioned to review and update the former SFRA.

The aim of this revised Level 1 SFRA is to identify the spatial variation in flood risk across the Borough from all sources, facilitating a borough-wide comparison of future development sites with respect to flood risk considerations.

The Environment Agency identifies the fluvial floodplains associated with main rivers across the Borough, presented in the maps included in Appendix A. These should be used for planning purposes when determining the suitability of development.

Potential risk of flooding from other sources exists throughout the Borough, including surface water flooding and groundwater emergence. As the Lead Local Flood Authority (LLFA), LB Waltham Forest takes the lead in flood incident reporting from these sources and has compiled a database of significant flood events in the Borough.

This revised Level 1 SFRA provides an overview of the risk of flooding from all sources across LB Waltham Forest Borough, including flooding from rivers, surface water, groundwater, sewers and other artificial sources, and should be used to assist in the development of policy formulation, strategic planning, and application of the Sequential Test, development control and emergency planning.

In the future, climate change is anticipated to have an impact on all sources of flood risk within the Borough. It is important that planning decisions recognise the potential risk that increased runoff poses to property and plan development accordingly to ensure that development is appropriately flood resilient and resistant, safe for its users for the development’s lifetime and will not increase flood risk overall.

# 1. Introduction

In its role as the Local Planning Authority (LPA), the LB Waltham Forest is currently preparing documents that will form part of the new Local Plan and set out a vision and framework for development in the Borough.

The National Planning Policy Framework[1] (NPPF) and accompanying Planning Practice Guidance (PPG)[2] emphasise the responsibilities for LPAs to ensure that flood risk is understood and managed effectively using a risk-based approach through all stages of the planning process. As such, LPAs are required to undertake a Strategic Flood Risk Assessment (SFRA) to support the preparation of their Local Plan.

AECOM has been commissioned by the LB Waltham Forest to review and revise their existing SFRA which was completed in August 2008. The methodology followed in this study complies with the NPPF[1] as well as guidelines from the Environment Agency and forms a Level 1 SFRA. The SFRA has been completed in collaboration with the LB Waltham Forest, the Environment Agency and Thames Water. The results of this SFRA are intended to inform strategic land use planning and decision making from a flood risk perspective and to inform the preparation of the Local Plan.

## 1.1 Approach to Flood Risk Management

The NPPF[1] and associated PPG for Flood Risk and Coastal Change[2] emphasise the active role LPAs such as LB Waltham Forest should take to ensure that flood risk is assessed, avoided, and managed effectively and sustainably throughout all stages of the planning process. The overall approach for the consideration of flood risk set out in Section 1 of the PPG can be summarised as follows:


This has implications for LPAs and developers as described below.

### 1.1.1 Assess flood risk

Local Plans should be supported by a SFRA and LPAs should use the findings to inform strategic land use planning. The aim of this SFRA is to collate and present the most up to date flood risk information from all sources for use by LB Waltham forest to inform the preparation of the Waltham Forest Local Plan and prudent decision-making by Development Management officers on a day-to-day basis.

In order to achieve this, the SFRA will:

- Refine information on the areas that may flood taking into account all sources of flooding and the impacts of climate change;
- Inform the Sustainability Appraisal process, so that flood risk is fully taken into account;
- Inform the application of the Sequential and, if necessary, Exception Tests in the allocation of future development sites, as required by the NPPF[1], and planning application process;
- Identify the requirements for site-specific Flood Risk Assessments;
- Inform the preparation of flood risk policy and guidance;

[1] Communities and Local Government. July 2018. *Revised National Planning Policy Framework*. Available at: https://www.gov.uk/government/collections/revised-national-planning-policy-framework
[2] Communities and Local Government. 6th March 2014. Planning Practice Guidance: Flood Risk and Coastal Change. Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

- Provide information for use by LLFA emergency planning teams to help plan an effective response to flood risk; and,
- Consider opportunities to reduce flood risk to existing communities and developments through better management of surface water, provision for conveyance and storage for flood water.

The 2018 SFRA report will be used by LB Waltham Forest to inform the allocation of sites within the Local Plan. If land outside of flood risk areas cannot appropriately accommodate all necessary development required within the LB Waltham Forest, the information in this SFRA may be used in application of the Sequential Test and, where necessary, the Exception Test.

Figure 1-1 reproduced from the PPG[2], illustrates how flood risk should be taken into account in the preparation of the Local Plan by LB Waltham Forest.

For sites in areas at risk of flooding (Refer to Section 2.5, Section 6 and Figure 4 A-E of Appendix A), or with an area of 1 hectare or greater, developers must undertake a site-specific Flood Risk Assessment (FRA) to accompany planning applications (or prior approval for certain types of permitted development).

### 1.1.2 Avoid flood risk

LB Waltham Forest should apply the sequential approach to site selection so that development is, as far as reasonably possible, located where the risk of flooding from all sources is lowest, taking account of climate change and the vulnerability of future users to flood risk.

In decision-making this involves applying the Sequential Test and, if necessary, the Exception Test for specific development proposals (ensuring that even within sites, vulnerable uses are directed to areas of lowest risk). Detail of when applicants will need to evidence passing of the tests is provided in Section 4.

### 1.1.3 Manage and mitigate flood risk

Where alternative sites in areas at lower risk of flooding are not available, it may be necessary to locate development in areas at risk of flooding. In these cases, LB Waltham Forest and developers must ensure that development is appropriately flood resilient and resistant, safe for its users for the lifetime of the development, and will not increase flood risk overall.

LB Waltham Forest and developers should seek flood risk management opportunities to reduce the level of flood risk in the area e.g. safeguarding land for flood risk management or where appropriate, through designing off-site works required to protect and support development in ways that benefit the area more generally.

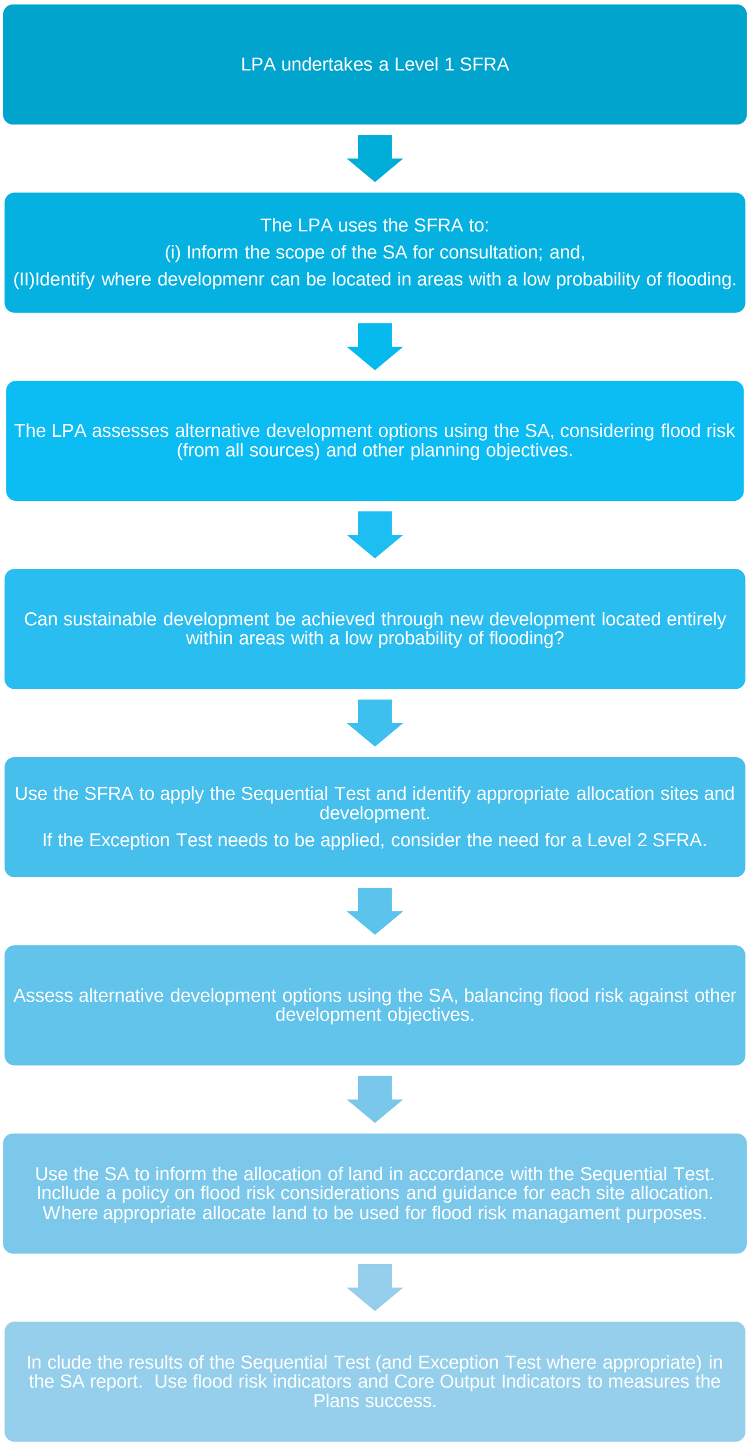



**Figure 1-1 Taking flood risk into account in the preparation of a Local Plan (PPG21 for Flood Risk and Coastal Change, p6)**

## 1.2 Flood Risk Policy and Guidance

There is an established body of policy and guidance documents which are of particular importance when considering development and flood risk. These are identified in Table 1-1 along with links for where these documents can be found for further detail.

**Table 1-1 Flood Risk Policy and Guidance Documents**

| | | |
|---|---|---|
| **National Policy Documents** | | |
| Revised National Planning Policy Framework (2018) | The NPPF[1] was published by the UK's DCLG in March 2012 and updated in July 2018, consolidating over two dozen previously issued documents called Planning Policy Statements (PPS) and Planning Policy Guidance Notes (PPG[2]) for use in England. | https://www.gov.uk/government/collections/revised-national-planning-policy-framework |
| Flood and Water Management Act (2010) | Provides for a more comprehensive management of flood risk. | http://www.legislation.gov.uk/ukpga/2010/29/pdfs/ukpga_20100029_en.pdf |
| Flood Risk Regulations (2009) | The Flood Risk Regulations transpose the EU Floods Directive into law in England. It aims to provide a consistent approach to flood risk across Europe. | http://www.legislation.gov.uk/uksi/2009/3042/pdfs/uksi_20093042_en.pdf |
| **Regional Flood Risk Policy** | | |
| London Plan (2016) | The London Plan is the statutory spatial development strategy for the Greater London area that is published by the GLA. To ensure clarity for stakeholders, it is important that LB Waltham Forest local policy is aligned with the minimum recommendations of the London Plan. | https://www.london.gov.uk/what-we-do/planning/london-plan |
| Draft New London Plan (2018) | The updated London Plan includes changes to the Mayor's policies. in respect of the development and use of land in Greater London including requirements relating to flood resilience (policy GG6), flood risk management (policy SI12) and development drainage (policy SI13) | https://www.london.gov.uk/what-we-do/planning/london-plan/new-london-plan |
| Thames Catchment Flood Management Plan (2009) | Role of the CFMP is to establish flood risk management policies which will deliver sustainable flood risk management for the long term (an Environment Agency Document). | https://www.gov.uk/government/collections/catchment-flood-management-plans |
| Managing Flood Risk in the Lower Lee Catchment, today and into the future (2013) | The Environment Agency has developed a detailed strategy for the Lower Lee catchment and provides a basis for implementing wider CFMP strategies within the Lower Lee catchment. E.g. ongoing maintenance and improvement of River Lee Flood Relief Channel and associated hydraulic control structures. | https://www.gov.uk/government/publications/managing-flood-risk-lower-lee-catchment |
| **Guidance Documents** | | |
| Planning Policy Guidance – Flood Risk and Coastal Change (2014) | Describes the planning approach to development within areas at risk of flooding from all sources | http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/ |
| Environment Agency Standing Advice | Guidance on information to be included within robust site specific FRAs | https://www.gov.uk/guidance/flood-risk-assessment-standing-advice |
| London Sustainable Drainage Action Plan, GLA October 2015 | A plan to inspire, facilitate and co-ordinate a change in how we manage rainwater in London. It seeks to replace impermeable surfaces with green, sustainable drainage systems. | https://www.london.gov.uk/sites/default/files/lsdap_final.pdf |
| Sustainable Design and | Guidance on greenfield runoff rates, Sustainable | https://www.london.gov.uk/sites/de |

| | | |
|---|---|---|
| Construction SPG, GLA, April 2014 | Drainage Systems, flood resilience / resistance and flood risk management linking back to policies contained within the London Plan. | fault/files/gla_migrate_files_destination/Sustainable%20Design%20%26%20Construction%20SPG.pdf |
| **Local Documents and Strategies** | | |
| LB Waltham Forest Core Strategy Policy CS4: Minimising and Adapting to Climate Change And Development Management Policies DPD policy DM34 (2012) | Core strategy sets out the Boroughs plans for development within the Borough up to 2026, including policy guidance on flood risk. | https://walthamforest.gov.uk/node/1423 |
| LB Waltham Forest Local Flood Risk Management Strategy (LFRMS) (2015) | As LLFA, LB Waltham Forest has created the LFRMS to understand and manage flood risk within the borough. | https://democracy.walthamforest.gov.uk/documents/s46175/Appendix%20A%20-%20Local%20Flood%20Risk%20Management%20Strategy.pdf |
| LB Waltham Forest Surface Water Management Plan (2011) | A SWMP was produced for LB Waltham Forest as part of the Drain London (GLA) study. This study included an assessment of flooding from sewers, drains, groundwater and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall. | Available from the LB Waltham Forest Council |
| LB Waltham Forest Multi-Agency Flood Plan (2015) | Describes the management structures and actions of local responders in response to a flooding event in LB Waltham Forest. | LB Waltham Forest internal document. |
| LB Waltham Forest Preliminary Flood Risk Assessment (PFRA) (2017) | In accordance with the Flood Risk Regulations 2009, LB Waltham Forest provided a PFRA to provide a high level overview of flood risk from local sources for provision to the Environment Agency, ultimately reporting to Europe. The 2011 report was updated in 2017. | http://webarchive.nationalarchives.gov.uk/20140328094444/http://www.environment-agency.gov.uk/research/planning/135542.aspx#31 |

# 2. Assessing Flood Risk in Waltham Forest

## 2.1 Study Area

The study area is defined by the administrative boundary of the LB Waltham Forest, located in the north east of London. LB Waltham Forest borders the LB of Redbridge to the east, LB of Newham to the south east, LB of Hackney to the south west and LB of Haringey and Enfield to the west and North West.

The borough boundary encompasses an area of 3,800 ha and is bound on three sides by two main rivers, the River Lee and the Ching Brook. The River Lee flows along the western and southern edge of the borough boundary. The Ching Brook is a tributary of the River Lee and flows along the north eastern edge of the Borough before flowing west through the borough.

The Borough is predominantly developed but does have some notable areas of open space including a number of parks and sports grounds. The land along the River Lee includes an area of marshes and parkland, forming a green corridor along the south western edge of the borough. A number of reservoirs are located along the western edge of the borough, which separates the urban areas in the LB of Waltham Forest from the neighbouring boroughs.

There are significant targets for new homes and jobs in Waltham Forest to meet both local and strategic needs. In the 2012 Local Plan Core Strategy[3], LB Waltham Forest projected a total of 10,320 new homes to be generated by 2026, demonstrating a significant growth projection across the Borough.

## 2.2 Topography

The River Lee flows south along the southern and western edge of the borough boundary where the land is low lying at levels of approximately 0m to 10m Above Ordnance Datum (AOD). Lower topography is also located in the south and west of the borough and in the centre of the borough, associated with the Ching Brook catchment where ground levels fluctuate from 20m and rising to 70m AOD to the east. To the north of the borough, ground levels rise from 70m up to approximately 80m AOD.

Figure 1 included in Appendix A shows Light Detection and Ranging (LiDAR) data. This is an airborne mapping technique, which uses a laser to measure the distance between the aircraft and the ground. Up to 100,000 measurements per second are made of the ground, allowing highly detailed terrain models to be generated at spatial resolutions of between 25cm and 2 metres. The data used in this study covering LB Waltham Forest has a spatial resolution of 2m. The Environment Agency's LiDAR data archive contains digital elevation data derived from surveys carried out since 1998.

| Appendix A, Figure 1 Topography and Main Rivers |
|---|

## 2.3 Geology

The geology of the Borough is comprised of underlying bedrock with a small part of the borough overlain by superficial deposits. The superficial deposits in the area include River Terrace deposits covering the south of the borough and Alluvium present along the western edge of the borough.

The bedrock geologies include Thames Group (or London Clay) which underlies the majority of the borough, and a small area of Lambeth Group present to the south of the borough.

Further information on geology can be found on the BGS Website[4].

| Appendix A, Figure 2 Bedrock Geology and Figure 3 Superficial Deposits |
|---|

[3] https://walthamforest.gov.uk/content/core-strategy
[4] http://www.bgs.ac.uk

# 2.4 River Network

All watercourses in England and Wales are classified as either 'Main Rivers' or 'Ordinary Watercourses'. The difference between the two classifications is based largely on the perceived 'importance' of the watercourse with particular reference to its potential to cause significant and widespread flooding. However, it is not always the case the watercourses classed as ordinary watercourses cannot cause localised flooding.

The Environment Agency 'Detailed River Network' dataset has been used to identify watercourses in the study area and their designation (i.e. Main River or Ordinary Watercourse). The Environment Agency 'Statutory Main River Map' has been used to map the main rivers within the borough. The Environment Agency have duties and powers in relation to Main Rivers and the LLFA (LB Waltham Forest) have duties and powers in relation to ordinary watercourses including ditches, dykes, rivers, streams and drains (not public sewers).

There are three Main Rivers present within the Borough (River Lee, Ching Brook and the Dagenham Brook) as described below.

Appendix A, Figure 1 Topography and Main Rivers

## 2.4.1 River Lee

The River Lee is located along the southern and western boundary of the Borough (as shown in Figure 2-1). The River originates near Luton and flows through Bedfordshire, Hertfordshire and London. The river drains an area of approximately 1400km$^2$ before meeting the River Thames at Bow Creek.

The Lower River Lee is largely an artificial watercourse containing multiple channels. As the River Lee enters the north western corner of the borough – immediately to the north of the William Gurling reservoir – it flows along the eastern bank of the William Gurling reservoir within the River Lee Diversion channel until it reaches south of the Lockwood Reservoir.

The River Lee Flood Relief Channel flows from the River Lee Diversion, to the west of the Banbury Reservoir, through the borough along the eastern edges of the reservoirs (located to the south west of the Borough) and joins the River Lee at Hackney Marsh, to the south of the borough.

The River Lee Navigation flows into the borough to the west of the Banbury Reservoir and flows along the western edge of the borough. In addition to being designated a Main River, the Lee Navigation is also part of the Canals and River Trust. Locks on the River Lee Navigation are administered by British Waterways.

The naturalised River Lee flows to the south of the borough- to the east of Hackney Marsh- into the neighbouring borough of the London Borough of Newham.

## 2.4.2 Ching Brook

The Ching Brook is located in the northern part of the LB of Waltham Forest (See Figure 2-1). The Ching Brook arises at Connaught Water as an ordinary watercourse flowing south. Where the Brook crosses under Whitehall Road, located along the north-eastern boundary of the borough it is then classified as a main river as it continues to flow south then west to enter the River Lee to the north of Banbury Reservoir. The total catchment area for the Ching Brook is 1747 hectares. .

## 2.4.3 Dagenham Brook

The Dagenham Brook rises along Priestley Way and flows south, parallel to the River Lee Flood Relief Channel, before flowing south east at Low Hall Sports Ground (see Figure 2-1). The Dagenham Brook continues to flow south east before joining the River Lee at New Spitalfields Market.

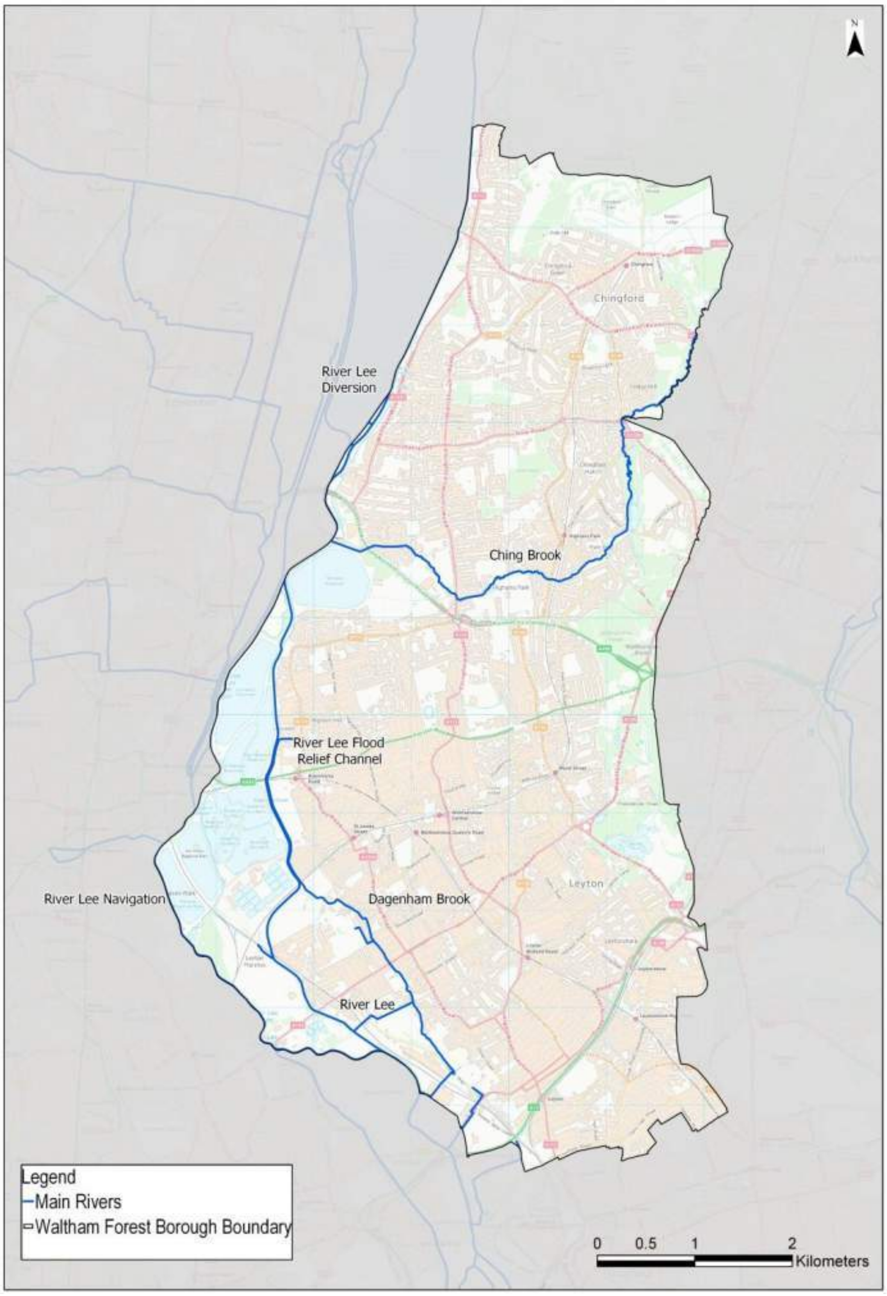





**Figure 2-1 Main Rivers in the Borough**

## 2.5 Fluvial Flood Risk

Flooding from rivers occurs when water levels rise higher than bank levels causing floodwater to spill across adjacent land (floodplain). The main reasons for water levels rising in rivers are:

- Intense or prolonged rainfall causing runoff rates and flows to increase in rivers, exceeding the capacity of the channel. This can be exacerbated by wet conditions and where there is significant groundwater base flow.
- Constrictions in the river channel causing flood water to back up; and
- Constrictions preventing discharge at the outlet of the river e.g. locked flood gates, or tide locking.

### 2.5.1 Flood Map for Planning (Rivers and Sea) Flood Zone 1, 2 & 3

The risk of flooding is a function of the probability that a flood will occur and the consequence to the community or receptor as a direct result of flooding. The NPPF[1] seeks to assess the probability of flooding from rivers by categorising areas within the fluvial floodplain into zones of low, medium and high probability, as defined in Table 2-1 and presented on the Flood Map for Planning (Rivers and Sea) available on the Environment Agency website. These Flood Zones have been presented in Figure 4A to 4E included in Appendix A.

**Table 2-1 Fluvial Flood Zones (extracted from the PPG[2], 2014)**

| Flood Zone | Flood Zone Definition for River Flooding | Probability of Flooding |
|---|---|---|
| Flood Zone 1 | Land having a less than 1 in 1,000 chance of river flooding each year (0.1% annual exceedance probability (AEP)). Shown as clear on the Flood Map – all land outside Flood Zones 2 and 3. | Low |
| Flood Zone 2 | Land having between a 1 in 100 and 1 in 1,000 chance of river flooding each year (between 1% and 0.1% AEP). | Medium |
| Flood Zone 3a | Land having a 1 in 100 or greater chance of river flooding each year (greater than 1% AEP). | High |
| Flood Zone 3b | Land where water has to flow or be stored in times of flood, or land purposely designed to be flooded in an extreme flood event (flood storage area).<br><br>Flood Zone 3b is defined by the LPA, in this instance the 1 in 20 annual probabilities have been used to define Flood Zone 3b. Note: Flood Zone 3b is not separately distinguished from Flood Zone 3a on the Flood Map for Planning (Rivers and Sea). | Functional Floodplain |

The Environment Agency 'Flood Map for Planning (Rivers and the Sea)' provides information on the areas that would flood if there were no flood defences or buildings in the "natural" floodplain. The 'Flood Map for Planning (Rivers and Sea)' dataset is available on the Environment Agency website[5] and is the main reference for planning purposes as it contains the Flood Zones which are referred to in the NPPF[1].

This Environment Agency dataset has been used to define and illustrate Flood Zone 1, 2 and 3 on Figure 4 and 4A-E contained within Appendix A of this SFRA. The current proportions of the Borough located within Flood Zone 2 and 3 are shown below:

- Flood Zone 2- 482 hectares
- Flood Zone 3- 222 hectares

It should be noted that the Flood Zones shown on the Environment Agency Flood Map for Planning do not take account of the possible impacts of climate change and are updated on a regular basis. Further information on climate change can be found in Section 3 of this report.

The 'Flood Map for Planning (Rivers and Sea)' was first developed in 2004 using national generalised modelling (JFLOW) and is routinely updated and revised using results from the Environment Agency's ongoing programme of river catchment studies. The studies can include topographic surveys and hydrological and/or hydraulic modelling as well as incorporating information from recorded flood events.

| |
|---|
| Appendix A, Figure 4 and 4A-E Risk of Flooding from Rivers |

[5] Environment Agency Flood Map for Planning (Rivers and Sea) http://apps.environment-agency.gov.uk/wiyby/37837.aspx

It should be noted that a separate map is available on the Environment Agency website which is referred to as 'Risk of Flooding from Rivers and Sea'[6]. This map takes into account the presence of flood defences and so describes the actual chance of flooding, rather than the chance if there were no defences present. While flood defences reduce the level of risk they do not completely remove it as they can be overtopped or fail (breach) in extreme weather conditions, or if they are in poor condition. This data has not been mapped as part of the SFRA.

For planning purposes the 'Flood Map for Planning (Rivers and the Sea)' and associated Flood Zones' remain the primary source of information.

### 2.5.2 Hydraulic Modelling Studies

Table 2-1 provides a summary of the hydraulic modelling studies that have been undertaken for the Main Rivers in LB Waltham Forest and used to inform the Environment Agency's Flood Map for Planning (Rivers and Sea). The type of model (1D or 2D) is also specified, along with the corresponding available outputs for each model.

The scope of these modelling studies typically covers flooding associated with Main Rivers, and therefore Ordinary Watercourses that form tributaries to the Main Rivers may not always be included in the model. Modelling of Ordinary Watercourses available on the Flood Map for Planning (Rivers and Sea) may be the result of the national generalised JFLOW modelling carried out by the Environment Agency and may need to be refined when determining the probability of flooding for an individual site and preparing a site-specific FRA.

**Table 2-2 Hydraulic models for Main Rivers in LB Waltham Forest (fluvial flood risk)**

| Watercourse | Catchment Description | Modelling Study |
|---|---|---|
| River Lee | The catchment of the Lower Lee is approximately 370km$^2$. The Lower Lee flows through a heavily urbanised area for 34km from Feildes Weir in a southerly direction through North London entering the River Thames at Canning Town, just upstream of the Thames Barrier at the boundary between LB Tower Hamlets and LB Newham.<br><br>The River Lee is tidally influenced to the Lee Bridge sluices.<br><br>Further detail with regard to the River Lee and the hydraulic model used to inform this SFRA can be found from the Environment Agency. | CH2MHill, 2014, River Lee 2D Modelling and Mapping Technical Report.<br><br>Existing Environment Agency baseline model re-run in 2017 by AECOM using new inflow data to illustrate new *climate change* allowances (1 in 100 year(1% AEP) + 10%, 15%, 25%, 35% & 70%).<br><br>Note for the purposes of mapping, Appendix A map 4 illustrates the 1% AEP +20% *climate change* event for the Ching Brook.<br><br>Updated modelling is also used to delineate Flood Zone 3b (1 in 20 year (5%) flood outline) for the Ching Brook. |
| River Lee | The modelling of a section of the River Lee was completed from just upstream of the River Lee Diversion by Heriot Avenue to the confluence with the River Thames. | Capita AECOM, 2017, Environment Agency Hertfordshire and North London (HNL) options assessment studies<br><br>Note for the purposes of mapping, Appendix A map 4 illustrates the 1% AEP +70% *climate change* event.<br><br>Updated modelling is also used to delineate Flood Zone 3b (1 in 20 year (5%) flood outline). |

### 2.5.3 Functional Floodplain

The Functional Floodplain is defined in the NPPF[1] as 'land where water has to flow or be stored in times of flood'. The Functional Floodplain (also referred to as Flood Zone 3b), is not separately distinguished from Flood Zone 3a on the Flood Map for Planning. Rather the SFRA is the place where LPAs should identify areas of Functional Floodplain in discussion with the Environment Agency.

[6] https://flood-warning-information.service.gov.uk/long-term-flood-risk

For the purposes of this SFRA, reference has been made to hydraulic modelling of the River Lee and Ching Brook completed as part of the Environment Agency Hertfordshire and North London (HNL) options assessment studies (CAPITA AECOM 2017) Existing hydraulic modelling data from the updated HNL Package 1 modelling[7] has been interrogated to identify areas with an annual probability of 1 in 20 (5%), or greater flood extents to be delineated as Flood Zone 3b. There are no main river channels in the borough where Flood Zone 3b is not illustrated through reference to existing hydraulic modelling. The results are illustrated in Appendix A Figure 4 and 4A-E.

Appendix A Figure 4 and 4A-E Risk of Flooding from Rivers

### 2.5.4 Flood Depth and Hazard

A Level 1 SFRA should be sufficiently detailed to allow application of the Sequential Test to the location of development and to identify whether development can be allocated outside high and medium flood risk areas, based on all sources of flooding, without application of the Exception Test.

Where a Level 1 Assessment shows that land outside flood risk areas cannot appropriately accommodate all the necessary development, it may be necessary to increase the scope of the SFRA to a Level 2 SFRA to provide the information necessary for application of the Exception Test (where appropriate). A Level 2 Strategic Flood Risk Assessment should consider the detailed nature of the flood characteristics within a flood zone including:

1. flood probability;
2. flood depth;
3. flood velocity;
4. rate of onset of flooding;
5. duration of flood

Therefore flood depth and hazard have not been mapped as part of this Level 1 SFRA. Reference to flood depth and flood hazard mapping should be made where appropriate within a Level 2 assessment or a site specific FRA.

## 2.6 Surface water flood risk

Overland flow and surface water flooding typically arise following periods of intense rainfall, often of short duration, that is unable to soak into the ground or enter drainage systems. It can run quickly off land and result in localised flooding.

This source of flooding can be compounded when combined with impermeable sub-soils or significant areas of development with associated hard standing areas. As the majority of the study area is heavily developed, the risk of surface water flooding is increased.

### 2.6.1 Surface Water management Plan (SWMP)

The LB Waltham Forest Surface Water Management Plan (SWMP) undertook a comprehensive review of pluvial flood risk and identified Local Flood Risk Zones where surface water flooding may affect homes, businesses or infrastructure. This information was used to create a long-term action plan for the LB Waltham Forest to assist in their role as LLFA.

Thirteen critical drainage areas (CDAs) were identified, defined within the SWMP as ‘a discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer and/or river) often cause flooding in a Flood Risk Area during severe weather thereby affecting people, property or local infrastructure’. In addition, three of these CDAs have been ‘prioritised’ by LB Waltham Forest Council as areas for action being;

- Chestnuts;

[7] The 2014 River Lee modelling was updated as part of the Outline Business Case for the Dagenham Brook Flood Alleviation Scheme (FAS). The Dagenham Brook FAS was part of the HNL Package 1 modelling.

- South Chingford; and,
- Fillebrook.

Further information on the actions proposed for these CDA's is included in Section 2.12.

Post completion of the 2011 SWMP, the Environment Agency has undertaken further detailed modelling of surface water flood risk at a national scale and produced mapping identifying and classifying those areas at risk of surface water flooding:

- 3.33% annual probability (1 in 30 year), 'high'
- 1% annual probability (1 in 100 year), 'medium' and
- 0.1% annual probability (1 in 1,000 years) 'low'.

### 2.6.2 Risk of Flooding from surface water mapping

The latest version of Environment Agency surface water flood risk mapping is referred to as the 'Risk of Flooding from Surface Water Map' (RoFfSW) and the extents have been made available to LB Waltham Forest as GIS layers. This dataset is also available nationally on the Environment Agency website, and is referred to as 'Risk of Flooding from Surface Water'[8].

| Appendix A, Figures 5A-C Risk of Flooding from Surface Water |
| --- |

## 2.7 Geology and Groundwater flood risk

### 2.7.1 Groundwater Flooding

Groundwater flooding usually occurs in low lying areas underlain by permeable rock and aquifers that allow groundwater to rise to the surface through the permeable subsoil following long periods of wet weather. Low lying areas may be more susceptible to groundwater flooding because the water table is usually at a much shallower depth and groundwater paths tend to travel from high to low ground.

There are many mechanisms associated with groundwater flooding which are linked to high groundwater levels and can be broadly classified as:

- Direct contribution to channel flow – where the river channel intersects the water table and groundwater enters the streambed increasing water levels and causing flooding;
- Springs erupting at the surface;
- Inundation of drainage infrastructure – potentially where drainage infrastructure has eroded over time;
- Inundation of low lying property (basements).

The main impacts of groundwater flooding are:

- Flooding of basements of buildings below ground level – in the mildest case this may involve seepage of small volumes of water through walls, temporary loss of services etc. In more extreme cases larger volumes may lead to the catastrophic loss of stored items and failure of structural integrity;
- Overflowing of sewers and drains, where high groundwater has either penetrated underground pipes or entered the sewer from the surface (or a combination of the two) – surcharging of drainage networks can lead to overland flows causing significant but localised damage to property. Sewer surcharging can lead to inundation of property by polluted water. Note: it is complex to separate this flooding from other sources, notably surface water or sewer flooding;
- Flooding of buried services or other assets below ground level – prolonged inundation of buried services can lead to interruption and disruption of supply;

[8] https://flood-warning-information.service.gov.uk/long-term-flood-risk

- Inundation of roads, commercial, residential and amenity areas – inundation of grassed areas can be inconvenient; however the inundation of hard-standing areas can lead to structural damage and the disruption of commercial activity. Inundation of agricultural land for long durations can have financial consequences; and

- Flooding of ground floors of buildings above ground level – can be disruptive, and may result in structural damage. In addition, typically a groundwater flood event will have a long duration (when compared to other flood sources) which adds to the disruptive nature of the flood event.

Reference to the Environment Agency dataset 'Areas Susceptible to Groundwater Flooding' included in Appendix A Figure 6, identifies that the north and east of the borough is at low risk from groundwater flooding. The risk increases to the south and south west of the borough where areas with a higher risk of groundwater flooding are identified.

For more information on the BGS geology datasets please refer to the BGS website[9].

| Appendix A, Figure 6 Areas Susceptible to Groundwater Flooding |
|---|

# 2.8 Sewer Flood Risk

During heavy rainfall, flooding from the sewer system may occur if:

1. *The rainfall event exceeds the capacity of the sewer system/drainage system:*

Sewer systems are typically designed and constructed to accommodate rainfall events with an annual probability of 3.3% (1 in 30 chance each year) or greater. Therefore, rainfall events with an annual probability less than 3.3% would be expected to result in surcharging of some of the sewer system.

While TWUL, as the sewerage undertaker recognise the impact that more extreme rainfall events may have, it is not cost beneficial to construct sewers that could accommodate every extreme rainfall event.

2. *The system becomes blocked by debris or sediment:*

Over time there is potential that road gullies and drains become blocked from fallen leaves, build-up of sediment and debris (e.g. litter).

3. *The system surcharges due to high water levels in receiving watercourses:*

Within the study area there is potential for surface water outlets to become submerged due to high river levels. Once storage capacity within the sewer system itself is exceeded, the water will overflow into streets and potentially into houses.

Water companies are required to maintain a register of properties which are at risk of flooding due to hydraulic overloading of the sewers (the sewer pipe is too small, or at too shallow a gradient). This is called the DG5 risk register.

Appendix A Figures 7A and 7B show the internal and external sewer flood incident records from the DG5 Risk Register that has been supplied by Thames Water. It should be noted that these are flooding incidents that have been reported to TWUL by the home owners. There are obviously incidents that don't get reported and therefore will not show on the database. Incidents of sewer flooding can be retrospectively reported to TWUL via their website – http://thameswater.co.uk/help-and-advice/9782.htm. Records of sewer flooding can help to inform TWUL of areas in need of funding for further maintenance and development of the sewer system.

This dataset has identified that greater incidents of external sewer flooding have occurred in the south of the borough, in the area of Walthamstow and to the north of the borough within the area of Chingford Hatch. A number of internal sewer flood incidences have occurred to the south of the borough in the areas of Walthamstow and Leyton.

| Appendix A, Figures 7A and 7B Sewer Flooding |
|---|

[9] http://mapapps.bgs.ac.uk/geologyofbritain/home.html

## 2.9 Risk of Flooding from Reservoirs

The failure of a reservoir has the potential to cause catastrophic damage due to the sudden release of large volumes of water. The NPPF encourages LPAs to identify any impounded reservoirs and evaluate how they might modify the existing flood risk in the event of a flood in the catchment it is located within, and/or whether emergency draw-down (release of water to reduce the water level within the reservoir and therefore reduce flood risk) of the reservoir will add to the extent of flooding.

Reservoirs in the UK have an extremely good safety record. The Environment Agency is the enforcement authority for the Reservoirs Act 1975 in England and Wales. All large reservoirs must be inspected and supervised by reservoir panel engineers. It is assumed that these reservoirs are regularly inspected and essential safety work is carried out. These reservoirs therefore present a minimal risk.

If the reservoir was to breach, the extent of flooding would pose a significant risk of flooding both to large parts of the Borough and to neighbouring Boroughs. The Environment Agency's Risk of Flooding from Reservoirs mapping is available on their website[10]

The extent of flooding from a reservoir failure follows the path of the River Lee, putting the areas of Chingford, Chingford Mount and Walthamstow at risk. The extent of flooding also extends to the neighbouring boroughs of Haringey and Enfield affecting the areas of Enfield Highway, Lower Edmonton and Upper Edmonton.

## 2.10 Historic Flood Events

The Environment Agency and LB Waltham Forest have provided their Flood History datasets for use in this SFRA.

The Environment Agency has provided their 'Historic Flood Map' which shows the maximum extent of all individual recorded flood outlines (from rivers, the sea and groundwater springs) and shows areas of land that have previously been subject to flooding in England. LB of Waltham Forest has supplied a database of flood incidences within the borough. This has been mapped on Figure 8 included within Appendix A of this report.

The Environment Agency Historic Flood Map data shows records of flooding from the River Lee and the Dagenham Brook including extensive flooding in the south east of the borough. Records of flooding are also recorded along the Ching Brook which extends into the areas of South Chingford.

There are flood defences in place on these watercourses, however they offer varying levels of protection and any proposed development within areas shown to have a flood history should investigate this risk further as part of a site specific flood risk assessment.

| Appendix A, Figure 8 Flood Incidences |
|---|

LB Waltham Forest has provided further details of previous flood events within the Borough. Further details can be found in Appendix B.

## 2.11 Flood Risk Management Infrastructure

There are two main categories of flood defences, formal and informal. Formal defences are specifically constructed to control floodwater. Informal defences include structures that have not necessarily been constructed for this purpose but do have an impact on retaining flood water, such as railway and road embankments or other linear infrastructure such as boundary walls and buildings. The flood defences located along the watercourses within the Borough are described below.

### 2.11.1 River Lee

The modified and unmodified sections of the River Lee are protected by a number of hard defences. The Environment Agency AIMS data identifies the type and standard of protection provided by the defences along the watercourse. These are shown below in Table 2-3. The location of these defences is shown in Appendix A Figure 9.

[10] Environment Agency's Risk of Flooding from Reservoirs https://flood-warning-information.service.gov.uk/long-term-flood-risk/

Appendix A, Figure 9 Flood Warning Areas and Areas Benefitting from Defences

**Table 2-3 River Lee Flood Defences**

| Watercourse name | Defence type | Standard of protection offered |
|---|---|---|
| River Lee Diversion | High Ground | 1 in 5 year to 1 in 50 year event |
| River Lee Flood Relief Channel | High Ground | 1 in 5 year to 1 in 70 year |
| River Lee Navigation | High Ground | 1 in 2 year to 1 in 50 year |

### 2.11.2 Dagenham Brook

The flood defences for the Dagenham Brook are shown below in Table 2-4. The location of these defences are shown in Appendix A Figure 9

Appendix A, Figure 9 Flood Warning Areas and Areas Benefitting from Defences

**Table 2-4 Dagenham Brook Flood Defences**

| Watercourse name | Defence type | Standard of protection offered |
|---|---|---|
| Dagenham Brook | Embankment | 1 in 5 year to 1 in 200 year |
| | High Ground | 1 in 5 year to 1 in 10 year |
| | Culvert | 1 in 5 year |
| | Flood Wall | 1 in 70 year |

### 2.11.3 Ching Brook

**The flood defences for the Ching Brook are shown below in**
Table 2-5. The locations of these defences are shown in Appendix A Figure 9.

Appendix A, Figure 9 Flood Warning Areas and Areas Benefitting from Defences

**Table 2-5 Dagenham Brook Flood Defences**

| Watercourse name | Defence type | Standard of protection offered |
|---|---|---|
| Ching Brook | Flood Wall | 1 in 25 year |
| | Culvert | 1 in 2 year |
| | High Ground | 1 in 2 year to 1 in 200 year |

## 2.12 Surface Water Management Schemes- Options Appraisal

In 2011 a Surface Water Management Plan was created through the Drain London project to identify ‘critical drainage areas’ throughout the borough where further assessment of mitigation measures would be ‘focused’.

Following this study LB Waltham Forest as LLFA commissioned Surface Water Flood Risk Investigations in three CDA’s: Fillebrook, Chestnuts Showground and South Chingford. A summary of the proposed mitigation schemes are provided in Table 2-6 below:

**Table 2-6 Surface Water Management schemes**

| CDA Name | Preferred option | Further information |
|---|---|---|

| CDA Name | Preferred option | Further information |
|---|---|---|
| Chestnuts Showground | The outline scheme includes the construction of a wetland system within the Chestnuts Showground open space.<br>An assessment of the benefits generated from the wetland show a direct reduction in flood depths for all modelled events, with the greatest benefit identified during the lower rainfall events.<br>The council is currently consulting external stakeholders to procure the necessary funding to construct this feature within the parkland. The council is also evaluating options to improve the cost / benefit ratio of scheme'. The scheme currently has a negative cost benefit ratio and will not, as a first step, be eligible for Grant in Aid (GiA) funding until the benefits outweigh the costs. | BMT, 2018, London Borough of Waltham Forest Surface Water Investigations – Chestnuts Showground |
| South Chingford | No formal options assessment was undertaken for the South Chingford CDA. Four areas of open space have been identified as possible location to include flood attenuation and SuDS measures. These are consistent with those identified by Thames 21 who are currently undertaking maintenance work on the Ching Brook.<br>LB Waltham Forest has identified three sites as potential sustainable drainage proposals for Thames Water's next asset management period. These areas are referred to as Mandeville Court, Maple Avenue and Rolls Court. | BMT, 2018, London Borough of Waltham Forest Surface Water Investigations – South Chingford |
| Fillebrook | A flood storage scheme was proposed that comprises of two basins interconnected with a swale within the Whipps Cross Hospital site. This area has been identified in the Local Plan as a preferred site for development.<br>Flow routes from Peterborough Road would be addressed via temporary storage. Agreement on this would need to be sought by LB Waltham Forest. | BMT, 2018, London Borough of Waltham Forest Surface Water Investigations –Fillebrook |

# 3. Impact of Climate Change

The NPPF[1] and supporting practice guide sets out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. This includes demonstrating how flood risk will be managed now and over the lifetime of development, taking climate change into account.

In previous SFRAs and site specific Flood Risk Assessments an allowance of 20% was added to the 1 in 100 year (1% AEP) return period to account for increases in flood risk due to climate change. In February 2016, the Environment Agency published revised guidance on climate change allowances[11] including predictions of anticipated change for:

- Peak river flow by river basin district;
- Peak rainfall intensity;
- Sea level rise;
- Offshore wind speed and extreme height.

The guidance reflects an assessment completed by the Environment Agency between 2013 and 2015 using United Kingdom Climate Projections 2009 (UKCP09) data to produce more representative climate change allowances across England. The full guidance can be found using the following link to the .gov.uk website and is discussed further below. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

## 3.1 Peak River Flow

### 3.1.1 Strategic Planning

For the purposes of strategic planning and completion of the sequential test, LB Waltham Forest are advised to use the '2070 to 2115' 100 year development lifetime outlined in Table 3-2 below. For more vulnerable, residential development this correlates to a climate change range of impacts of between + 25% and + 70% on the 1 in 100 year (1%) AEP.

**River Lee and Dagenham Brook -** Hydraulic modelling is available from the Environment Agency for the River Lee and Dagenham Brook, therefore, for the purposes of mapping climate change flood outlines within this SFRA and sequential testing, climate change mapping is based on the 1 in 100 year (1%) AEP + 70% climate change as a conservative approach.

**Ching Brook -** The Ching Brook does not have modelled extents for Climate Change. In the absence of updated hydraulic modelling the 1 in 1000 year flood outline will be used as a proxy for the 1% + 70% Climate change. Please refer to stage discharge calculations included in Appendix C.

### 3.1.2 Site Specific Flood Risk Assessments

When considering peak river allowances the NPPF[1] flood zone and flood risk vulnerability classification needs to be considered to confirm which range of climate change allowances should be assessed. This is set out in Table 3-1 below:

[11] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

### Table 3-1 NPPF[1] Flood Zone and Vulnerability

| Flood Zone (Table 2-1) | Vulnerability (Table 4-2) | River Flow Allowances (Table 3-2) |
|---|---|---|
| Flood Zone 2 | Essential Infrastructure | Higher Central and Upper End |
| | Highly Vulnerable | Higher Central and Upper End |
| | More Vulnerable | Central and Higher Central |
| | Less Vulnerable | Central |
| | Water Compatible | None of the allowances |
| Flood Zone 3a | Essential Infrastructure | Upper End |
| | Highly Vulnerable | Development should not be permitted |
| | More Vulnerable | Higher Central and Upper End |
| | Less Vulnerable | Central and Higher Central |
| | Water Compatible | Central |
| Flood Zone 3b | Essential Infrastructure | Upper End |
| | Highly Vulnerable | Development should not be permitted |
| | More Vulnerable | Development should not be permitted |
| | Less Vulnerable | Development should not be permitted |
| | Water Compatible | Central |

In order to determine which allowance category to use, the development lifetime should be considered. This should be judged based on the characteristics of development and applicants should be able to justify the chosen lifetime. Typically:

- Residential developments should apply a minimum lifetime of 100 years, unless there is specific justification for considering a shorter period;
- Non- residential developments should apply a 75 year lifetime.

Therefore, in this locality, if a residential (more vulnerable/100 year lifetime) development were proposed within Flood Zone 3a an allowance of between 35% and 70% should be applied typically to the 1 in 100 year (1%) AEP to account for the potential impacts of climate change on Peak River flows (as the development would still be in place in the 2080s).

Climate change allowances applicable to LB Waltham Forest (Thames River Basin District) are set out in Table 3-2 below.

### Table 3-2 Peak River Flow Allowances[12] for Thames River Basin District

| River Basin District | Allowance Category | Total potential change anticipated for the '2020's (2015 to 2039) | Total potential change anticipated for the '2050's (2040 to 2069)) | Total potential change anticipated for the '2080's (2070 to 2115) |
|---|---|---|---|---|
| Thames | Upper End | 25% | 35% | 70% |
| | Higher Central | 15% | 25% | 35% |
| | Central | 10% | 15% | 25% |

**'Allowances' in this context is the amount as a % that is added to estimated peak river flows to account for climate change increases.*

[12] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

#### 3.1.2.1 Ching Brook

As noted above, there is no hydraulic modelling available for the Ching Brook that includes allowances for climate change. In the absence of the updated allowances and based on the information currently available the 0.1% AEP (1 in 1000 year) fluvial event can be used to represent an estimated 1% AEP event with allowances for the updated climate change allowance. In order to determine the validity of using the 0.1% AEP flood as a proxy event, two methods have been applied to analyse the Ching Brook model.

1. Analysis of the stage-discharge relationship at nodes throughout the model has been undertaken in accordance with the suggested approach set out in the guidance document published by the Environment Agency 'Flood Risk Assessment: Climate Change Allowances'[13].
2. Analysis of the inflows through the model has been undertaken to determine the ratio between the 1% AEP flood event and the 0.1% AEP flood event and how it compares to the 25%, 35% and 70% increases.

The results of these analyses are described in Appendix C. Overall; the extent of the 1% AEP event is unlikely to exceed the extent of the 0.1% AEP event after adjustments for climate change. However, there are some reaches of Ching Brook where the relationship between flow and stage is more complex.

In order to satisfy Environment Agency requirements, site specific FRAs will be expected to undertake hydraulic modelling where modelled data is not already available. Reference should be made to Environment Agency Technical Note 'Flood Risk Assessments: Climate Change Allowances Hertfordshire and North London' (available from the Environment Agency) for further guidance.

## 3.2 Climate change for Surface Water flow

Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding. Currently there is no Environment Agency modelled data available for the updated climate change scenario for surface water flood risk. In the absence of this data, the 1 in 1000 year surface water risk outline from the Environment Agency RoFfSW mapping will be used as a proxy for the 1 in 100 year + 40% climate change. This is displayed in Appendix A Figures 5A-C

| Appendix A Figures 5A-C |
|---|

[13] Environment Agency (2016) East Anglia, Essex, Norfolk and Suffolk Area – Flood Risk Assessment: Climate Change Allowances.

# 4. Avoiding Flood Risk – Risk Based Approach to Planning

The NPPF[1] approach aims to ensure that flood risk is considered at all stages of the planning process, and to avoid inappropriate development in areas of greatest flood risk; steering development towards areas of lower risk.

Development is only permissible in areas at risk of flooding (see Table 4-1 below) in exceptional circumstances where it can be demonstrated that there are no reasonably available sites in areas of lower risk, the sustainability benefits outweigh flood risks and, the development will be safe for its lifetime without increasing flood risk elsewhere. Such development is required to include mitigation/management measures to minimise risk to life and property should flooding occur.

Building on these principles, the NPPF[1] and Technical Guidance have established a process for the assessment of flood risk, with each stage building upon the previous assessment with a refinement of the evidence base. Utilising a Source – Pathway – Receptor approach, the source of flooding, the spatial distribution of flood risk and the vulnerability of development types are assessed to inform decision making through each of the key stages of the Flood Risk Management Hierarchy, as outlined in the Technical Guidance and shown in Table 4-1 below.

**Table 4-1 Flood Risk Management Hierarchy and the SFRA Process**

Hierarchy

| Stage | Approach |
|---|---|
| Level 1 SFRA | Assessment (broad scale and comprehensive) |
| Sequential Test Across Planning Area | Avoidance |
| Level 2 SFRA (if required) | Detailed Assessment (Growth Area or Site Specific) |
| Sequential Approach at Site | Avoidance |
| Control and Improvement | Through Design (e.g. SuDS) |
| Mitigate Remaining Risks | Flood Resilient Design and Construction |

## 4.1 Sequential Approach

This Section guides the application of the Sequential Test and Exception Test in the plan-making and planning application processes. Not all development will be required to undergo these tests, as described below, but may still be required to undertake a site specific FRA, guidance about which is included in Section 6.

The sequential approach is a decision-making tool designed to ensure that sites at little or no risk of flooding are developed in preference to sites at higher risk. This will help avoid the development of sites that are inappropriate on flood risk grounds. The subsequent application of the Exception Test (where required) will ensure that new developments in flood risk areas will only occur where flood risk is clearly outweighed by other sustainability drivers.

The sequential approach can be applied at all levels and scales of the planning process, both between and within Flood Zones. However, sites located further from the flood defence walls may be at a reduced flood risk than sites adjacent to the flood defence walls. In this instance breach modelling can be used to provide a greater understanding of the risk within the Flood Zone. All opportunities to locate new developments (except Water Compatible (Table 4-2)) in reasonably available areas of little or no flood risk should be explored, prior to any decision to locate them in areas of higher risk.

## 4.2 Applying Sequential Test – Plan Making

Regarding the allocation of sites through the Local Plan, it should be demonstrated that a range of possible sites were considered in conjunction with the Flood Zone and vulnerability information provided by the SFRA, and the Sequential Test, and where necessary, the Exception Test applied. Figure 1-1 illustrates the approach for applying the Sequential Test that LB Waltham Forest should adopt in the allocation of sites as part of the preparation of the Waltham Forest Local Plan (note that the process for planning applications is examined in 4.4). The Sequential Test should be undertaken by LB Waltham Forest and accurately documented to ensure decision processes are consistent and transparent

The *Sequential Test* requires an understanding of the Flood Zones in the study area and the vulnerability classification of the proposed developments. Flood Zone definitions are provided in Table 2-1 and mapped in the figures in Appendix A (and the Environment Agency's Flood Map for Planning (Rivers and Sea)). Flood risk vulnerability classifications, as defined in the NPPF are presented in Table 4-2.

NPPF[1] acknowledges that some areas will (also) be at risk of flooding from sources other than fluvial. All sources must be considered when planning for new development including: flooding from land or surface water runoff; groundwater; sewers; and artificial sources.

If a location is recorded as having experienced repeated flooding from the same source this should be acknowledged within the Sequential Test.

The flow diagram presented in Figure 4-1 illustrates how the Sequential Test process should be applied to identify the suitability of a site for allocation, in relation to the flood risk classification.

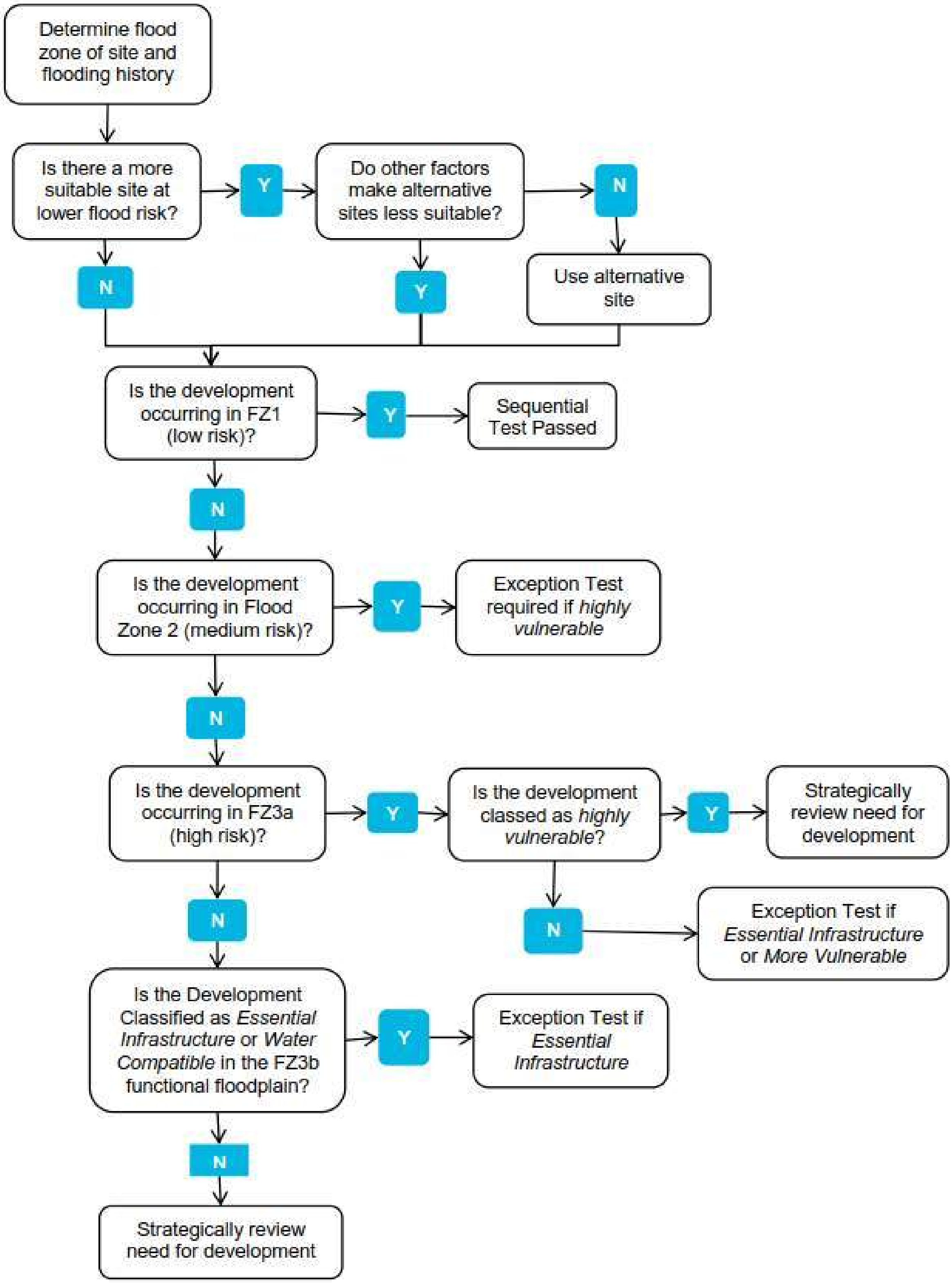



**Figure 4-1 Application of the Sequential Test for the Plan Making Process** ***(after Diagram 2 Application of the Sequential Test for Local Plan Preparation NPPF[1])***

**Table 4-2 Flood Risk Vulnerability Classification** ***(after Table 2 PPG[2] March 2014)***

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

**Table 4-3 Flood Risk Vulnerability and Flood Zone 'Compatibility' (PPG[2], 2014)**

| Flood Risk Vulnerability Classification | | Essential Infrastructure | Highly Vulnerable | More Vulnerable | Less Vulnerable | Water Compatible |
|---|---|---|---|---|---|---|
| Flood Zone | 1 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 2 | ✓ | Exception test Required | ✓ | ✓ | ✓ |
| | 3a | Exception Test Required | × | Exception Test Required | ✓ | ✓ |
| | 3b *[1] | Exception Test Required* | × | × | × | ✓* |

✓ - Development is appropriate × - Development should not be permitted

* In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:
- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

The recommended steps in undertaking the Sequential Test are detailed below. This is based on the Flood Zone and Flood Risk Vulnerability and is summarised in Table 4-3. The information required to address many of these steps is provided in the accompanying maps presented in Appendix A.

- Assign potential developments with a vulnerability classification (Table 4-2). Where development is mixed, the development should be assigned the highest vulnerability class of the developments proposed.
- The location and identification of potential development should be recorded.
- The Flood Zone classification of potential development sites should be determined based on a review of the Flood Map for Planning (Rivers and Sea). Where these span more than one Flood Zone, all zones should be noted, preferably using percentages.
- The design life of the development should be considered in accordance with NPPF[1] guidelines with respect to *climate change*, being:
    - **Residential development** should be considered for a minimum of **100 years**, unless there is specific justification for considering a shorter period.
    - The lifetime of non-residential development depends on the characteristics of that development. Planners should use their experience within their locality to assess how long they anticipate the development being present for. Developers would be expected to justify why they have adopted a given lifetime for the development, for example when they are preparing a site-specific flood risk assessment. Typically a timeframe of **75 years** is applied to **commercial / industrial** developments.
- Identify existing flood defences serving the potential development sites to outline areas at residual flood risk. However, it should be noted that for the purposes of the Sequential Test, Flood Zones ignoring defences should be used.
- Highly Vulnerable developments to be accommodated within the Borough should be located on those sites identified as being within Flood Zone 1. If these cannot be located in Flood Zone 1, because the identified sites are unsuitable or there are insufficient sites in Flood Zone 1, sites in Flood Zone 2 can then be considered. If sites in Flood Zone 2 are inadequate then additional sites in Flood Zones 1 or 2

may need to be identified to accommodate development or opportunities sought to locate the development outside the Borough.

- Once all Highly Vulnerable developments have been allocated to a development site, consideration can be given to those development types defined as More Vulnerable. In the first instance More Vulnerable development should be located on sites in Flood Zone 1. Where these sites are unsuitable or there are insufficient sites remaining, sites in Flood Zone 2 can be considered. If there are insufficient sites in Flood Zone 1 or 2 to accommodate More Vulnerable development, sites in Flood Zone 3a can be considered. More Vulnerable developments in Flood Zone 3a will require application of the Exception Test.

- Once all More Vulnerable developments have been allocated to a development site, consideration can be given to those development types defined as Less Vulnerable. In the first instance Less Vulnerable development should be located on sites in Flood Zone 1, continuing sequentially with Flood Zone 2, then 3a. Less Vulnerable development types are not appropriate in Flood Zone 3b – Functional Floodplain.

- Essential Infrastructure should be preferentially located in the lowest flood risk zones, however this type of development may be located in Flood Zones 3a and 3b, provided the Exception Test is satisfied.

- Water Compatible development has the least constraints with respect to flood risk and it is considered appropriate to allocate these sites last. The sequential approach should still be followed in the selection of sites; however it is appreciated that Water Compatible development by nature often relies on access and proximity to water bodies.

- Where required, a more detailed Level 2 SFRA should consider the nature of flood risk and hazard to allow a sequential approach to site allocation within a Flood Zone. Consideration of flood hazard within a flood zone would include:

    - Flood risk management measures,
    - The rate of flooding,
    - Flood water depth,
    - Flood water velocity.

### 4.2.1 Windfall Sites

Windfall sites are those that have not been specifically identified as available in the Local Plan process. Given the patterns of development in LB Waltham Forest it's likely that most windfall sites would be within the 'Urban Waltham Forest' area where flood risk is lower and, as such, development is inherently preferable. Such sites should be assessed at application stage as required.

## 4.3 Applying Sequential Test – Planning Applications

It is necessary to undertake a *sequential test* for a planning application if both of the following apply (also refer to 4.1 above):

- The proposed development is in Flood Zone 2 or 3.

- A sequential test hasn't already been completed for a development of the type you plan to carry out on your proposed site (check with LB Waltham Forest).

### 4.3.1 Sequential Test Exemptions[14]

It should be noted that the Sequential Test does not need to be applied in the following circumstances:

- Individual developments proposed on sites which have been allocated in development plans through the Sequential Test.
- Minor development, which is defined in the NPPF[1] as:
    1. Minor non-residential extensions: industrial / commercial / leisure etc. extensions with a footprint <250m$^2$.
    2. Alterations: development that does not increase the size of buildings e.g. alterations to external appearance.
    3. Householder development: for example; sheds, garages, games rooms etc. within the curtilage of the existing dwelling, in additional to physical extensions to the existing dwelling itself. This definition excludes any proposed development that would create a separate dwelling within the curtilage of the existing dwelling e.g. subdivision of houses into flats.
- Change of Use applications, unless it is for a change of use of land to a caravan, camping or chalet site, or to a mobile home site or park home site. However, such sites still need to meet the requirements for site-specific flood risk assessments[15].
- Development proposals in Flood Zone 1 (land with a low probability of flooding from rivers or the sea) unless the SFRA, or other more recent information, indicates there may be flooding issues now or in the future (for example, through the impact of *climate change*).
- Redevelopment of existing properties (e.g. replacement dwellings), provided they do not increase the number of dwellings in an area of flood risk (i.e. replacing a single dwelling within an apartment block).

### 4.3.2 Applying the Sequential Test to planning applications

The Environment Agency publication 'Demonstrating the flood risk *Sequential Test* for Planning Applications[16]' sets out the procedure for applying the *sequential test* to individual applications as follows:

- Identify the geographical area of search over which the test is to be applied; this could be the Borough area, or a specific catchment if this is appropriate and justification is provided (e.g. school catchment area or the need for affordable housing within a specific area).
- Identify the source of 'reasonably available' alternative sites; usually drawn from evidence base / background documents produced to inform the Local Plan.
- State the method used for comparing flood risk between sites; for example the Environment Agency Flood Map for Planning, the SFRA mapping, site-specific FRAs if appropriate, other mapping of flood sources.
- Apply the Sequential Test; systematically consider each of the available sites, indicate whether the flood risk is higher or lower than the application site, state whether the alternative option being considered is allocated in the Local Plan, identify the capacity of each alternative site, and detail any constraints to the delivery of the alternative site(s).
- Conclude whether there are any reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed.
- Where necessary, as indicated by Table 4-3, apply the Exception Test.
- Apply the Sequential approach to locating development within the site.

[14] Refer to NPPF for guidance https://www.gov.uk/guidance/flood-risk-assessment-the-sequential-test-for-applicants
[15] Note that while the sequential test is not required, a site specific FRA is required for all proposals for new development including minor development and change of use in Flood Zone 2 and 3. NPPF Footnote 50 referring to paragraph 103
[16] Environment Agency, April 2012, 'Demonstrating the flood risk Sequential Test for Planning Applications', Version 3.1

Ultimately, after applying the Sequential Test, LB Waltham Forest (taking advice from the Environment Agency) needs to be satisfied in all cases that the proposed development would be safe and not lead to increased flood risk elsewhere. This needs to be demonstrated within a FRA and is necessary regardless of whether the Exception Test is required.

## 4.4 Exception Test

The purpose of the Exception Test is to ensure that, following the application of the *Sequential Test*, new development is only permitted in Flood Zone 2 and 3 where flood risk is clearly outweighed by other sustainability factors and where the development will be safe during its lifetime, considering *climate change*.

The Exception Test provides a method of managing flood risk while still allowing necessary sustainable development to occur. The test is used when there are large areas in Flood Zones 2 and 3a (consistent with LB Waltham Forest Appendix A Figure 4 and 4A-D) where the Sequential Test alone cannot deliver acceptable sites, but where some continuing development is necessary for wider sustainable development reasons. The flow chart presented in Figure 4-1 demonstrates the methodology to determine whether an Exception Test is required for proposed site allocations.

In order to pass the Exception Test, the NPPF[1] paragraph 160 identifies two elements that need to be demonstrated/fulfilled to the satisfaction of the LPA:

1. The development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared; and

2. A site-specific flood risk assessment (FRA) must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, reducing flood risk overall.

Satisfying the Exception Test involves consideration of the reasons behind the selection of the site for development (from the sustainability appraisal), as well as consideration in planning and design, such that the site will remain safe and operational in the event of flooding. This may involve demonstrating that:

- A sequential approach is taken to development site layout, such that within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
- Buildings are designed to be appropriately flood resilient and resistant, with essential services remaining functional in the event of flooding, and quick recovery following a flood;
- there is a safe means of access and egress during a flood event;
- Emergency evacuation procedures are developed, to be utilised following receipt of a flood warning;
- Priority is given to the use of sustainable drainage systems

A proportion of LB Waltham Forest is located within Flood Zone 3a of the River Lee and Ching Brook (Appendix A Figure 4 and 4A-D); therefore it is likely that the requirements of the Exception Test will need to be satisfied for ‘more vulnerable’ e.g. residential, development in this area.

# 5. Managing and Mitigating Flood Risk through Spatial Planning and Development Control

## 5.1 Overview

The NPPF[1] appreciates that it may not always be possible to avoid locating development in areas at risk of flooding. This section builds on the findings of the SFRA to provide guidance on the range of measures that could be considered on site in order to manage and mitigate flood risk. These measures should be considered when preparing a site-specific FRA as described in Section 6. Section 7 outlines the approach that LB Waltham Forest could adopt in relation to flood risk planning policy and development management decisions.

## 5.2 Design Flood Level

Where a development is identified as being located within an area at risk of fluvial flooding, the design flood is an important part of the flood risk planning process which needs to be defined in a site specific Flood Risk Assessment to support the planning application process. The design flood event is the largest flood that a given project is designed to safely accommodate. The 1 in 100 year fluvial (1% AEP) including a suitable allowance for climate change[17] is typically used.

## 5.3 Development Layout and Sequential Approach

> A sequential approach to site planning should be applied within new development sites

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development. Most large development proposals include a variety of land uses of varying vulnerability to flooding. The sequential approach should be applied within development sites to locate the most vulnerable elements of a development in the lowest risk areas (considering all sources of flooding) e.g. residential elements should be restricted to areas at lower probability of flooding whereas parking, open space or proposed landscaped areas can be placed on lower ground with a higher probability of flooding.

## 5.4 Finished Floor Levels

> For the purposes of informing a site specific FRA, all More Vulnerable and Highly Vulnerable development within Flood Zones 2 and 3 should set Finished Floor Levels to whichever is higher, 300mm above the general ground level of the site or 600mm above the estimated river or sea flood level.

Where developing in Flood Zone 2 and 3 is unavoidable, the recommended method of mitigating flood risk to people, particularly with More Vulnerable (residential) and Highly Vulnerable land uses, is to ensure internal floor levels are raised a freeboard level above the design flood level .

With reference to the 'Flood risk assessment: standing advice for the flood risk'[18], finished floor levels should be a minimum of whichever is higher, 300mm above the finished ground floor level of the site or 600mm above the estimated river or sea flood level.

In certain situations (e.g. for proposed extensions to buildings with a lower floor level or conversion of existing historical structures with limited existing ceiling levels), it could prove impractical to raise the internal ground floor

[17] Climate change guidance is periodically updated – reference should be made to the Environment Agency via https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances Latest climate change guidance was published on 19th Feb 2016 and updated 3rd Feb 2017.
[18] https://www.gov.uk/guidance/flood-risk-assessment-standing-advice

levels to sufficiently meet the general requirements. In these cases, the Environment Agency and/or LB Waltham Forest should be approached to discuss options for a reduction in the minimum internal ground floor levels provided flood resistance measures are implemented up to an agreed level.

There are also circumstances where flood resilience measures should be considered first. These are described further below. For both Less and More Vulnerable developments where internal access to higher floors is required, the associated plans showing the access routes and floor levels should be included within any site-specific FRA.

## 5.5 Flood Resistance 'Water Exclusion Strategy'

There is a range of flood resistance and resilience construction techniques that can be implemented in new developments to mitigate potential flood damage. The Department for Communities and Local Government (CLG) have published a document 'Improving the Flood Performance of New Buildings, Flood Resilient Construction[19]', the aim of which is to provide guidance to developers and designers on how to improve the resistance and resilience of new properties to flooding through the use of suitable materials and construction details. Figure 5-1 provides a summary of the Water Exclusion Strategy (flood resistance measures) and Water Entry Strategy (flood resilience measures) which can be adopted depending on the depth of floodwater that could be experienced.

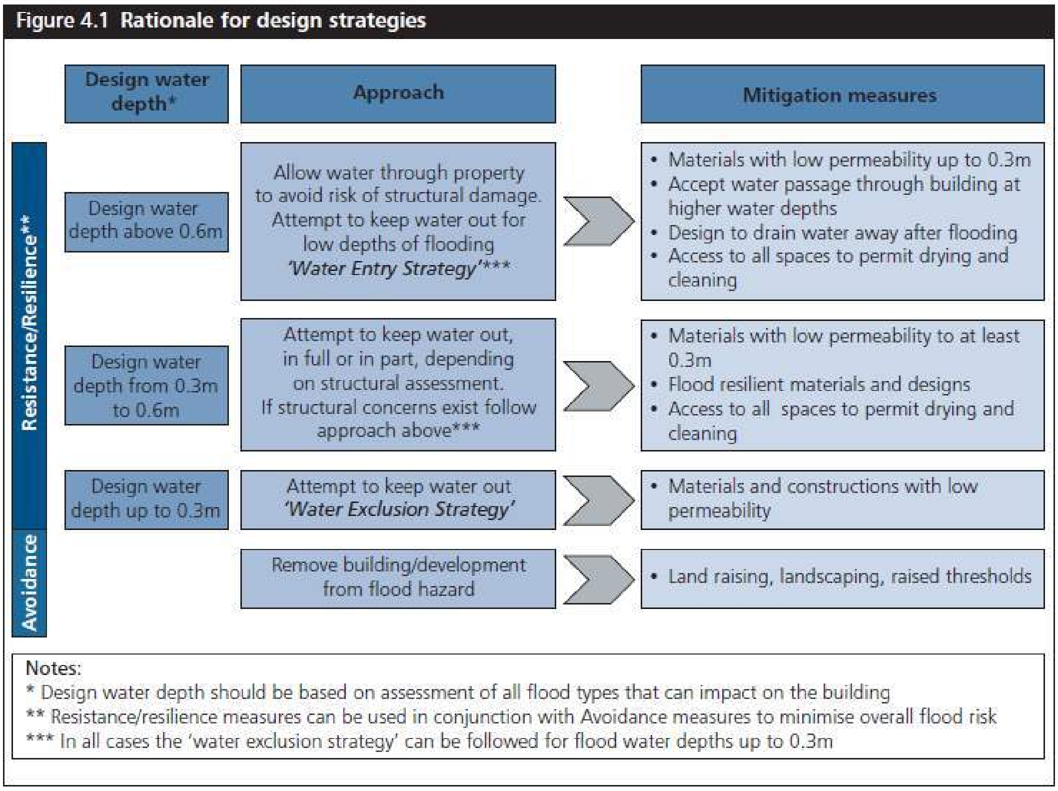



**Figure 5-1 Flood Resistant / Resilient Design Strategies, Improving Flood Performance, CLG 2007**

Resistance measures are aimed at preventing water ingress into a building (Water Exclusion Strategy); they are designed to minimise the impact of floodwaters directly affecting buildings and to give occupants more time to relocate ground floor contents. These measures will probably only be effective for short duration, low depth flooding, i.e. less than 0.3m, although these measures should be adopted where depths are between 0.3m and 0.6m and there are no structural concerns

In areas at risk of flooding of low depths (<0.3m), implement flood resistance measures such as:

- Using materials and construction with low permeability.
- Land raising.

19 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/7730/flood_performance.pdf

- Landscaping e.g. creation of low earth bunds (subject to this not increasing flood risk to neighbouring properties).
- Raising thresholds and finished floor levels e.g. porches with higher thresholds than main entrance.
- Flood gates with waterproof seals.
- Sump and pump for floodwater to remove waste faster than it enters.

There are a range of property flood protection devices available on the market which are designed specifically to resist the passage of floodwater. These include removable flood barriers and gates designed to fit openings, vent covers and stoppers designed to fit WCs. These measures can be appropriate for preventing water entry associated with fluvial flooding as well as surface water and sewer flooding. The efficacy of such devices relies on their being deployed before a flood event occurs. It should also be borne in mind that devises such as air vent covers, if left in place by occupants as a precautionary measure, may compromise safe ventilation of the building in accordance with Building Regulations.

## 5.6 Flood Resilience 'Water Entry Strategy'

For flood depths greater than 0.6m, it is likely that structural damage could occur in traditional masonry construction due to excessive water pressures. In these circumstances, the strategy should be to allow water into the building, but to implement careful design in order to minimise damage and allow rapid re-occupancy. This is referred to as the Water Entry Strategy. These measures are appropriate for uses where temporary disruption is acceptable and suitable flood warning is received.

Materials should be used which allow the passage of water whilst retaining their structural integrity and they should also have good drying and cleaning properties. Alternatively sacrificial materials can be included for internal and external finishes; for example the use of gypsum plasterboard which can be removed and replaced following a flood event. Flood resilient fittings should be used to at least 0.1m above the design flood level. Resilience measures are either an integral part of the building fabric or are features inside a building that will limit the damage caused by floodwaters.

In areas at risk of frequent or prolonged flooding, implement flood resilience measures such as:

- Use materials with either, good drying and cleaning properties, or, sacrificial materials that can easily be replaced post-flood.
- Design for water to drain away after flooding.
- Design access to all spaces to permit drying and cleaning.
- Raise the level of electrical wiring, appliances and utility metres.
- Coat walls with internal cement based renders; apply tanking on the inside of all internal walls.
- Ground supported floors with concrete slabs coated with impermeable membrane.
- Tank basements, cellars or ground floors with water resistant membranes.
- Use plastic water resistant internal doors.

Further specific advice regarding suitable materials and construction techniques for floors, walls, doors and windows and fittings can be found in 'Improving the Flood Performance of New Buildings, Flood Resilient Construction[19]' .

Structures such as (bus, bike) shelters, park benches and refuse bins (and associated storage areas) located in areas with a high flood risk should be flood resilient and be firmly attached to the ground and designed in such a way as to prevent entrainment of debris which in turn could increase flood risk and/or breakaway posing a danger to life during high flows.

## 5.7 Safe Access/ Egress

Safe access and egress is required to enable the evacuation of people from the development, provide the emergency services with access to the development during times of flood and enable flood defence authorities to carry out any necessary duties during periods of flood.

A safe access/egress route should allow occupants to safely enter and exit the buildings and be able to reach land outside the flooded area (e.g. within Flood Zone 1) using public rights of way without the intervention of emergency services or others during design flood conditions, including climate change allowances.

For developments located in areas at risk of fluvial flooding, safe access/egress must be provided for new development as follows in order of preference:

- Safe dry route for people and vehicles
- Safe dry route for people
- If a dry route for people is not possible, a route for people where flood hazard (in terms of depth and velocity of flooding) is low and should not cause risk to people.
- If a dry route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity of flooding) is low to permit access for emergency vehicles. However the public should not drive vehicles in floodwater.

In all these cases, a 'dry' access/egress is a route located above the 1% annual probability flood level (1 in 100 year) including an allowance for climate change.

## 5.8 Safe Refuge

In exceptional circumstances, dry access above the 1% annual probability (1 in 100 year) flood level including climate change may not be achievable. In these circumstances the Environment Agency and LB Waltham Forest should be consulted to ensure that the safety of the site occupants can be satisfactorily managed; this will be informed by the type of development, the number of occupants and their vulnerability and the flood hazard along the proposed egress route. For example, this may entail the designation of a safe place of refuge on an upper floor of a building, from which the occupants can be rescued by emergency services. It should be noted that sole reliance on a safe place of refuge is a last resort, and all other possible means to evacuate the site should be considered first. Provision of a safe place of refuge will not guarantee that an application will be granted.

## 5.9 Floodplain Compensation Storage

All new development within Flood Zone 3 must not result in a net loss of flood storage capacity. Where possible, opportunities should be sought to achieve an increase in the provision of floodplain storage.

Where proposed development results in a change in building footprint, the developer must ensure that it does not impact upon the ability of the floodplain to store water, and should seek opportunities to provide a betterment with respect to floodplain storage.

Similarly, where ground levels are elevated to raise the development out of the floodplain, compensatory floodplain storage within areas that currently lie outside the floodplain must be provided to ensure that the total volume of the floodplain storage is not reduced.

Floodplain compensation must be provided on a level for level, volume for volume basis on land which does not already flood and is within the site boundary. Where land is not within the site boundary, it be in the immediate vicinity, in the applicant's ownership and linked to the site. Floodplain compensation must be considered in the context of the 1% annual probability (1 in 100 year) flood level including an allowance for climate change. When designing a scheme flood water must be able to flow in and out and must not pond. An FRA must demonstrate that there is no loss of flood storage capacity and include details of an appropriate maintenance regime to ensure mitigation continues to function for the life of the development. Guidance on how to address floodplain compensation is provided in Appendix A3 of the CIRIA Publication C624.

The requirement for no loss of floodplain storage means that it is not possible to modify ground levels on sites which lie completely within the floodplain (when viewed in isolation), as there is no land available for lowering to bring it into the floodplain. It is possible to provide off-site compensation within the local area e.g. on a neighbouring or adjacent site, or indirect compensation, by lowering land already within the floodplain, however, this would be subject to detailed investigations and agreement with the Environment Agency to demonstrate (using an appropriate flood model where necessary) that the proposals would improve and not worsen the existing flooding situation or could be used in combination with other measures to limit the impact on floodplain storage

## 5.10 Flood Voids

The use of under-floor voids with adequate openings beneath the raised finished floor levels can be considered for development in Flood Zone 2 and 3. They are generally considered to provide indirect compensation or mitigation, but not true compensation for loss of floodplain storage. The use of under-floor voids will typically require a legal agreement or planning condition and maintenance plan for them to remain open for the lifetime of the development and agreement that LB Waltham Forest will enforce. Sole reliance on the use of under-floor voids to address the loss of floodplain storage capacity is generally not acceptable on undeveloped sites or for individual properties.

Should it not be possible to achieve all the level for level compensation required, the Environment Agency may consider that the remainder be provided through the use of under-floor voids instead. The amount of level for level compensation would need to be maximised and any under-floor voids would need to be appropriately designed and kept clear to enable them to function effectively.

Ideally, void openings should be a minimum of 1m long and open from existing ground levels to at least the 1% annual probability (1 in 100 year) plus climate change flood level. By setting finished floor levels at 300mm above the design flood level, there is usually enough space provision for voids below. There should be a minimum of 1m of open void length per 5m length of wall. Void openings should be provided along all external walls of the proposed extension. If security is an issue, 10mm diameter vertical bars set at 100mm centres can be incorporated into the void openings. The Environment Agency is likely to seek confirmation from LB Waltham Forest that the voids be maintained in a free and open condition for the lifetime of the development.

## 5.11 Car Parks

Where car parks are specified as areas for the temporary storage of surface water and fluvial floodwaters, flood depths should not exceed 300mm given that vehicles may be moved by water of greater depths. Where greater depths are expected, car parks should be designed to prevent the vehicles from floating out of the car park. Signs should be in place to notify drivers of the susceptibility of flooding and flood warning should be available to provide sufficient time for car owners to move their vehicles if necessary.

## 5.12 Flood Routing

All new development in Flood Zones 2 and 3 should not adversely affect flood routing and thereby increase flood risk elsewhere.

Opportunities should be sought within the site design to make space for water, such as:

- Removing boundary walls or replacing with other boundary treatments such as hedges, fences (with gaps).
- Considering alternatives to solid wooden gates, or ensuring that there is a gap beneath the gates to allow the passage of floodwater.
- On uneven or sloping sites, consider lowering ground levels to extend the floodplain without creating ponds. The area of lowered ground must remain connected to the floodplain to allow water to flow back to river when levels recede.
- Create under-croft car parks or consider reducing ground floor footprint and creating an open area under the building to allow flood water storage.
- Where proposals entail floodable garages or outbuildings, consider designing a proportion of the external walls to be committed to free flow of floodwater.

In order to demonstrate that 'flood risk is not increased elsewhere', development in the floodplain will need to prove that flood routing is not adversely affected by the development, for example giving rise to backwater affects or diverting floodwaters onto other properties.

Potential overland flow paths should be determined and appropriate solutions proposed to minimise the impact of the development, for example by configuring road and building layouts to preserve existing flow paths and improve flood routing, whilst ensuring that flows are not diverted towards other properties elsewhere.

Careful consideration should be given to the use of fences and landscaping walls so as to prevent causing obstruction to flow routes and increasing the risk of flooding to the site or neighbouring areas.

## 5.13 Riverside Development

Retain an 8 metre wide undeveloped buffer strip alongside Main Rivers and explore opportunities for riverside restoration. Retain a 5 metre wide buffer strip alongside Ordinary Watercourses. New development within 8m of a Main River or Ordinary Watercourse will require consent from either the Environment Agency or LB Waltham Forest Council (as LLFA) respectively.

The Environment Agency is likely to seek a 8 metre wide undeveloped buffer strip alongside main fluvial rivers for maintenance purposes, and would also ask developers to explore opportunities for riverside restoration as part of any development. LB Waltham Forest Council will seek a 5 metre wide undeveloped buffer strip to be retained alongside Ordinary Watercourses.

Under the Environmental Permitting (England and Wales) Regulations (2016), an environmental permit is required if works are to be carried out:

- on or near a main river
- on or near a flood defence structure
- in a flood plain

Further guidance is available on the Environment Agency website[20]

[20] https://www.gov.uk/guidance/flood-risk-activities-environmental-permits

Since requirements of the consenting process in relation to flood risk, biodiversity and pollution may result in changes to development proposals or construction methods, the Environment Agency aims to advise on such issues as part of its statutory consultee role in the planning process. Should proposed works not require planning permission the Environment Agency can be consulted regarding permission to do work on or near a river, floor or sea defence by contacting enquiries@environment-agency.gov.uk. As of 6 April 2012 responsibility for the consenting of works by third parties on Ordinary watercourses under Section 23 of the Land Drainage Act 1991 (as amended by the Flood and Water Management Act 2010) has transferred from the Environment Agency to the Lead Local Flood Authority, LB Waltham Forest. LB Waltham Forest is now responsible for the consenting of works to ordinary watercourses and has powers to enforce un-consented and non-compliant works. This includes any works (including temporary) within 8 metres that affect flow within the channel (such as in channel structures or diversion of watercourses).

Consent will be refused if the works would result in an increase in flood risk, a prevention of operational access to the watercourse and/ or an unacceptable risk to nature conservation.

## 5.14 Flood Warning Areas

The Environment Agency provides a free flood warning service for many areas at risk of flooding from rivers and the sea. In some parts of England, the Environment Agency may be able to provide warnings where flooding from groundwater is possible. This free warning service can provide advance notice of flooding can provide time to prepare.

The Environment Agency issue flood warnings to homes and businesses when flooding is expected. Upon receipt of a warning, occupants should take immediate action.

To sign up to get warnings in England by phone, email or text message if your home or business is at risk of flooding visit the GOV.UK website.

## 5.15 Surface Water Management

All major developments and other development should not result in an increase in surface water runoff, and should aim to achieve Greenfield runoff rate..

Sustainable Drainage Systems (SuDS) should be used to reduce and manage surface water run-off to and from proposed developments as near to source as possible in accordance with the requirements of the Technical Standards and supporting guidance published by DCLG and Department for the Environment, Food and Rural Affairs (DEFRA)[21]. Developers should aim to achieve the greenfield runoff rate from proposed development sites. For policy requirements please refer to the London Plan[22] ,the LB Waltham Forest Core Strategy[23] and the LB Waltham Forest LFRMS[24]. Guidance on implementing SuDS in London is available in the Sustainable Design and Construction Supplementary Planning Guidance[25].

## 5.16 Natural Flood Management

Natural flood management (NFM) is when natural processes are used to reduce the risk of flooding. NFM should be an integral part of sustainable management and reduction of flood risk within LB Waltham Forest and should be incorporated into new developments where possible.

There are three main mechanisms for NFM that can be used to mitigate flooding. These are:

- Increasing infiltration

[21] Sustainable drainage systems: non-statutory technical standards - https://www.gov.uk/government/publications/sustainable-drainage-systems-non-statutory-technical-standards; PPG Flood Risk and Coastal Change – 23rd March 2015 http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/reducing-the-causes-and-impacts-of-flooding/why-are-sustainable-drainage-systems-important/

[22] https://www.london.gov.uk/what-we-do/planning/london-plan

[23] https://walthamforest.gov.uk/content/core-strategy

[24] http://static.walthamforest.gov.uk/sp/Documents/Adopted%20Local%20Flood%20Risk%20Management.pdf

[25] https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/supplementary-planning-guidance/sustainable-design-and

- Storing water
- Slowing flows

Further guidance on NFM can be sought from the Environment Agency and LB Waltham Forest Council.

## 5.17 Recommendations for Policy and Practice

Further recommendations for policy and practice across LB Waltham Forest are contained within Section 7 of this report including:

- Strategic planning;
- Development control;
- Emergency planning;
- Flood Defences, and;
- SuDS.

# 6. Guidance for Developers

## 6.1 What is a Flood Risk Assessment?

A site-specific FRA is a report suitable for submission with a planning application which provides an assessment of flood risk to and from a proposed development, and demonstrates how the proposed development will be made safe, will not increase flood risk elsewhere and where possible will reduce flood risk overall in accordance with paragraph 160 of the NPPF[1]

and PPG[2]. A FRA must be prepared by a suitably qualified and experienced person and must contain all the information needed to allow LB Waltham Forest to satisfy itself that policy requirements have been met.

## 6.2 When is a Flood Risk Assessment required?

The NPPF states that a site-specific FRA is required in the following circumstances:

- Proposals for new development (including minor development and change of use) in Flood Zones 2 and 3;
- Proposals for new development (including minor development and change of use) in an area within Flood Zone 1 which has critical drainage problems (as notified by the Environment Agency);
- Proposals of 1 hectare or greater in Flood Zone 1;
- Where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

## 6.3 How detailed should a FRA be?

The PPG[2] states that site-specific FRAs should be proportionate to the degree of flood risk, the scale and nature of the development, its vulnerability classification and the status of the site in relation to the Sequential and Exception Tests. Site-specific FRAs should also make optimum use of readily available information, for example the mapping presented within this SFRA and available on the Environment Agency website, although in some cases additional modelling or detailed calculations will need to be undertaken.

Table 6-1 presents the different levels of site-specific FRA as defined in the CIRIA publication C62426 and identifies typical sources of information that can be used.

**Table 6-1 Levels of Site-Specific Flood Risk Assessment**

| Description |
|---|
| **Level 1 Screening** study to identify whether there are any flooding or surface water management issues related to a development site that may warrant further consideration. This should be based on readily available existing information. The screening study will ascertain whether a FRA Level 2 or 3 is required.<br><br>Typical **sources of information** include:<br><br>1. LB Waltham Forest SFRA<br>2. Flood Map for Planning (Rivers and Sea)<br>3. Environment Agency Standing Advice<br>4. |
| **Level 2 Scoping** study to be undertaken if the Level 1 FRA indicates that the site may lie within an area that is at risk of flooding, or the site may increase flood risk due to increased run-off. This study should confirm the |

[26] CIRIA, 2004, Development and flood risk – guidance for the construction industry C624.

| |
|---|
| sources of flooding which may affect the site. The study should include:<br>• An appraisal of the availability and adequacy of existing information;<br>• A qualitative appraisal of the flood risk posed to the site, and potential impact of the development on flood risk elsewhere; and<br>• An appraisal of the scope of possible measures to reduce flood risk to acceptable levels.<br>The scoping study may identify that sufficient quantitative information is already available to complete a FRA appropriate to the scale and nature of the development.<br>Typical **sources of information** include those listed above, plus:<br>• Local policy statements or guidance.<br>• Thames *Catchment Flood Management Plan.*<br>• Data request from the EA to obtain result of existing hydraulic modelling studies relevant to the site and outputs such as maximum flood level, depth and velocity.<br>• Consultation with EA/LB Waltham Forest/sewerage undertakers and other flood risk consultees to gain information and to identify in broad terms, what issues related to flood risk need to be considered including other sources of flooding.<br>• Historic maps.<br>• Walkover survey to assess potential sources of flooding, likely routes for floodwaters, the key features on the site including flood defences, their condition.<br>• Site survey to determine general ground levels across the site, levels of any formal or informal flood defences |
| **Level 3 Detailed** study to be undertaken if a Level 2 FRA concludes that further quantitative analysis is required to assess flood risk issues related to the development site. The study should include:<br>• Quantitative appraisal of the potential flood risk to the development;<br>• Quantitative appraisal of the potential impact of the development site on flood risk elsewhere; and<br>• Quantitative demonstration of the effectiveness of any proposed mitigations measures.<br>Typical **sources of information** include those listed above, plus:<br>• Detailed topographical survey.<br>• Detailed hydrographic survey.<br>• Site-specific hydrological and hydraulic modelling studies which should include the effects of the proposed development.<br>• Monitoring to assist with model calibration/verification.<br>• Continued consultation with the LPA, Environment Agency and other flood risk consultees. |

## 6.4 What needs to be addressed in a Flood Risk Assessment?

The PPG[2] states that the objectives of a site-specific flood risk assessment are to establish:

- Whether a proposed development is likely to be affected by current or future flooding from any source;
- Whether it will increase flood risk elsewhere;

- Whether the measures proposed to deal with these effects and risks are appropriate;
- The evidence for the local planning authority to apply (if necessary) the Sequential Test, and;
- Whether the development will be safe and pass the Exception Test, if applicable.

## 6.5 Flood Risk Assessment Checklist

Table 6-2 provides a checklist for site-specific FRAs listing the information that will likely need to be provided along with references to sources of relevant information. As described in Section 6.3, the exact level of detail required under each heading will vary according to the scale of development and the nature of the flood risk.

**Table 6-2 Site-Specific Flood Risk Assessment Checklist (building on guidance in PPG[2])**

| | What to Include in the FRA | Source(s) of Information |
|---|---|---|
| **1.Site Description** | | |
| Site address | - | - |
| Site description | - | - |
| Location plan | Including geographical features, street names, catchment areas, watercourses and other bodies of water | - |
| Site plan | Plan of site showing development proposals and any structures which may influence local hydraulics e.g. bridges, pipes/ducts crossing watercourses, culverts, screens, embankments, walls, outfalls and condition of channel | OS Mapping<br>Site Survey |
| Topography | Include general description of the topography local to the site.<br>Where necessary, site survey may be required to confirm site levels (in relation to Ordnance datum).<br>Plans showing existing and proposed levels. | SFRA Appendix A, Figure 1 |
| Geology | General description of geology local to the site. | SFRA Appendix A, Figures 2 and 3 |
| Watercourses | Identify Main Rivers and Ordinary Watercourses local to the site. | SFRA Appendix A, Figure 1 |
| Status | Is the development in accordance with the Council's Spatial Strategy? | Seek advice from LB Waltham Forest if necessary |
| **2. Assessing Flood Risk** | | |
| The level of assessment will depend on the degree of flood risk and the scale, nature and location of the proposed development. Refer to Table 6-1 regarding the levels of assessment. Not all of the prompts listed below will be relevant for every application. | | |
| Flooding from Rivers | Provide a plan of the site and Flood Zones.<br>Identify any historic flooding that has affected the site, including dates and depths where possible.<br>How is the site likely to be affected by climate change?<br>Determine flood levels on the site for the 1% annual probability (1 in 100 chance each year) flood event including an allowance for climate change.<br>Determine flood hazard on the site (in terms of flood depth and velocity).<br>Determine the flood level, depth, velocity, hazard, rate of onset of flooding on the site. | SFRA Appendix A, Figure 4 and 4A-D<br>Environment Agency Flood Map for Planning (Rivers and Sea).<br>Environment Agency Products 1-7.<br>New hydraulic model (where EA data not available) |
| Flooding from Land | Identify any historic flooding that has affected the site.<br>Review the local topography and conduce a site walkover to determine low points at risk of surface water flooding.<br>Review the Risk of Flooding from Surface Water mapping & SWMP report. | SFRA Appendix A, Figures 1, 5 and 8.<br>Topographic survey.<br>Site walkover.<br>Risk of Flooding from Surface Water mapping (EA website). |
| Flooding from | Desk based assessment based on high level BGS mapping in | SFRA Appendix A, Figure 6 |

| | | |
|---|---|---|
| Groundwater | the SFRA.<br>Ground survey investigations.<br>Identify any historic flooding that has affected the site. | Ground Investigation Report |
| Flooding from Sewers | Identify any historic flooding that has affected the site. | SFRA Appendix A. Figures 7A and 7B<br>Where appropriate an asset location survey can be provided by Thames Water Utilities Ltd<br>http://www.thameswater-propertysearches.co.uk/ |
| Reservoirs, Docks, canals and other artificial sources | Identify any historic flooding that has affected the site.<br>Review the Risk of Flooding from Reservoirs mapping & EA breach modelling for the Docks | Risk of Flooding from Reservoirs mapping (EA website). |
| **3. Proposed Development** | | |
| Current use | Identify the current use of the site. | - |
| Proposed use | Will the proposals increase the number of occupants / site users on the site such that it may affect the degree of flood risk to these people? | - |
| Vulnerability Classification | Determine the vulnerability classification of the development.<br>Is the vulnerability classification appropriate within the Flood Zone? | SFRA Table 4-2<br>SFRA Table 4-3 |
| **4. Avoiding Flood Risk** | | |
| Sequential Test | Determine whether the Sequential Test is required.<br>Consult LB Waltham Forest to determine if the site has been included in the Sequential Test.<br>If required, present the relevant information to LB Waltham Forest to enable their determination of the Sequential Test for the site on an individual basis. | SFRA 4.1 |
| Exception Test | Determine whether the Exception Test is necessary.<br>Where the Exception Test is necessary, present details of:<br>Part 1) how the proposed development contributes to the achievement of wider sustainability objectives as set out in the LB Waltham Forest Sustainability Appraisal Scoping Report.<br>(Details of how part 2) can be satisfied are addressed in the following part 5 'Managing and Mitigating Flood Risk'.) | SFRA Table 4-3<br><br>Refer to LB Waltham Forest sustainability objectives |
| **5. Managing and Mitigating Flood Risk** | | |
| Section 5 of the SFRA presents measures to manage and mitigate flood risk and when they should be implemented.<br>Where appropriate, the following should be demonstrated within the FRA to address the following questions:<br>How will the site/building be protected from flooding, including the potential impacts of climate change, over the development's lifetime?<br>How will you ensure that the proposed development and the measures to protect your site from flooding will not increase flood risk elsewhere?<br>Are there any opportunities offered by the development to reduce flood risk elsewhere?<br>What flood-related risks will remain after you have implemented the measures to protect the site from flooding (i.e. residual risk) and how and by whom will these be managed over the lifetime of the development (e.g. flood warning and evacuation procedures)? | | |
| Development Layout and Sequential Approach | Plan showing how sensitive land uses have been placed in areas within the site that are at least risk of flooding. | SFRA Section 5.3 |
| Finished Floor Levels | Plans showing finished floor levels in the proposed development in relation to Ordnance Datum taking account of indicated flood depths. | SFRA Section 5.4 |
| Flood Resistance | Details of flood resistance measures that have been | SFRA Section 5.5 |

| | | |
|---|---|---|
| | incorporated into the design. Include design drawings where appropriate. | |
| Flood Resilience | Details of flood resilience measures that have been incorporated into the design. Include design drawings where appropriate. | SFRA Section 5.6 |
| Safe Access / Egress | Provide a figure showing proposed safe route of escape away from the site and/or details of safe refuge. Include details of signage that will be included on site.<br>Where necessary this will involve mapping of flood hazard associated with river flooding. This may be available from Environment Agency modelling, or may need to be prepared as part of hydraulic modelling specific for the proposed development site. | SFRA Section 5.7 |
| Flow Routing | Provide evidence that proposed development will not impact flood flows to the extent that the risk to surrounding areas is increased. Where necessary this may require modelling. | SFRA Section 5.12 |
| Riverside Development Buffer Zone | Provide plans showing how a buffer zone of relevant width will be retained adjacent to any Main River or Ordinary Watercourse in accordance with requirements of the Environment Agency LB Waltham Forest | SFRA Section 5.13 |
| Surface Water Management | Pre application advice from LB Waltham Forest should be sought to gain advice on suitable SuDS and drainage for individual development sites.<br>Details of the following should be included within the FRA:<br>- Calculations (and plans) showing areas of the site that are permeable and impermeable pre and post-development.<br>- Calculations of pre and post-development runoff rates and volumes including consideration of climate change over the lifetime of the development.<br>- Details of the methods that will be used to manage surface water (e.g. permeable paving, swales, wetlands, rainwater harvesting).<br>- Information on proposed management arrangements<br>Where appropriate, reference the supporting Outline or Detailed Drainage Strategy for the site.<br>. | SFRA Section 5.15 |
| Flood Warning and Evacuation Plan | Where appropriate reference the Flood Warning and Evacuation Plan or Personal Flood Plan that has been prepared for the proposed development (or will be prepared by site owners). | |

## 6.6 Pre-application Advice

At all stages, LB Waltham Forest, and where necessary the Environment Agency and/or the Statutory Water Undertaker may need to be consulted to ensure the FRA provides the necessary information to fulfil the requirements for planning applications.

The Environment Agency and LB Waltham Forest each offer pre-application advice services which should be used to discuss particular requirements for specific applications.

- Environment Agency http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/research/planning/33580.aspx
- LB Waltham Forest https://walthamforest.gov.uk/content/get-planning-pre-application-advice

The following government guidance sets out when LPAs should consult with the Environment Agency on planning applications https://www.gov.uk/flood-risk-assessment-local-planning-authorities .

# 7. Recommendations for Policy and Practice

Adopting a holistic approach to flood risk management should help ensure that flooding is taken into account at all stages of the planning process. To aid this holistic approach, it is recommended that all key recommendations set out in this report are considered and incorporated into the emerging LB Waltham Forest Local Plan.

LB Waltham Forest is bordered by the River Lee and is therefore highly reliant on flood defences. Ongoing maintenance of these defences is critical, and priority should be given to safeguarding the standard of protection provided by defences over the lifetime of any development. However, redevelopment rates in areas of the Borough are very high and may additionally offer the opportunity to reduce the current risk and the reliance on flood defences. This includes making the urban environment more resilient and with a layout that offers added options for managing future flood risk and the impacts of climate change. As such, it is recommended that policy options are expanded to include greater emphasis on active floodplain management, in addition to flood defence maintenance. This may include promoting more appropriate use of floodplain areas (Flood Zone 3), making space for water, improved flood preparedness and enhanced emergency planning and response measures.

## 7.1 Strategic Planning

When considering strategic spatial planning across the Borough, flood risk should be an early and primary consideration. A sequential approach should be taken to allocating strategic development areas in regions of lowest flood risk, taking into account vulnerability of land use. Consideration should also be given to strategic allocation of open space and preserving and expanding river corridors to create space for flooding to be managed effectively.

In particular, the following specific recommendations are made:

- Ensure the Sequential Test is undertaken for all strategic land allocations and check that the vulnerability classification of the proposed land use is appropriate to the Flood Zone classification;
- Pursue potential opportunities to move existing development from within the floodplain to areas with a lower risk of flooding. This should include consideration of the vulnerability of existing developments and whether there is potential for land swap with lower vulnerability uses.
- Identify opportunities to create space for water through appropriate location, layout and design of development, in order to accommodate *climate change* and assist in managing future flood risk. This can be achieved by restoring floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for storage. Equally, existing flood storage areas should be identified, conserved and protected against loss through redevelopment.
- Safeguard existing corridors of land along the River Lee and the Ching Brook and promote the setting back of development to enable sustainable and cost effective flood risk management, including upgrading of river walls and embankments. As a minimum, an 8 m strip should be maintained along fluvial river corridors, respectively.
- Consider opportunities to realign or set back defences and improve the riverside frontage to provide amenity space and environmental enhancement. A combination of defence realignment and floodplain management could reduce the impact of flooding to existing properties and other assets located in the floodable areas on the river side of realigned defences.
- The consultation and initial investigation associated with detailed site specific flood risk assessments should be undertaken at an early stage for major development locations to ensure opportunities to reduce flood risk are identified early and maximised wherever possible.
- Ensure that developments at residual risk of flooding are designed to be flood compatible and/or flood resilient and maximise the use of open spaces within these developments to make space for water during times of flooding. Opportunities should be sought to identify a safe route for any exceedance flow of floodwaters and a suitable storage or discharge location, to avoid any risk to people.

- Strategic development allocations should specifically consider the issues of water supply and drainage infrastructure to service development proposed, taking into account regional constraints. An early and integrated approach should be taken to holistically assessing and planning for the flood risk, water supply and drainage requirements and constraints in these areas. This is likely to be an issue of particular importance in certain Opportunity Areas, where limited drainage capacity may create challenges for strategic development.

## 7.2 Development Control

In consulting on and determining development applications, LB Waltham Forest must ensure that all new developments have considered flood risk management from the planning stage. In general, this means that:

- Development is located in the lowest risk area where possible;
- New development is flood-proofed to a satisfactory level/standard and does not increase flood risk elsewhere; and
- Surface water is managed effectively on site using the SuDS hierarchy and the latest guidance and best practice.

When a proposed development is located within an area perceived to be at risk of flooding, then a suitably detailed FRA should determine the actual level of risk to the development and identify options to mitigate the flood risk to the development, site users and surrounding area. In particular, development located adjacent to flood defences is required to demonstrate that these defences will be safe over the lifetime of the development. The requirements for site specific flood risk assessments and their contents are further detailed in Section 6. Planning applications should be considered and assessed in line with the sequential approach detailed in Section 4.2. Specific recommendations and considerations for development planning are provided below:

- If development is to be constructed with less vulnerable uses on the ground level, covenants need to be put in place to prevent future alteration of these areas to 'more vulnerable' uses without further consideration of the associated flood risk.
- Single storey residential development should not be considered in high flood risk areas as they offer no opportunity for safe refuge.
- NPPF does not permit basement dwellings to be located within Flood Zone 3a, and as such these should not be permitted in any areas at risk of flooding. This would include the excavation of basements under existing dwellings.
- A safe means to escape via internal access to higher floors.
- Finished floor levels for vulnerable development should be a minimum of whichever is higher, 300mm above the general ground level of the site 600mm above the estimated river or sea flood level.
- Basement development may affect groundwater flows, and even though the displaced water will find a new course around the area of obstruction this may have other consequences for nearby receptors e.g. buildings, trees. Emerging evidence shows that even where there are a number of consecutively constructed basement developments, the groundwater flows will find a new path.
- Residual flood risk should be managed through emergency planning, site design and protection measures. The key residual flood risks within Waltham Forest are overtopping of the River Lee, Dagenham Brook and Ching Brook.
- Where development within flood risk areas is necessary due to wider sustainability/regeneration objectives, flood resistance and resilience practices should be followed in the construction and operation of the buildings to minimise the impact of flooding.
- Flood risk from all sources should be considered when identifying the perceived level of flood risk affecting a site. Robust consideration of surface water flood risk is particularly important in certain regions of the Borough.
- Opportunities should be taken to identify sites where developer contributions could be used to fund future flood risk management schemes, improvements to surface water drainage systems or flood

defences in adjacent areas. However, it should be noted that developer installed defences should not wholly justify development in locations with inappropriate levels of flood risk.

- Existing flood storage areas within development areas should be identified, conserved and protected against loss through redevelopment.
- An 8m buffer strip should be maintained along fluvial river corridors, respectively, to ensure maintenance of the channel can be undertaken. As such, any new development should be avoided in existing buffer areas. A pragmatic approach should be adopted for existing development in these areas and opportunities pursued for small scale set back of development from river walls to enable these structures to be modified, raised and maintained as needed.
- For developments adjacent the River Lee and the Ching Brook, particular consideration should be given to facilitating the recommendations of the Thames CFMP in maintaining, enhancing and replacing flood defences, and safeguarding riverside land.

## 7.3 Flood Defences

The SFRA has highlighted the importance of flood defences to the Borough. As such, future policy should seek to ensure that the current high level of protection is retained (and improved where possible) by those responsible for maintaining flood defences in the area (i.e. riparian land owners, EA, others). Any development located adjacent to flood defences is required to demonstrate that these defences will be safeguarded and maintained over the lifetime of the development.

In particular, the future sustainability of the Borough (and London as a whole) is dependent to a large degree upon the retention and ongoing maintenance of flood defence infrastructure, including the River Lee Defences. However, decisions surrounding investment of this nature in future years cannot be predicted with any certainty. Additionally, the exact impact of climate change, and the interaction of the resulting hydrological effects with operational and wider issues is still uncertain. It is therefore imperative that planning decisions are taken with a clear understanding of the potential risks posed to property and life should things ultimately go wrong. As such, redevelopment must ensure that residual flood risk is reduced in areas benefiting from flood defence measures through prevention and effective mitigation.

As discussed, management of defences within the Borough will include routine inspection, maintenance, repair and replacement, in addition to eventual raising of levels to allow for the impact of climate change. However, raising the level of defences on the current footprint may introduce visual barriers and will not achieve any wider sustainability objectives. Therefore, opportunities should be pursued for subsequent improvement of the riverside through integrated design, considering public access and connectivity, amenity, landscaping and environmental enhancement.

As such, where fluvial defences require replacement, consideration should be given to flood defence adaptation rather than like-for-like replacement, utilising a combination of flood storage, river defences and floodplain attenuation.

- Raising existing flood defences to the required levels in preparation for future climate change impacts or otherwise demonstrate how flood defences can be raised in the future, through submission of plans and cross-sections of the proposed raising;
- Demonstrating the provision of improved access to existing flood defences and safeguarding land for future flood defence raising and landscape, amenity and habitat improvements;
- Maintaining, enhancing or replacing flood defences to provide adequate protection for the lifetime of the development;
- Where opportunities exist, re-aligning or setting back flood defence walls and improving the river frontage to provide amenity space, habitat, access and environmental enhancements; and
- Securing financial contributions towards the anticipated costs of flood risk management infrastructure required to protect the proposed development over its lifetime.

Local policy should continue to maintain and expand assets that are effective in managing current and future flood risk and promote wider sustainability.

## 7.4 Sustainable Drainage Systems

Sustainable Drainage Systems must be included in new developments as a way to manage surface water flood risk, improve water quality and increase amenity and biodiversity.

Runoff rates from new development must be restricted to Greenfield runoff rates wherever possible. Robust justification must be provided for any sites where this is not achievable and an alternative discharge rate agreed with LB Waltham Forest.

Limiting the volume and rate of discharge, particularly for surface water entering the foul and combined surface water networks, is of critical importance within the Borough to help ensure the sewage network has the capacity to cater for population growth and the effects of climate change.

In line with the Sustainable Drainage Hierarchy, set out in Policy 5.13 of the London Plan, surface water should be prevented and controlled at source wherever possible through rainwater harvesting and infiltration techniques. Managed discharge of surface water to adjacent surface water bodies should also be considered. However, controls would need to be implemented to avoid any adverse harm to biodiversity and ecological habitat within receiving waters. Sustainable drainage should be delivered in accordance with the LB Waltham Forest SuDS Guidance, the London Plan and new London Plan, the Sustainable Design and Construction SPG, the London Sustainable Drainage Action Plan and CIRIA guidance C753.

Presently, there is a tendency for required attenuation volumes to be accommodated below ground. However, preference should be given to the installation of blue-green surface infrastructure wherever possible, as opposed to hardscape or underground solutions, due to the wider benefits for biodiversity, amenity and microclimate.

The underlying geology within parts of the LB Waltham Forest may impose constraints on the implementation of some infiltration SuDS; however, there are a number of design options that can be explored with the expectation from LB Waltham Forest that SUDS to be included in all new developments.

The BGS Suitability for Infiltration SuDS map for the Borough is shown in Figure 10 and provides an indication on where infiltration SuDS may or may not be suitable at a strategic level but site specific assessment of geological conditions should be undertaken as a part of the drainage strategy for new developments. A greater understanding of the geology within the site area may identify areas where a more permeable layer exists below shallow impermeable layers. The installation of lined or shallow infiltration systems may still be suitable to provide *attenuation* and reduction of runoff rates and the use of attenuation SuDS above ground or in the form of blue roof should also be investigated.

## 7.5 Emergency Planning

It is strongly recommended that emergency planning strategies are put in place in areas deemed at actual and/or residual risk of flooding to ensure adequate preparation and response during flood events. Where a new development or change of land use is proposed, flood evacuation plans should be developed through liaison with the emergency planners and the emergency services.

Additionally, following production of this SFRA, it is recommended that emergency planning strategies should be reviewed to determine the suitability of refuge centres and evacuation routes based on the updated flood risk mapping produced.

Emergency Planning can be broadly split into three phases, all of which should be considered in managing flood risk across the Borough:

- Before a flood – raising flood awareness, ensuring no inappropriate use of the floodplain/flow paths, preparing suitable flood emergency plans and communicating them to the wider community;
- During a flood – Flood alerts and communication, rescuing occupants, providing safe refuge and alternative accommodation;
- After the flood – providing support to help people recover and return to their homes and businesses.

Consideration of emergency planning is even more critical when it relates to vulnerable sites and essential infrastructure, as further described below.

### 7.5.1 Vulnerable Sites

Emergency service authorities responsible for hospitals, ambulance, fire and police stations as well as prisons should ensure that emergency plans, in particular for facilities in flood risk areas, are in place and regularly reviewed so that they can cope in the event of a major flood. These plans should put in place cover arrangements through other suitable facilities, if deemed needed.

The NPPF classifies police stations, ambulance stations, fire stations and command centres as Highly Vulnerable buildings. It is essential that all establishments related to these services are located in the lowest flood risk zones to ensure that in the event of an emergency those services vital to the rescue operation are not impacted by flood water. Furthermore, development control policies should seek to locate more vulnerable uses such as schools and care homes in areas at the lowest risk of flooding to minimise the impact of a flood on their vulnerable users.

Allied to this, nominated rest and reception centres should also be identified within the study area and compared with the outputs of this SFRA to ensure that these centres are not at risk of flooding, so that evacuees will be safe during a flood event. Developments that would be suitable for such uses would include leisure centres, churches, schools and community centres.

On occasions where development of vulnerable sites within flood risk areas is unavoidable, necessary measures should be implemented to ensure the site is as safe as possible.

### 7.5.2 Critical Infrastructure

In the event of a flood incident, it is essential that the evacuation and rescue routes to and from any proposed development remain safe. Floodplain management and emergency response activities must have a focus on key infrastructure such as the London Underground network and any properties that are below sea level. Essential infrastructure located in Flood Zone 3a or 3b must be operational during a flood event to assist in the emergency evacuation process.

Relevant transport authorities and operators should examine and regularly review their infrastructure including their networks, stations, and depots, for potential flooding locations and to identify the need for any flood risk reduction measures. For large stations and depots, solutions should be sought to store or disperse rainwater from heavy storms in a sustainable manner.

## 7.6 Water Environment

It is recommended that LB Waltham Forest take a holistic approach to flood risk management across the Borough within the wider context of the water cycle and local environment. Within Waltham Forest, the majority of waterbodies are designated as heavily modified (as defined by the Water Framework Directive), with an absence of natural river processes leading to lost habitat diversity and poor water quality.

Additionally, it is anticipated that growing population numbers and changing climate patterns will place increased pressure on already stressed water resources across Greater London. New development can assist in alleviating this water scarcity by incorporating water efficiency measures such as grey water recycling, rainwater harvesting and water use minimisation technologies. This will also have a substantial benefit on the sewer system which will receive less wastewater from properties, potentially freeing up capacity during flood events.

Consideration should be given to maximising the benefits of surface water management infrastructure, enhance the urban environment for the benefit of communities and biodiversity. Through high quality design and installation, such infrastructure can contribute to multi-functional benefit in the following areas:

- Provision of habitat and biodiversity - when adequately planned, the delivery of diverse, high quality green spaces can provide valuable habitat to a range of flora and fauna.
- Recreation and community - provision of space for recreation and contribution to community health, wellbeing and social cohesion. Water features can create a sense of place.
- Microclimate adaptation - Reducing the impact of the urban heat island effect by providing shading to protect against radiations, reducing local temperatures through evapotranspiration and reducing heat absorbed and then released by surfaces.

- Public realm - street greening and the delivery of effectively landscaped open spaces can substantially improve the amenity value of neighbourhoods.

## 7.7 Consultation and Coordination

For future flood risk management within the Borough to be successful, it is essential that relevant partners and stakeholders, who have responsibility for flood risk management assets, work collaboratively to reduce flood risk.

In particular, LB Waltham Forest should continue to work with the Environment Agency and others to ensure ongoing maintenance and improvement of the River Lee defences.

Ongoing coordination with the Canal and Rivers Trust will additionally be required to manage the flood risk associated with canals across the Borough, and the hydraulic interaction of these systems within the River Lee.

Similarly, opportunities should be sought to reduce the risk of flooding from surface water and sewer surcharge through consultation with Thames Water, to determine key areas for maintenance and locations that would benefit from flood alleviation schemes.

It is further recommended that LB Waltham Forest continues to collaborate with stakeholders to maintain and expand upon the existing understanding of flood risk across the Borough.

# 8. Summary

## 8.1 Overview

The NPPF and accompanying Guidance emphasise the responsibility of LPAs to ensure that flood risk is understood and managed effectively and sustainably throughout all stages of the planning process. This SFRA aims to facilitate this process by identifying the spatial variation in flood risk across the Borough, allowing an area-wide comparison of future development sites with respect to flood risk considerations. In addition to the SFRA report, planners and developers should use supporting mapping to inform borough wide and site specific flood risk assessments.

The Borough is bounded to the south and west by the River Lee (and its tributaries) and to the east by the Ching Brook. The River Lee and Ching Brook are also defended. The rivers and watercourses within the Borough pose a risk of fluvial flooding if defences were to fail or to be overtopped.

A potential risk of flooding from other (non-river related) sources exists throughout the Borough, including sewer surcharge, and surface water flooding as a result of heavy rainfall and limited capacity of drainage infrastructure. Geological indicators also suggest that certain areas of the Borough may be susceptible to elevated groundwater levels which may additionally interact with and exacerbate these sources of flood risk. It is expected that changing climate patterns will have a substantial impact on the level of flood risk from all sources within the Borough.

This SFRA identifies the floodplain areas associated with the River Lee and Ching Brook and presents Flood Zone Maps that delineate the flood zones outlined in the NPPF. These maps provide the necessary information to facilitate the NPPF risk-based approach to planning. This process determines the compatibility of various types of development within each flood zone, subject to the application of the Sequential Test and the Exception Test when required

Given the position of the Borough adjacent to the River Lee and Ching Brook, it is highly reliant on flood defences. Ongoing maintenance of these defences is critical, and priority should be given to safeguarding the standard of protection provided by defences over the lifetime of any development.

However, it is further recommended that policy options are expanded to include greater emphasis on floodplain management to complement flood defence infrastructure, by promoting appropriate use of the floodplain and making space for water. Existing corridors of land along the river frontage should be safeguarded and opportunities taken to set back development to enable sustainable and cost effective flood risk management, including upgrading of river walls and embankments. Natural flood management is, and should be, an integral part of sustainable management and reduction of flood risk within the LB Waltham Forest authority area. Flood awareness and robust emergency planning and response will additionally be critical to sustainable ongoing flood risk management.

# Appendix A Mapping

# Appendix B Flood Records

## B.1 Flooding Records

| Date | Type of Flooding | Description | Source of data |
|---|---|---|---|
| 11 & 12 November 2002 | Groundwater | Standing water observed at Kingswood and Harold Road, Leytonstone and Russell Road, Chingford | Environment Agency- Taken from the Waltham Forest PFRA |
| 29 & 30 January 2004 | Groundwater | Standing water observed at Grange Park and Abbotts Park Roads, Leyton | Environment Agency- Taken from the Waltham Forest PFRA |
| 11 & 13 October 2006 | Groundwater | Standing water observed at Grove Green and Essex Roads, Wanstead | Environment Agency- Taken from the Waltham Forest PFRA |
| 29 May 2007 | Pluvial | Pavement flooded on Sanderstead Road during heavy rain. | LB of Waltham Forest SWMP |
| 11 & 13 July 2007 | Surface Water | Flooding in front gardens of Shernhall Street and Rosslyn Road, Walthamstow. Approximately 8 inches of water observed on garden path near Hale End Road, Hale end. | LB of Waltham Forest- Taken from the Waltham Forest PFRA |
| 11 January 2008 | Surface Water | Gully observed to be flooded along Chingford Avenue, opposite Ingrebourne Court. | LB of Waltham Forest SWMP |
| 21 January 2008 | Surface Water | Flooding observed by the entrance to Asda on Marshall Road. | LB of Waltham Forest SWMP |
| 27 February 2008 | Surface Water | Flooding occurred across the whole of the westbound bus lane on Forest Road, in the dip beyond Blackhorse Road Station. | LB of Waltham Forest SWMP |
| 29 April 2008 | Surface Water | Due to the angling in the road, flood water ponded opposite the crossing on Lea Bridge Road (270) as well as opposite the bus stop and the Hare and Hounds pub and the E10 night club. | LB of Waltham Forest SWMP |
| 25 June 2008 | Surface Water | Alexandra Road and York Road into Ruckholt Road flooded and regularly does when it rains. | LB of Waltham Forest SWMP |
| 12 August 2008 | Surface Water | Deep flooding occurred at the junction of Chingford Avenue and Old Church Road. | LB of Waltham Forest SWMP |
| 5 November 2008 | Surface Water | North circular underpass at Hall Lane flooded. | LB of Waltham Forest SWMP |
| 2009 | Pluvial/Sewer | 9 recorded incidents of flooding at the Greenman Roundabout underpass, Leyton. | LB of Waltham Forest- Taken from the Waltham Forest PFRA |
| 19 January 2009 | Surface Water | Warwick Road flooded | LB of Waltham Forest SWMP |

| Date | Type of Flooding | Description | Source of data |
|---|---|---|---|
| 10 & 11 February 2009 | Pluvial/fluvial/ Groundwater | Fluvial and pluvial incident recorded at Lower Hall Lane, Chingford on the 10th and 11th February 2009 respectively. Six other recorded incidents scattered throughout the Borough recorded on these dates. | LB of Waltham Forest- Taken from the Waltham Forest PFRA |
| 10 & 11 February 2009 | Surface Water | The junction of Raglan Road, Shernhall Street and Eastern Road observed to flood during rainfall affecting all the residencies and businesses in the area. | LB of Waltham Forest SWMP |
| 15 & 16 June 2009 | Pluvial/Sewer | 18 recorded incidents the majority of which are from surface water flooding on the 15th June 2009. Most incidents occurred in the north of the borough between Highams Park and Chingford. | LB of Waltham Forest- Taken from the Waltham Forest PFRA |
| 12 August 2009 | Surface Water | Underpass at Whipps Cross Road entering Tesco flooded. | LB of Waltham Forest SWMP |
| 16 &17 November 2011 | Pluvial/Sewer | 5 recorded incidents in the east of the Borough in Leytonstone. | LB of Waltham Forest- Taken from the Waltham Forest PFRA |
| 23 November 2009 | Surface Water | No. 77 and neighbours on Heathcote Grove had flooded front gardens and water coming into the airbricks and garage. | LB of Waltham Forest SWMP |
| 3 December 2009 | Surface Water | Reported at least 20 inches of water ponded in the underpass at Hall Lane and Southend Road (A406). | LB of Waltham Forest SWMP |
| 4 & 5 January 2010 | Pluvial | 4 recorded incidents of flooding mainly in the south of the Borough in Leyton. | LB of Waltham Forest- Taken from the Waltham Forest PFRA |
| 22 & 23 February 2010 | Pluvial | 4 recorded incidents of flooding scattered throughout the Borough. Flooding of roads and gardens reported. | LB of Waltham Forest- Taken from the Waltham Forest PFRA |
| 22 February 2010 | Surface Water | Flooding on Hitcham Road near Emmanuel Forest Church. | LB of Waltham Forest SWMP |
| 8th February 2014 | Fluvial | Overtopping of the Lower Hall Sluices | LB Waltham Forest Flood Investigation Report |
| 23 June 2016 | Pluvial/Sewer | Flooding on Brooke Road and Oliver Road. | LB Waltham Forest Flood Investigation Report |
| Various | Highways Flooding | Unknown | LB Waltham Forest Council |

## B.2 Highways Flooding Events

| Date | Location |
|---|---|
| 25/08/2015 | Closest Street: St.Georges Road |
| 31/08/2015 | Closest Street: Sewardstone Road |
| 07/09/2015 | Closest Street: Sewardstone Road |
| 17/09/2015 | Closest Street: Sewardstone Road |
| 17/09/2015 | Closest Street: Sewardstone Road |
| 24/09/2015 | Closest Street: Francis Road |
| 30/09/2015 | Closest Street: Sewardstone Road |
| 26/10/2015 | Closest Street: Francis Road |
| 26/10/2015 | Closest Street: Francis Road |
| 28/10/2015 | Closest Street: Beach Hall Road |
| 28/10/2015 | Closest Street: Boundary Road |
| 28/10/2015 | Closest Street: Hall Lane |
| 28/10/2015 | Closest Street: Sewardstone Road |
| 28/10/2015 | Closest Street: Sewardstone Road |
| 03/11/2015 | Closest Street: Sewardstone Road |
| 11/11/2015 | Closest Street: Montalt Road |
| 11/11/2015 | Closest Street: Sewardstone Road |
| 12/11/2015 | Closest Street: Sewardstone Road |
| 16/11/2015 | Closest Street: Hawkwood Crescent |
| 18/11/2015 | Closest Street: Cherrydown Avenue |
| 18/11/2015 | Closest Street: Sewardstone Road |
| 19/11/2015 | Closest Street: Boundary Road |
| 19/11/2015 | Closest Street: Sewardstone Road |
| 25/11/2015 | Closest Street: Sewardstone Road |
| 25/11/2015 | Closest Street: Sewardstone Road |
| 25/11/2015 | Closest Street: Sewardstone Road |
| 25/11/2015 | Closest Street: Sewardstone Road |
| 02/12/2015 | Closest Street: Sewardstone Road |
| 02/12/2015 | Closest Street: Sewardstone Road |
| 02/12/2015 | Closest Street: Sewardstone Road |
| 03/12/2015 | Closest Street: Sewardstone Road |
| 07/12/2015 | Closest Street: Sewardstone Road |
| 21/12/2015 | Closest Street: Edinburgh Road |
| 04/01/2016 | Closest Street: Sewardstone Road |
| 04/01/2016 | Closest Street: Sewardstone Road |
| 04/01/2016 | Closest Street: Sewardstone Road |
| 04/01/2016 | Closest Street: Sewardstone Road |
| 04/01/2016 | Closest Street: Sewardstone Road |

| Date | Location |
|---|---|
| 04/01/2016 | Closest Street: Sewardstone Road |
| 05/01/2016 | Closest Street: Sewardstone Road |
| 05/01/2016 | Closest Street: Sewardstone Road |
| 07/01/2016 | Closest Street: Yardley Lane |
| 08/01/2016 | Closest Street: Sewardstone Road |
| 08/01/2016 | Closest Street: Yardley Lane |
| 12/01/2016 | Closest Street: Kings Road |
| 12/01/2016 | Closest Street: Sewardstone Road |
| 12/01/2016 | Closest Street: Sewardstone Road |
| 12/01/2016 | Closest Street: Sewardstone Road |
| 12/01/2016 | Closest Street: Yardley Lane |
| 05/02/2016 | Closest Street: Grantock Road |
| 08/02/2016 | Closest Street: Woodbury Road |
| 04/03/2016 | Closest Street: Hall Lane |
| 19/05/2016 | Closest Street: Forest Road |
| 01/06/2016 | Closest Street: Vallentin Road |
| 13/06/2016 | Closest Street: Sylvester Road |
| 27/06/2016 | Closest Street: Hillside Gardens |
| 27/06/2016 | Closest Street: Larkswood Road |
| 27/06/2016 | Closest Street: Vallentin Road |
| 30/06/2016 | Closest Street: Larkswood Road |
| 01/07/2016 | Closest Street: Hillside Gardens |
| 01/07/2016 | Closest Street: James Lane |
| 01/07/2016 | Closest Street: Ranelagh Road |
| 07/07/2016 | Closest Street: Brooke Road |
| 07/07/2016 | Closest Street: Carr Road |
| 18/07/2016 | Closest Street: Brooke Road |
| 21/09/2016 | Closest Street: Chestnut Avenue South |
| 21/09/2016 | Closest Street: Chestnut Avenue North |
| 29/09/2016 | Closest Street: Hall Lane |
| 26/10/2016 | Closest Street: Hall Lane |
| 27/10/2016 | Closest Street: Hall Lane |
| 03/11/2016 | Closest Street: Hall Lane |
| 14/11/2016 | Closest Street: Hall Lane |
| 22/11/2016 | Closest Street: Frith Road |
| 22/11/2016 | Closest Street: Hall Lane |
| 22/11/2016 | Closest Street: Hall Lane |
| 29/11/2016 | Closest Street: Path in Leyspring Rd to Mornington Rd |
| 12/12/2016 | Closest Street: Dawlish Road |

| Date | Location |
|---|---|
| 15/12/2016 | Closest Street: Queens Road |
| 08/02/2017 | Closest Street: Knebworth Avenue |
| 25/04/2017 | Closest Street: Hoe Street |
| 25/04/2017 | Closest Street: Warboys Crescent |
| 07/06/2017 | Closest Street: Markhouse Avenue |
| 07/06/2017 | Closest Street: Markhouse Road |
| 07/06/2017 | Closest Street: Whipps Cross Road |
| 14/07/2017 | Closest Street: Aveling Park Road |
| 18/07/2017 | Closest Street: High Road Leytonstone |
| 18/07/2017 | Closest Street: Radbourne Crescent |
| 14/08/2017 | Closest Street: New Road |
| 22/08/2017 | Closest Street: Connington Crescent |
| 22/08/2017 | Closest Street: High Road Leyton |
| 02/10/2017 | Closest Street: Connington Crescent |
| 16/11/2017 | Closest Street: Church Road (Leyton) |
| 17/11/2017 | Closest Street: Lea Bridge Road |
| 19/11/2017 | Closest Street: Hoe Street |
| 23/11/2017 | Closest Street: Harrhow Road |
| 11/12/2017 | Closest Street: Clifford Road |
| 03/01/2018 | Closest Street: Forest Glade |
| 03/01/2018 | Closest Street: Francis Road |
| 08/01/2018 | Closest Street: Station Road |
| 08/01/2018 | Closest Street: Woodland Road |
| 29/01/2018 | Closest Street: Lea Bridge Road |
| 19/03/2018 | Closest Street: Woodberry Way |
| 09/04/2018 | Closest Street: Garfield Road |
| 09/04/2018 | Closest Street: The Drive, E17 |
| 16/04/2018 | Closest Street: Bisterne Avenue |
| 30/04/2018 | Closest Street: Kings Head Hill |
| 30/04/2018 | Closest Street: Richmond Road |

# Appendix C - Climate Change Analysis for Ching Brook

## Existing Ching Brook Model

The existing model for the Ching Brook[27] has been made available by the Environment Agency to inform the SFRA for Waltham Forest Council. As part of this hydraulic modelling study, simulations have been run for the 1% AEP (1 in 100 year) event including a standard percentage increase in river flow to account for the implications of climate change. This has been applied as a 20% increase to fluvial flows based on previous climate change guidance[28]. As a result, modelling results assessing a full suite of allowances such as those presented in Table 4-1 of the SFRA are not currently available.

In the absence of the updated allowances and based on the information currently available a surrogate event of the 0.1% AEP (1 in 1000 year) fluvial event can be mapped to represent an estimated 1% AEP event with allowances for the updated climate change allowance. In order to determine the validity of using the 0.1% AEP flood as a proxy event, two methods have been applied to analyse the Ching Brook model.

3. Analysis of the stage-discharge relationship at nodes throughout the model has been undertaken in accordance with the suggested approach set out in the guidance document published by the Environment Agency 'Flood Risk Assessment: Climate Change Allowances'[29].
4. Analysis of the inflows through the model has been undertaken to determine the ratio between the 1% AEP flood event and the 0.1% AEP flood event and how it compares to the 25%, 35% and 70% increases.

The results of these analyses are described below.

## Method 1: Stage-Discharge analysis for Ching Brook

For the hydraulic model for Ching Brook, an output file was provided detailing the flows (discharge) and levels (stage) at each node within the model for each of the simulated return periods. Outputs were available for events with annual return periods of 2, 5, 10, 20, 50, 75, 100, 200 and 1000 years.

The Ching Brook runs through an urbanised catchment and the modelled reach contains numerous culverts, bridges and structures which will impact on the flow and stage of the watercourse, e.g. a culvert can limit flows passing into the reach downstream. The variable nature of the Ching Brook floodplain means that some sections of the watercourse will be flow limited (e.g. due to the presence of a constricting culvert at the upstream end) while in other sections the stage will be more limited (e.g. due to the presence of an open floodplain with significant floodwater storage capacity). The appropriateness of using the 0.1% AEP flood event as a proxy for climate change will be therefore vary along the modelled reach.

In order to take account of this variation, the Ching Brook was split into eight different reaches, each with a constriction to flow at either end. The reaches are as follows:

- Reach 1 – Whitehall Road to Chingford Lane
- Reach 2 – Chingford Lane to The Avenue
- Reach 3 – The Avenue to Falmouth Avenue
- Reach 4 – Falmouth Avenue to Hale End Road
- Reach 5 – Hale End Road to Triple Road/Railway Bridges
- Reach 6 – Triple Bridges to Chingford Road
- Reach 7 – Chingford Road to Culvert North of Trinity Way
- Reach 8 – Folly Lane to River Lee Flood Relief Channel

[27] Work undertaken as part of the River Lee 2D Modelling Study (2014), CH2M Hill
[28] Climate Change Allowances for Planners, Guidance to Support the National Planning Policy Framework, September 2013
[29] Environment Agency (2016) East Anglia, Essex, Norfolk and Suffolk Area – Flood Risk Assessment: Climate Change Allowances.

Data for stage and discharge at upstream and downstream nodes were plotted for all modelled scenarios and a trend line fitted to the stage-discharge relationship. Based on the existing modelled discharge values for the available return periods, stage values were interpolated for the discharge for the following climate change events, as set out in the guidance for the Thames River Basin District[30]:

- Central allowance (1% AEP event including 25%)
- Higher central (1% AEP event including 35%)
- Upper end (1% AEP event including 70%)

The reaches were also classified as flow limited, stage limited or both and a conclusion drawn about the validity of using the 0.1% AEP event and Flood Zone 2 outline as a proxy for climate change in each reach.

A graph showing the stage-discharge relationship for each node was produced as part of the analysis. An example is provided below (Figure C1) for a node at the upstream end of the model, at the top of reach 1. This area is characterised by a large area of open floodplain which allows both flow and stage to increase, although there is some evidence of flattening of the flood growth curve for larger events. In this location, the 0.1% AEP event is a reasonable approximation of the additional extent of flooding which would be expected to occur due to climate change.

Figure C1 Stage-discharge relationship for the Ching Brook at CL.044

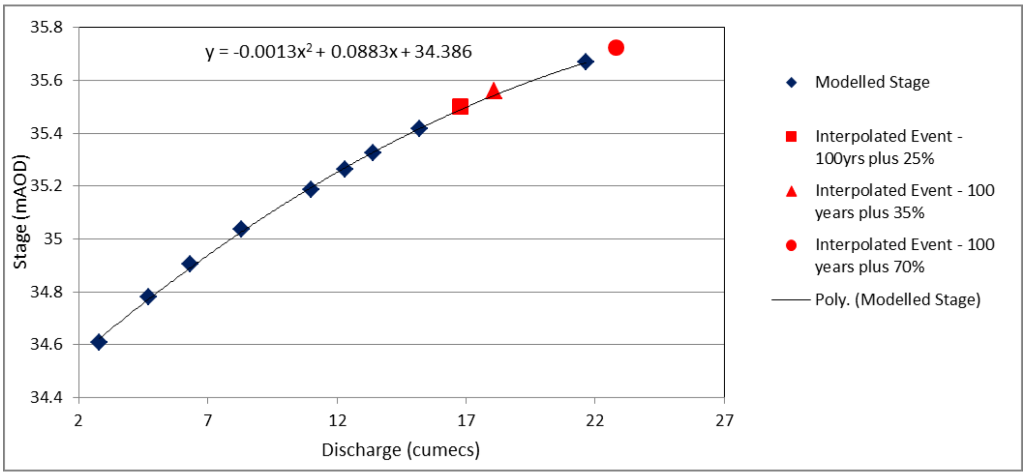



Table C1: Analysis of existing modelled flood water levels at CL.044

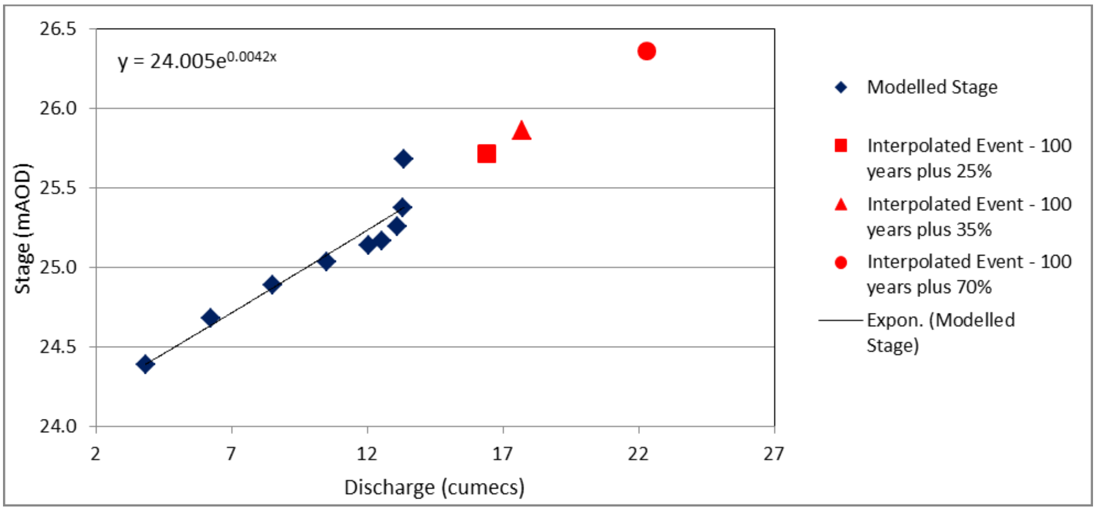
| Flood event AEP (years) | Model Scenarios Flow ($m^3$/s) | River Stage (m AOD) |
|---|---|---|
| 2 | 2.808 | 34.609 |
| 5 | 4.716 | 34.78 |
| 10 | 6.337 | 34.903 |
| 50 | 8.294 | 35.038 |
| 75 | 11.008 | 35.185 |
| 100 | 12.308 | 35.263 |
| 200 | 13.407 | 35.324 |
| 1000 | 15.202 | 35.418 |
| **Interpolated events** | | |
| 1 in 100 year plus 25% climate change | 22.792 | 35.723 |
| 1 in 100 year plus 35% climate change | 16.759 | 35.501 |
| 1 in 100 year plus 70% climate change | 18.099 | 35.558 |

In contrast, analysis of the data for node CI.006d, at the downstream end of reach 2, shows significant limiting of both flow and stage in up to the 0.1% AEP event, such there is less than 1$m^3$/s increase in flow between the

[30] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

1.3% AEP (1 in 75yrs) event and the 0.1% AEP event (see Figure C2 below). Theoretical adjustment for climate change of the 1% AEP flow in this location gives flows greatly in excess of the 0.1% AEP flow, which would suggest a significantly greater extent of flooding. However, in practice the climate change flows will also be limited by the culvert capacity, unless there is significant additional bypassing of the culvert during this event. The 0.1% AEP flood outline may be a less accurate proxy for climate change in this location.

**Figure C2 – Stage Discharge Relationship for Ching Brook at CI.006d**




The analysis demonstrates that based on an interpolation of the existing Ching Brook modelled flood levels for a range of return periods, utilising the 0.1% AEP as a proxy for the 1% AEP plus up to 70% allowance for climate change is appropriate only in some reaches of the Brook.  In other reaches the restriction on flow and stage mean that the 0.1% AEP event underestimates risk or that a more detailed review and potentially remodelling would be required. Finally, in some reaches the complex interactions between flows, structures and floodplain features means that the 0.1% AEP flood event would not be appropriate at all. The results of the analysis is summarised in Table C2 and Figure C3 below, which shows the location of the reaches referred to in Table C2.

**Figure C3 – Appropriateness of 1000 year proxy for effects of climate change on flood risk**

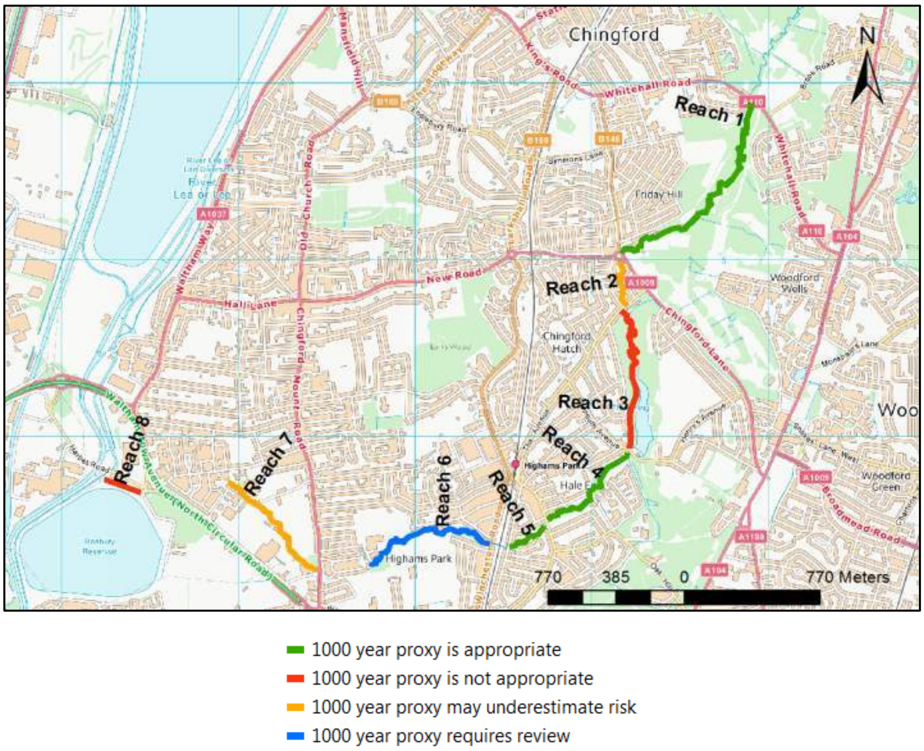


**Table C2 – Summary of Analysis of 0.1%AEP Event as a Proxy for the 1%AEP plus Climate Change Events**

| Reach | Appropriateness of 0.1% AEP proxy |
|---|---|
| 1 | The 0.1% AEP event is an appropriate proxy. The theoretical climate change flows and stages are all within the range of the existing model results. |
| 2 | The 0.1% AEP event may underestimate risk. Flows and stage are limited by upstream culverts which may experience additional by passing during larger flows. |
| 3 | Complex interactions between the upstream and downstream culverts, an extensive floodplain and large pond adjacent to the Brook results in limitations in both stage and flow and very different stage/flow curves at nodes in this reach. Theoretical climate change flows and stages are outside the range of existing model results. The 0.1% AEP event is not an appropriate proxy and more modelling would be needed to accurately assess the impacts of climate change. |
| 4 | The 0.1% AEP event is an appropriate proxy. The theoretical climate change flows and stages are within the range of the existing model results at most nodes in this reach. |
| 5 | The 0.1% AEP event is an appropriate proxy. The theoretical climate change flows and stages are within the range of the existing model results at most nodes in this reach. |
| 6 | The extent of limitation on flows and stage and the shape of the flow/stage relationship vary through this reach due to complex interactions between flows, structures and floodplain. The appropriateness of the 0.1% AEP proxy is different at different nodes and would need reviewing for proposals at specific locations. |
| 7 | The 0.1% AEP event may underestimate risk. Flows and stage are limited by upstream culverts which may experience additional by passing during larger flows. |
| 8 | Interactions between flood flows from the Ching Brook and flood flows from the River Lee, as well as flow limitations from the upstream culvert on the Ching Brook, mean that the relationship between flow and stage is not straightforward in this location. The 0.1% AEP event is not an appropriate proxy for climate change flows. |

# Method 2: Comparing Inflows

As an alternative method of assessing the suitability of using the 0.1% AEP flood outline as a proxy for the 1% AEP event including climate change, analysis of the model inflows has also been undertaken.

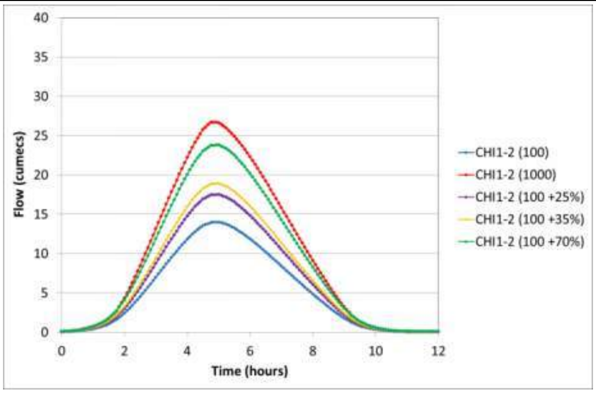
For the Ching Brook model there are 4 inflow nodes. By comparing hydrographs at each node with adjusted versions of the 1% AEP flow hydrographs it becomes clear that the 0.1% AEP peak inflow for the model is in fact greater than the 1% AEP plus climate change inflow for all adjustment values (Figure C3). This gives greater confidence in using the 0.1% AEP event as a proxy for the most extreme climate change scenarios, even in areas of the River Ching where relationships between flow and stage are more complex due to the effects of flow and stage limiting structures.

Developers should note that the Environment Agency guidance[31] should be used as a guide only and it is anticipated that there will be greater emphasis for site specific FRAs to include additional modelling scenarios to determine the future flood risk with respect to climate change where hydraulic modelling data is not available.

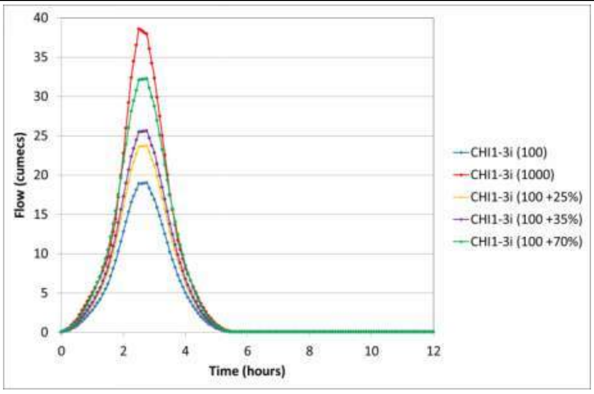
**It is recommended that developers contact the Environment Agency at the pre-planning application stage to confirm site specific flood risk assessment approach, on a case by case basis.**

[31] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

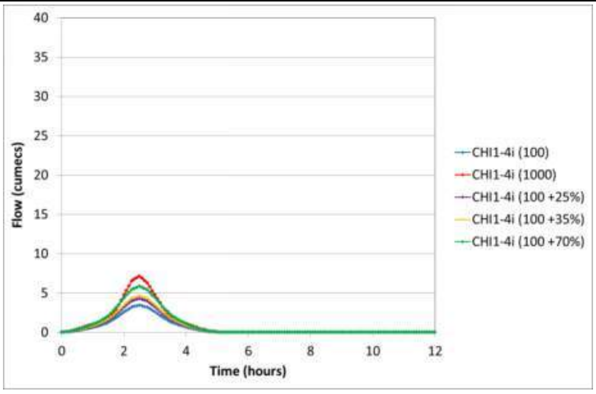
Figure C3: Inflow Hydrographs for River Ching Model with Adjustments for Climate Change



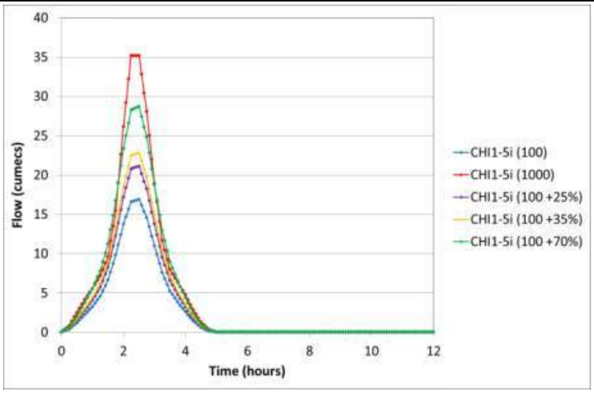

Inflow hydrograph at node CH1-2: Flow from upstream of modelled reach




Inflow hydrograph at reaches 1-4: urban runoff from northeast Chingford




Inflow hydrograph at reaches 5 and 6: urban runoff from southeast Chingford




Inflow hydrograph at reach 7: urban runoff from southwest Chingford

# Conclusions

The impact of climate change on flood risk along the River Ching has been assessed in accordance with the suggested approach set out in the guidance document published by the Environment Agency and through examination of modelled hydrograph inflows. This is in order to determine whether the impact of the 1% AEP flood, when adjusted for climate change, will exceed that of the current 0.1% AEP flood and therefore areas where the extent of flooding might extend outside Flood Zone 2.

Both methods suggest that the 0.1% AEP event can be used as an appropriate proxy for the maximum likely extent of flooding in the 1% AEP event when adjusted for climate change. The Environment Agency stage/discharge comparison approach does suggest that there are some reaches of Ching Brook where the interaction between flows, structures and the floodplain means that the relationship between flow and stage is more complex. In these areas, additional modelling would be needed at the site specific FRA stage to determine the actual impact of additional flows on flood levels and extents. Such modelling would be required if development was proposed in areas in Flood Zone 2.

# Appendix H
Surface Water Management Plan

# SURFACE WATER MANAGEMENT PLAN

*DRAIN LONDON*

LONDON BOROUGH OF WALTHAM FOREST

GREATER LONDON AUTHORITY

Thames Water

LONDON COUNCILS

Environment Agency

Waltham Forest

# Quality Management

## DOCUMENT INFORMATION

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## RELATED DOCUMENTS

| Doc Ref | Document Title | Author | Date of Issue | Version |
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| | | | | |
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- The British Geological Survey
- British Waterways
- Drain London Group 4 boroughs:
  - London Borough of Enfield
  - London Borough of Haringey
  - London Borough of Hackney
  - London Borough of Newham
  - London Borough of Tower Hamlets
- The Environment Agency
- The Greater London Authority
- London Councils
- The London Fire Brigade
- Network Rail
- Thames Water
- Transport for London and London Underground

# Executive Summary

This document forms the Surface Water Management Plan (SWMP) for the London Borough (LB) of Waltham Forest. The report outlines the preferred surface water management strategy for the borough. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall.

The SWMP has been delivered as part of the Tier 2 package of works of the Drain London Project and builds upon previous work undertaken as part of the Tier 1 package of works. A four phase approach has been undertaken in line with Defra's SWMP technical guidance documentation (2010). These are:

- Phase 1 – Preparation;
- Phase 2 – Risk Assessment;
- Phase 3 – Options; and
- Phase 4 – Implementation and Review.

**Phase 1: Preparation**

Phase 1 builds upon work undertaken during Tier 1 of the Drain London Project. The Tier 1 work involved the collection and review of surface water data from key stakeholders and the building of partnerships between key stakeholders responsible for local flood risk management. It was also decided that London would be delineated into 8 working groups. The LB of Waltham Forest forms part of Group 4 along with the LB's of Haringey, Hackney, Tower Hamlets, Newham, and Waltham Forest.

These six boroughs also form the North London Strategic Flood Group. The Group has been established in order for these local authorities to determine best practice and resources to enable each authority to discharge their responsibilities as Lead Local Flood Authority (LLFA) under the Flood and Water Management Act (FWMA) 2010.

**Phase 2: Risk Assessment**

As part of the Phase 2 Risk Assessment, direct rainfall modelling has been undertaken across the entire borough for five specified return periods. The results of this modelling have been used to identify Local Flood Risk Zones (LFRZs) where flooding affects houses, businesses and/or infrastructure. Those areas identified to be at more significant risk have been delineated into Critical Drainage Areas (CDAs) representing one or several LFRZs as well as the contributing catchment area and features that influence the predicted flood extent.

Within the LB of Waltham Forest, 13 CDAs have been identified and are presented in the figure below. The chief mechanisms for flooding in the LB of Waltham Forest can be broadly divided into the following categories:

- River Valleys (current and historical) - Across the study area, the areas particularly susceptible to overland flow are formed by narrow corridors associated with topographical valleys which represent the routes of the 'lost' rivers of London;
- Topographical Low Lying Areas - areas such as underpasses, subways and lowered roads beneath railway lines are more susceptible to surface water flooding;
- Railway Cuttings: stretches of railway track in cuttings are susceptible to surface water flooding and, if flooded, will impact on services;
- Railway Embankments - discrete surface water flooding locations along the upstream side of the raised rail embankment;
- Topographical Low Points – areas which are at topographical low points throughout the borough which result in small, discrete areas of deep surface water ponding;

- Sewer Flood Risk – areas where extensive and deep surface water flooding is likely to be the influence of sewer flooding mechanisms alongside pluvial and groundwater sources; and
- Fluvial Flood Risk - areas where extensive and deep surface water flooding is likely to be the influence of fluvial flooding mechanisms (alongside pluvial, groundwater and sewer flooding sources).

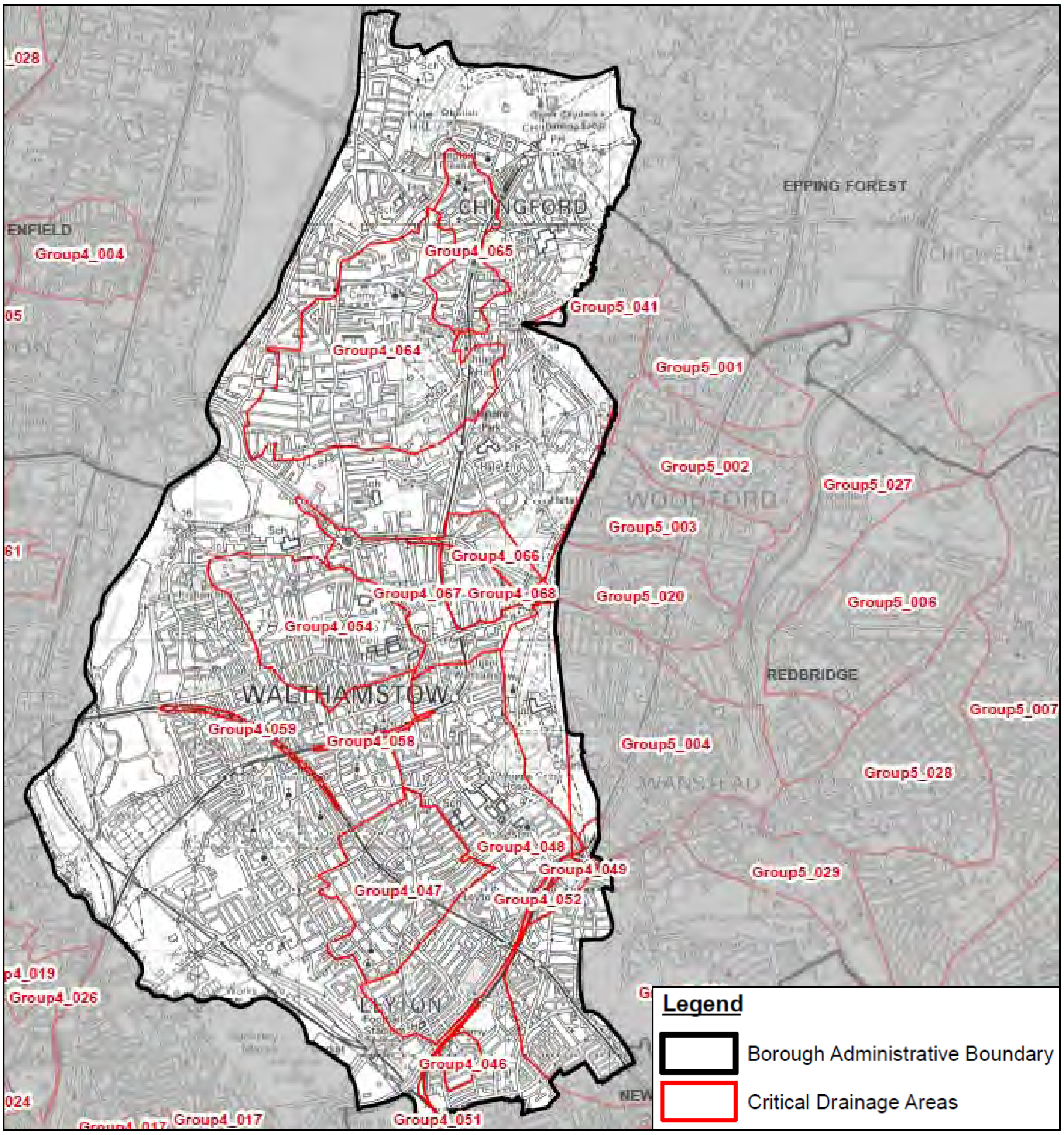



**Figure i Critical Drainage Areas within the London Borough of Waltham Forest**

Analysis of the number of properties at risk of flooding has been undertaken for the rainfall event with a 1 in 100 probability of occurrence in any given year. A review of the results demonstrate that 26,400 residential properties and 3,600 non-residential properties in the LB of Waltham Forest could be at risk of surface water flooding of a depth greater than 0.03m during a 100 year rainfall event (above an assumed 0.1m building threshold).

A review of these statistics coupled with local knowledge of the study area identifies that the following

CDAs are at greatest risk of flooding in terms of the number of receptors at risk:

| CDA ID | Infrastructure | | Households | | | | Commercial / Industrial | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | Non-Deprived | | Deprived | | | | |
| | All | > 0.5m Deep | All | > 0.5m Deep | All | > 0.5m Deep | All | > 0.5m Deep | |
| Group4_048 | 22 | 2 | 2691 | 68 | 1480 | 9 | 140 | 2 | 4333 |
| Group4_064 | 15 | 3 | 2180 | 1 | 284 | 5 | 99 | 9 | 2578 |
| Group4_054 | 16 | 3 | 1477 | 6 | 615 | 0 | 69 | 0 | 2177 |
| Group4_047 | 18 | 1 | 609 | 0 | 1061 | 0 | 114 | 0 | 1802 |
| Group4_067 | 8 | 2 | 543 | 0 | 371 | 0 | 41 | 0 | 963 |

One of the CDAs within the LB of Waltham Forest, CDA Group4_051, has cross-boundary issues where the southern portion extends into the LB of Newham. This CDA will require joint management to implement the potential options and manage surface water flood risk.

**Phase 3 Options Assessment**

There are a number of opportunities for measures to be implemented across the borough to reduce the impact of surface water flooding. Ongoing maintenance of the drainage network and small scale improvements are already undertaken as part of the operations of the borough. In addition, opportunities to raise community awareness of the risks and responsibilities for residents should be sought, and the LB of Waltham Forest may wish to consider the implementation of a Communication Plan to assist with this.

It is important to recognise that flooding within the borough is not confined to just the CDAs, and therefore, throughout the borough there are opportunities for generic measures to be implemented through the establishment of a policy position on issues including the widespread use of water conservation measures such as water butts and rainwater harvesting technology, use of soakaways, permeable paving, Bioretention carpark pods and green roofs. In addition, there are borough-wide opportunities to raise community awareness.

For each of the CDAs identified within the borough, site-specific measures have been identified that could be considered to help alleviate surface water flooding. These measures were subsequently short listed to identify a potential preferred option for each CDA.

Pluvial modelling undertaken as part of the SWMP has identified that flooding within the LB of Waltham Forest is heavily influenced by existing and historic river valleys, and impacts a number of regionally important infrastructure assets. Chapter 4 identifies the preferred surface water flood risk management options and measures to address the flood risk within the borough. Borough-wide, it is recommended that in the short-to-medium term the LB of Waltham Forest:

- Engage with residents regarding the flood risk in the borough, to make them aware of their responsibilities for property drainage (especially in the CDAs) and steps that can be taken to improve flood resilience;
- Provide an 'Information Portal' via the LB of Waltham Forest website, for local flood risk information and measures that can be taken by residents to mitigate surface water flooding to/around their property;
- Prepare a Communication Plan to effectively communicate and raise awareness of surface water flood risk to different audiences using a clearly defined process for internal and external communication with stakeholders and the public; and
- Improve maintenance regimes, and target those areas identified to regular flood or known to have blocked gullies.

**Phase 4 Implementation & Review**
Phase 4 establishes a long-term Action Plan for the LB of Waltham Forest to assist in their role under the FWMA 2010 to lead in the management of surface water flood risk across the borough. The purpose of the Action Plan is to:

- Outline the actions required to implement the preferred options identified in Phase 3;
- Identify the partners or stakeholders responsible for implementing the action;
- Provide an indication of the priority of the actions and a timescale for delivery; and
- Outline actions required to meet the requirements for the LB of Waltham Forest as LLFA under the FWMA 2010.

The SWMP Action Plan is a 'living' document, and as such, should be reviewed and updated regularly, particularly following the occurrence of a surface water flood event, when additional data or modelling becomes available, following the outcome of investment decisions by partners and following any additional major development or changes in the catchment which may influence the surface water flood risk within the borough.

# Glossary

| Term | Definition |
|---|---|
| Aquifer | A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water. |
| AMP | Asset Management Plan, see below |
| Asset Management Plan | A plan for managing water and sewerage company (WaSC) infrastructure and other assets in order to deliver an agreed standard of service. |
| AStSWF | Areas Susceptible to Surface Water Flooding. A national data set held by the Environment Agency and based on high level modelling which shows areas potentially at risk of surface water flooding. |
| Catchment Flood Management Plan (CFMP) | A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk. |
| CDA | Critical Drainage Area, see below. |
| Critical Drainage Area | A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure. |
| CFMP | Catchment Flood Management Plan, see entry above |
| CIRIA | Construction Industry Research and Information Association |
| Civil Contingencies Act | This UK Parliamentary Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums have a duty to put into place emergency plans for a range of circumstances including flooding. |
| CLG | Government Department for Communities and Local Government |
| Climate Change | Long term variations in global temperature and weather patterns caused by natural and human actions. |
| Culvert | A channel or pipe that carries water below the level of the ground. |
| Defra | Government Department for Environment, Food and Rural Affairs |
| DEM | Digital Elevation Model: a topographic model consisting of terrain elevations for ground positions at regularly spaced horizontal intervals. DEM is often used as a global term to describe DSMs (Digital Surface Model) and DTMs (Digital Terrain Models). |
| DG5 Register | A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years. |
| DSM | Digital Surface Model: a topographic model of the bare earth/underlying terrain of the earth's surface including objects such as vegetation and buildings. |
| DTM | Digital Terrain Model: a topographic model of the bare earth/underlying terrain of the earth's surface excluding objects such as vegetation and buildings. DTMs are usually derived from DSMs. |
| EA | Environment Agency: Government Agency reporting to Defra charged with protecting the Environment and managing flood risk in England. |
| Indicative Flood Risk Areas | Areas determined by the Environment Agency as potentially having a significant flood risk, based on guidance published by Defra and WAG and the use of certain national datasets. These indicative areas are intended to provide a starting point for the determination of Flood Risk Areas by LLFAs. |

| Term | Definition |
|---|---|
| FCERM | Flood and Coastal Erosion Risk Management Strategy. Prepared by the Environment Agency in partnership with Defra. The strategy is required under the Flood and Water Management Act 2010 and will describe what needs to be done by all involved in flood and coastal risk management to reduce the risk of flooding and coastal erosion, and to manage its consequences. |
| FMfSW | Flood Map for Surface Water. A national data set held by the Environment Agency showing areas where surface water would be expected to flow or pond, as a result of two different chances of rainfall event, the 1 in 30yr and 1 in 200yr events. |
| Flood defence | Infrastructure used to protect an area against floods such as floodwalls and embankments; they are designed to a specific standard of protection (design standard). |
| Flood Risk Area | See entry under Indicative Flood Risk Areas. |
| Flood Risk Regulations | Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management. |
| Floods and Water Management Act | An Act of Parliament which forms part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England. The Act was passed in 2010 and is currently being enacted. |
| Fluvial Flooding | Flooding resulting from water levels exceeding the bank level of a watercourse (river or stream). In this report the term Fluvial Flooding generally refers to flooding from Main Rivers (see later definition). |
| FRR | Flood Risk Regulations, see above. |
| IDB | Internal Drainage Board. An independent body with powers and duties for land drainage and flood control within a specific geographical area, usually an area reliant on active pumping of water for its drainage. |
| iPEG | Increased Potential Elevated Groundwater (iPEG) maps. The iPEG mapping shows those areas within the borough where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2 m of the ground surface. The mapping was carried out on a London-wide scale by Jacobs/JBA in March 2011. |
| IUD | Integrated Urban Drainage, a concept which aims to integrate different methods and techniques, including sustainable drainage, to effectively manage surface water within the urban environment. |
| LB | London Borough, e.g. LB Haringey, London Borough of Haringey |
| LDF | Local Development Framework. The spatial planning strategy introduced in England and Wales by the Planning and Compulsory Purchase Act 2004 and given detail in Planning Policy Statements 12. These documents typically set out a framework for future development and redevelopment within a local planning authority. |
| LFRZ | Local Flood Risk Zone, see below. |
| Local Flood Risk Zone | Local Flood Risk Zones are defined as discrete areas of flooding that do not exceed the national criteria for a ‘Flood Risk Area’ but still affect houses, businesses or infrastructure. A LFRZ is defined as the actual spatial extent of predicted flooding in a single location |
| Lead Local Flood Authority | Local Authority responsible for taking the lead on local flood risk management. The duties of LLFAs are set out in the Floods and Water Management Act. |
| LiDAR | Light Detection and Ranging, a technique to measure ground and building levels remotely from the air, LiDAR data is used to develop DTMs and DEMs (see definitions above). |
| LLFA | Lead Local Flood Authority, see above. |

| Term | Definition |
|---|---|
| Local Resilience Forum | A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner and respond in an emergency. Roles and Responsibilities are defined under the Civil Contingencies Act. |
| LPA | Local Planning Authority. The local authority or Council that is empowered by law to exercise planning functions for a particular area. This is typically the local borough or district Council. |
| LRF | Local Resilience Forum, see above. |
| Main River | Main rivers are a statutory type of watercourse in England and Wales and are usually larger streams and rivers, but may also include some smaller watercourses. A main river is defined as a watercourse marked as such on a main river map, and can include any structure or appliance for controlling or regulating the flow of water in, into or out of a main river. The Environment Agency's powers to carry out flood defence works apply to main rivers only. |
| NRD | National Receptor Dataset – a collection of risk receptors produced by the Environment Agency. A receptor could include essential infrastructure such as power infrastructure and vulnerable property such as schools and health clinics. |
| Ordinary Watercourse | All watercourses that are not designated Main River, and which are the responsibility of Local Authorities or, where they exist, IDBs are termed Ordinary Watercourses. |
| PA | Policy Area, see below. |
| Partner | A person or organisation with responsibility for the decision or actions that need to be taken. |
| PFRA | Preliminary Flood Risk Assessment, see below. |
| Pitt Review | Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England. |
| Pluvial Flooding | Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow. |
| Policy Area | One or more Critical Drainage Areas linked together to provide a planning policy tool for the end users. Primarily defined on a hydrological basis, but can also accommodate geological concerns where these significantly influence the implementation of SuDS |
| PPS25 | Planning and Policy Statement 25: Development and Flood Risk |
| Preliminary Flood Risk Assessment | Assessment required by the EU Floods Directive which summarises flood risk in a geographical area. Led by Local Authorities. |
| Resilience Measures | Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances. |
| Resistance Measures | Measures designed to keep flood water out of properties and businesses; could include flood guards for example. |
| Risk | In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, combined with the consequence of the flood. |
| Risk Management Authority | Defined by the Floods and Water Management Act as “the Environment Agency, a lead local flood authority, a district council for an area for which there is no unitary authority, an internal drainage board, a water company, and a highway authority”. |
| RMA | Risk Management Authority, see above |
| Sewer flooding | Flooding caused by a blockage or overflowing in a sewer or urban drainage system. |
| SFRA | Strategic Flood Risk Assessment, see below |

| Term | Definition |
|---|---|
| Stakeholder | A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities. |
| Strategic Flood Risk Assessment | A strategic framework for the consideration of flood risk when making planning decisions at Local Level. |
| SuDS | Sustainable Drainage Systems, see below. |
| Sustainable Drainage Systems | Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques. Includes swales, wetland sand ponds. |
| Surface water | Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer. |
| SWMP | Surface Water Management Plan |
| TE2100 | The Thames Estuary 2100 Project. Led by the Environment Agency, the project was established in 2002 with the aim of developing a long-term tidal flood risk management plan for London and the Thames estuary. |
| TfL | Transport for London |
| TWUL | Thames Water Utilities Ltd |
| UKCIP | The UK Climate Impacts Programme. Established in 1997 to assist in the co-ordination of research into the impacts of climate change. UKCIP publishes climate change information on behalf of the UK Government and is largely funded by Defra. |
| WaSC | Water and Sewerage Company |

# Table of Contents

**TABLES**



**FIGURES**

# 1 Introduction

## 1.1 What is a Surface Water Management Plan?

1.1.1 A Surface Water Management Plan (SWMP) is a plan produced by the Lead Local Flood Authority (in this case London Borough of Waltham Forest) which outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches that occurs as a result of heavy rainfall.

1.1.2 This SWMP study has been undertaken as part of the Drain London Project in consultation with key local partners who are responsible for surface water management and drainage in the London area – including Thames Water, the Environment Agency and Transport for London. The Partners have worked together to understand the causes and effects of surface water flooding and agree the most cost effective way of managing surface water flood risk for the long term.

1.1.3 This document also establishes a long-term action plan to manage surface water and will influence future capital investment, maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

## 1.2 Background

1.2.1 In May 2007 the Mayor of London consulted on a draft Regional Flood Risk Appraisal (RFRA). One of the key conclusions was that the threat of surface water flooding in London was poorly understood. This was primarily because there were relatively few records of surface water flooding and those that did exist were neither comprehensive nor consistent. Furthermore the responsibility for managing flood risk in London is split between boroughs and other organisations such as Transport for London, London Underground, Network Rail and relationships with the Environment Agency and Thames Water and the responsibility for managing sources of flood risk were unclear. To give the issue even greater urgency it is widely expected that heavy storms with the potential to cause flooding will increase in frequency with climate change.

1.2.2 The Greater London Authority, London Councils, Environment Agency and Thames Water commissioned a scoping study to test these findings and found that this was an accurate reflection of the situation. The conclusions were brought into sharp focus later in the summer of 2007 when heavy rainfall resulted in extensive surface water flooding in parts of the UK such as Gloucestershire, Sheffield and Hull causing considerable damage and disruption. It was clear that a similar rainfall event in London would have resulted in major disruption. The Pitt Review examined the flooding of 2007 and made a range of recommendations for future flood management, most of these have been enacted through the Flood and Water Management Act 2010 (FWMA).

1.2.3 The Department for Environment, Food and Rural Affairs (Defra) recognised the importance of addressing surface water flooding in London and fully funded the Drain London project. The Drain London project is being delivered through 3 'Tiers' as shown in Figure 1-1.

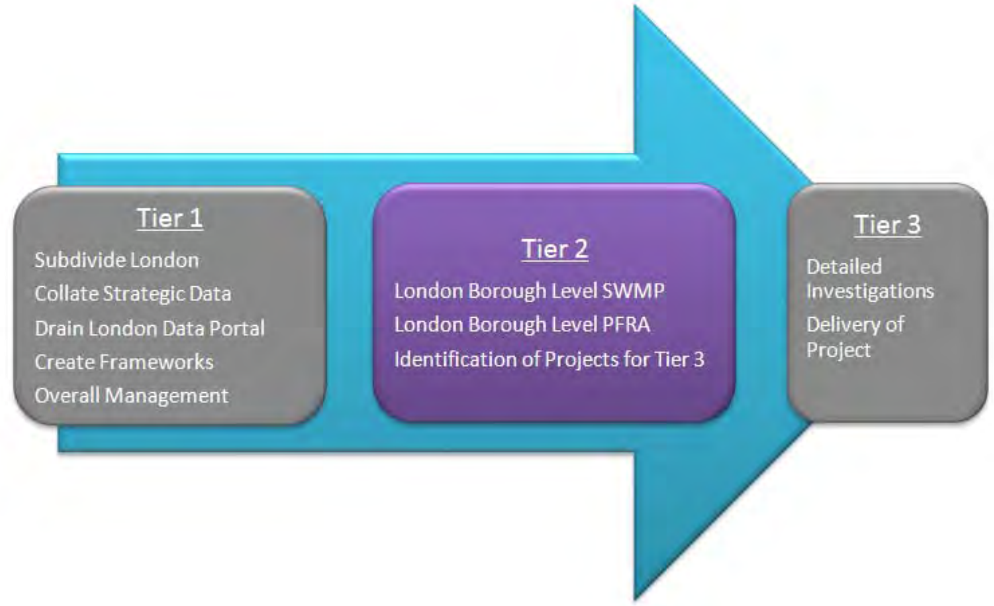



**Figure 1-1 Drain London Project 'Tier' Structure**

1.2.4 A description of the works within each Tier is described in Table 1-1. This SWMP forms part of Tier 2 package of works.

**Table 1-1 Summary of Drain London Project 'Tier' Structure**

| Phase | Summary of works |
|---|---|
| Tier 1 | a) A high level strategic investigation to group the 33 separate boroughs into a smaller number of more manageable units for further study under Tiers 2 and 3 in order to develop and refine an SWMP for each.<br>b) Development of a web based 'Portal' to provide data management, data storage and access to the various data sets and information across the 'Drain London Forum' participants and to Tier 2 & 3 consultants.<br>c) c) Provide programme management support for the duration of the Drain London project, including Tiers 2 and 3. |
| Tier 2 | a) Delivery of 33 borough-level **Surface Water Management Plans** to identify Local Flood Risk Zones and Critical Drainage Areas.<br>b) Creation of 33 borough-level **Action Plans** including capital and maintenance actions and programmes of work for each partner/stakeholder as well as actions required to meet the responsibilities as Lead Local Flood Authority required by the FWMA 2010.<br>c) Preparation of 33 borough-level **Preliminary Flood Risk Assessments** to meet the requirements of the Flood Risk Regulations 2009 on Lead Local Flood Authorities.<br>d) d) List of prioritised Critical Drainage Areas for potential further study or capital works in Tier 3 using the Drain London Tier 1 **Prioritisation Matrix**. |
| Tier 3 | a) Detailed investigations into high priority Critical Drainage Areas to further develop and prioritise mitigation options.<br>b) b) Development of cross-organisational action plans that include a costed list of identified flood risk management mitigation measures and community level flood plans. |

1.2.5 As described in Table 1-1, Tier 2 of the Drain London project involves the preparation of SWMPs for each London Borough. Through the subsequent enactment of the FWMA boroughs are also required to produce Preliminary Flood Risk Assessments (PFRA). The Drain London project has been extended to deliver both a PFRA and a SWMP for each London Borough. This will be a major step in meeting borough requirements as set out in the F&WM Act. Another key aspect of the Act is to ensure that boroughs work in partnership with other Local Risk Authorities. Drain London assists this by creating sub-regional partnerships as set out in Figure 1-2 below.

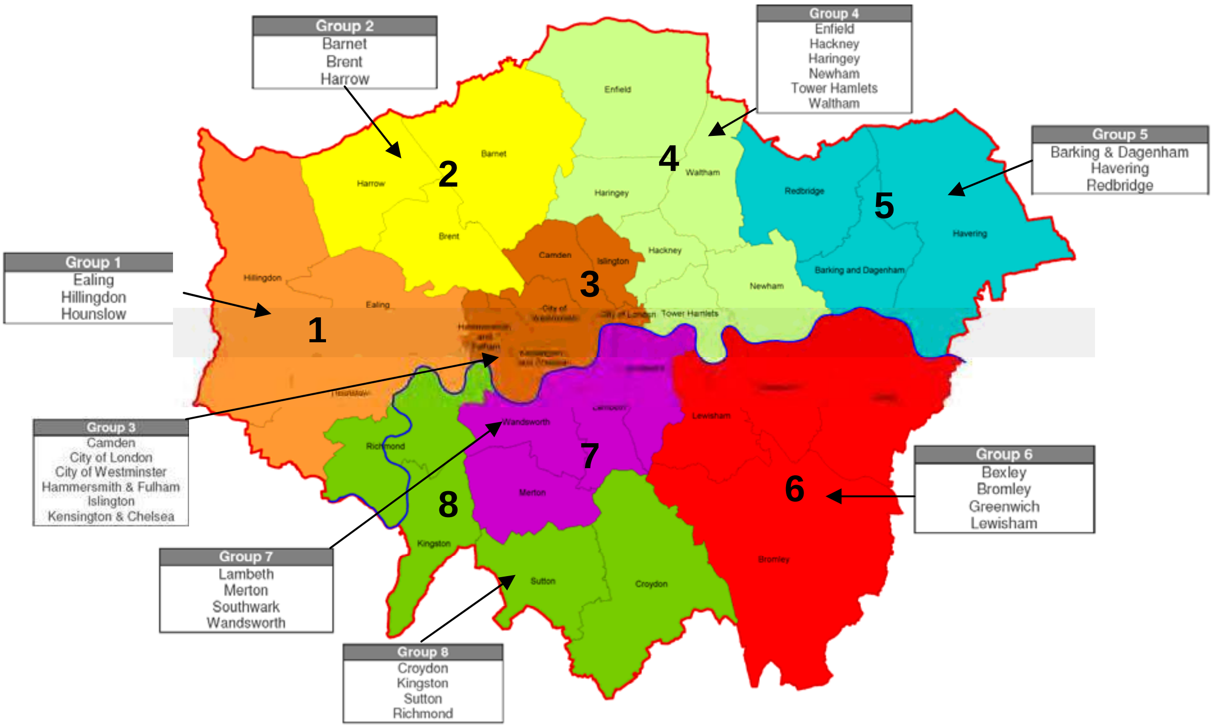



**Figure 1-2 Drain London Sub-regional Partnerships**

## 1.3 SWMP Process

1.3.1 The Defra SWMP Technical Guidance (2010) provides the framework for preparing SWMPs. This report has been prepared to reflect the four principal stages identified by the guidance (refer Figure 1-3):

- Preparation; Identify the need for a SWMP, establish a partnership with the relevant stakeholders and scope SWMP (refer to Chapter 2);
- Risk Assessment; Identify which level of detail is required for the SWMP – a Level 2 Intermediate assessment was selected for this study (refer to Chapter 3);
- Options: Identify options/measures (with stakeholder engagement) which seek to alleviate the surface water flood risk within the study area (refer to Chapter 4); and
- Implementation and Review: Prepare Action Plan and implement the monitoring and review process for these actions (refer to Chapter 5).


**Figure 1-3 Recommended Defra SWMP Process (Source Defra 2010)**

1.3.2 The scope of the Tier 2 work (refer to Table 1-1) falls within Phase 2 (Risk Assessment) and Phase 3 (Options) and partially within Phase 4 (Implementation and Review).

## 1.4 Objectives

1.4.1 The objectives of the SWMP are to:

- Develop a robust understanding of surface water flood risk in and around the study area, taking into account the challenges of climate change, population and demographic change and increasing urbanisation in London;
- Identify, define and prioritise Critical Drainage Areas, including further definition of existing local flood risk zones and mapping new areas of potential flood risk;

- Make holistic and multifunctional recommendations for surface water management which improve emergency and land use planning, and enable better flood risk and drainage infrastructure investments;

- Establish and consolidate partnerships between key drainage stakeholders to facilitate a collaborative culture of data, skills, resource and learning sharing and exchange, and closer coordination to utilise cross boundary working opportunities;

- Undertake engagement with stakeholders to raise awareness of surface water flooding, identify flood risks and assets, and agree mitigation measures and actions;

- Deliver outputs to enable a real change on the ground whereby partners and stakeholders take ownership of their flood risk and commit to delivery and maintenance of the recommended measures and actions;

- Meet borough specific objectives as recorded at the outset of the development of the SWMP (further details below);

- Facilitate discussions and report implications relating to wider issues falling outside the remit of this Tier 2 work, but deemed important by partners and stakeholders for effectively fulfilling their responsibilities and delivering future aspects of flood risk management.

1.4.2 Borough specific aims and objectives were discussed at the various meetings held throughout the development of the SWMP. These are summarised below:

- *Identify surface water flood risk areas to assist with spatial planning and future development;*
- *Identify surface water flood risk areas to assist with emergency planning within the borough;*
- *Provision of mapping which is suitable for public distribution;*
- *Determine (if possible) options to alleviate flood risk within the identified Critical Drainage Areas;*
- *Provide a clear Action Plan which the Council can implement (and/or areas to investigate) to assist in the further understanding of pluvial and groundwater flooding within the borough.*

## 1.5 Study Area

### Location and Characteristics

1.5.1 The LB of Waltham Forest is located in north east London bordering the local authority of Epping Forest as well as the LBs of Redbridge to the east, Enfield and Haringey to the west, and Hackney and Newham to the south.

1.5.2 The borough encompasses an area of 3,900ha and contains a mixture of urban and open space landuses. The open spaces are generally located along the western and eastern boundaries, whilst more densely urban areas in the centre of the Borough. Figure 3 within Appendix D provides an overview of the landuses within Waltham Forest.

1.5.3 The borough contains the following significant infrastructure:

- One gas holder station in Leyton and an electricity station in South Chingford;

- One Sewage Works in Leyton;

- Two Water Pumping Stations (South Chingford, Tottenham Hale), Coppermills Waterworks and Water Reservoirs (Lee Valley Reservoirs);

- Kilometres of Network Rail and London underground rail line along with tube/rail stations and rail maintenance assets and infrastructure;
- Four Fire Stations (Chingford, Walthamstow, Leyton, Leytonstone);
- Whipps Cross Hospital in Leytonstone; and
- Twelve (12) A roads.

**Major Rivers and Waterways within the Borough**

1.5.4 The River Lee is located along the western extent of the borough and flows in a southerly direction. The watercourse drains a large rural catchment to the north of London, extending as far as Luton and encompassing parts of Hertfordshire and Essex. The River Lee flows through the LBs of Enfield, Haringey, Hackney, Tower Hamlets, and Newham, where the watercourse outfalls to the River Thames.

1.5.5 Within the LB of Waltham Forest, tributaries of the River Lee include the Ching Brook, Dagenham Brook and the River Lee Flood Relief Channel. The Ching flows generally in a westerly direction through Highams Park near the centre of the prior to outfalling into the River Lee to the north of Banbury Reservoir. The total catchment area of the Ching is 1,700ha.

1.5.6 The Dagenham Brook lies in the south-western part of the LB of Waltham Forest. The watercourse flows from the River Lee Flood Relief Channel, through urban areas in Leyton, before outfalling into the River Lee near to the Temple Mills Marshalling Yard.

1.5.7 Construction on the River Lee Flood Relief Channel commenced in 1947 following severe flooding in the area. The channel was completed in 1976 and flows into Greater London from Hertfordshire. The channel joins the Old River Lee before outfalling in the Lee Navigation.

1.5.8 Figure 7 in Appendix D shows the locations of these watercourses within the borough.

**Topography and Geology**

1.5.9 Figure 1-4 indicates that the LB of Waltham Forest generally slopes in a westerly and south westerly direction towards the River Lee. The highest parts of the borough are in the east, along the boundaries with the LB of Redbridge and Epping Forest District Council. The lowest parts of the borough are alongside the River Lee, adjacent to the borough boundary with the LB of Hackney. Overland flow is likely to runoff high ground and pond in the low-lying areas in the south-west of the borough.

1.5.10 The LB of Waltham Forest lies within the London Basin, which has been shaped by a relatively thick (few hundred metres) chalk syncline. The basin has been infilled over time by a series of clays and sands, the most notable deposit being the fossil rich and impermeable London Clay. The clay layer can be up to a maximum of 150m thick beneath London. More recently in geological terms, the London Clay has been overlain by drift deposits from river terraces. As the River Lea has altered path and scoured channels deeper through time, they have left deposits of sand and gravel in terrace formations upon the underlying geology. Figure 12 within Appendix D provides an overview of the borough's geology.

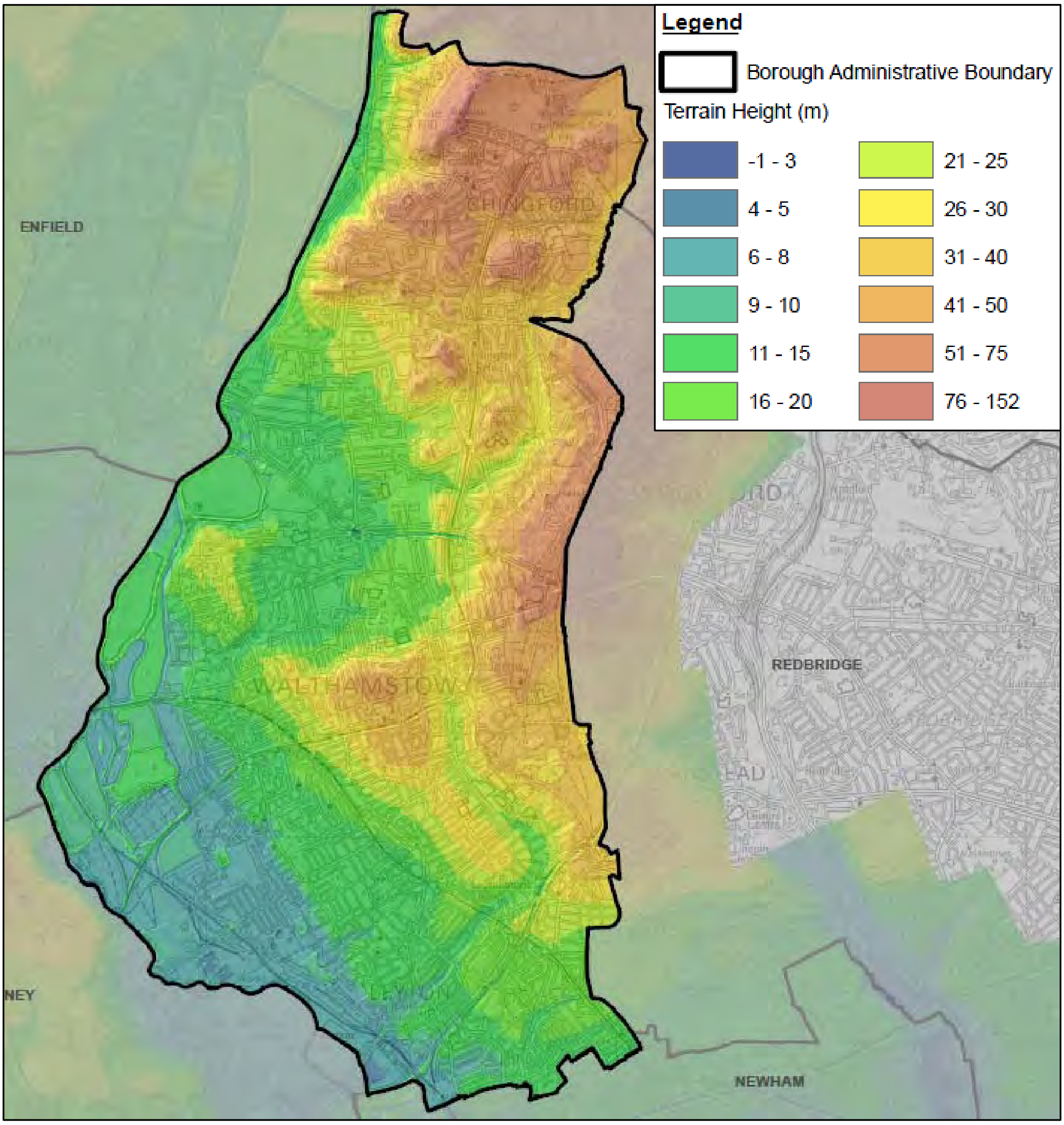



**Figure 1-4 LiDAR Representation of the Topography within Waltham Forest**

**Significant future development plans**

1.5.11 The Local Development Framework (LDF) for the LB of Waltham Forest identifies growth areas in:

- Blackhorse Lane Area;
- Walthamstow Town Centre Area;
- Wood Street Area; and
- North Olympic Fringe.

1.5.12 In each instance an Area Action Plan will be produced to provide further guidance on how development should be brought forward. Plans for urbanisation and redevelopment within the LB of Waltham Forest may present a challenge to the existing drainage systems. However, it is also affords a crucial opportunity to address long-standing issues and problems relating to surface water flooding through strategic improvements and upgrades to the drainage system. The SWMP for the LB of Waltham Forest should afford a particular focus on these areas allocated for further development and urbanisation and identify any potential locations for strategic improvements and upgrades to the existing drainage systems.

1.5.13 In the case of the identified North Olympic Fringe growth area, development offers the opportunity to reduce flood risk in 'critical drainage areas' identified in section 3.8 of this report.

**Interactions with neighbouring Boroughs / County Councils**

1.5.14 The need for an integrated approach between neighbouring boroughs has become apparent due to cross boundary flooding and drainage issues in recent years. This has become evident in the Drain London programme where a number of 'critical drainage areas' identified in section 3.8 of this report span across more than one borough.

1.5.15 The LB of Waltham Forest forms part of the 'Group 4' group of boroughs, established as part of the Drain London programme, formed to assist delivery of Drain London, but also to establish an ongoing working partnership for managing local flood risk in the area. The aims of this partnership are to understand flood risk to the group boroughs and to share best practice management procedures. Drain London Group 4 includes the London Boroughs of:

- Enfield
- Hackney
- Haringey
- Newham
- Tower Hamlets
- Waltham Forest

## 1.6 Flooding Interactions

1.6.1 The SWMP technical guidance (Defra 2010) identifies four primary sources of surface water flooding that should be considered within a SWMP as described below:

- **Pluvial flooding**: High intensity storms (often with a short duration) are sometimes unable to infiltrate into the ground or be drained by formal drainage systems since the capacity of the collection systems is not large enough to convey runoff to the underground pipe systems (which in turn might already be surcharging). The pathway for surface water flooding can include blockage, restriction of flows (elevated grounds), overflows of the drainage system and failure of sluice outfalls and pump systems.

- **Sewer flooding**: Flooding which occurs when the capacity of the underground drainage network is exceeded, resulting the surcharging of water into the nearby environment (or within internal and external building drainage networks). The discharge of the drainage network into waterways and rivers can also be affected if high water levels in receiving waters obstruct the drainage network outfalls.

- **Ordinary Watercourses**: Flooding from small open channels and culverted urban watercourses (which receive most of their flow from the urban areas) can either exceed their capacity and cause localised flooding of an area or can be obstructed (through debris or illegal obstruction) and cause localised out of bank flooding of nearby low lying areas.

- **Groundwater flooding:** Flooding occurs when the water level within the groundwater aquifer rises to the surface. In very wet winters these rising water levels may lead to flooding of areas that are normally dry. This can also lead to streams that only flow for part of the year being reactivated. These intermittent streams are typically known as bournes. Water levels below the ground can rise during winter (dependant on rainfall) and fall during drier summer months as water discharges from the saturated ground into nearby watercourses.

1.6.2 Figure 1-5 provides an illustration of these flood sources. Each of these sources of flood risk a futher explained within Chapter 3 of this report.

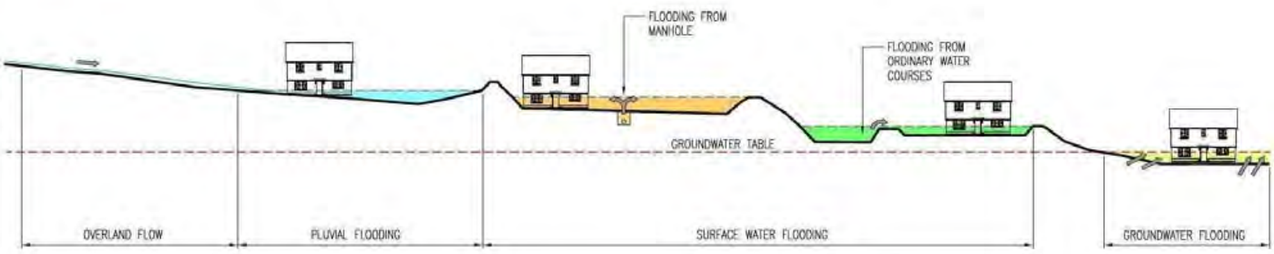



**Figure 1-5 Illustration of Flood Sources (source: WSP, 2010).**

## 1.7 Linkages with Other Plans

1.7.1 The increased focus on flood risk over recent years is an important element of adaptation to climate change. The clarification of the role of London Boroughs as Lead Local Flood Authorities (LLFA) is welcomed. The creation of a number of new documents can at times be confusing. Drain London links into all of these:

**Regional Flood Risk Appraisal (RFRA)**

1.7.2 The RFRA is produced by the Greater London Authority and gives a regional overview of flooding from all sources. The RFRA will be updated in 2012 to reflect the additional information on local sources of flood risk (surface water, groundwater and ordinary watercourses) from Drain London. This may also generate new policies that would be incorporated into the London Plan when it is reviewed.

**Thames Catchment Flood Management Plan (CFMP)**

1.7.3 The Thames Catchment Flood Management Plan (CFMP) was published in 2008 by the Environment Agency and sets out policies for the sustainable management of flood risk across the whole of the Thames catchment over the long-term (50 to 100 years) taking climate change into account. More detailed flood risk management strategies for individual rivers or sections of river may sit under these.

1.7.4 The CFMP emphasises the role of the floodplain as an important asset for the management of flood risk, the crucial opportunities provided by new development and regeneration to manage risk, and the need to re-create river corridors so that rivers can flow and flood more naturally.

1.7.5 This CFMP will be periodically reviewed, approximately five years from when it was published, to ensure that it continues to reflect any changes in the catchment. There are links to Drain London where there are known interactions between surface water and fluvial flooding.

**Preliminary Flood Risk Assessment (PFRA)**

1.7.6 These are required as part of the Flood Risk Regulations which implement the requirements of the European Floods Directive. Drain London is producing one of these for each London Borough (each of which is a Lead Local Flood Authority), to give an overview of all local sources of flood risk. In London the PFRA process is greatly assisted by the new data and information relating to surface water which comes from the Drain London SWMPs. Boroughs must review these PFRAs every 6 years.

**Surface Water Management Plans (SWMP)**

1.7.7 Drain London is producing one of these for each London Borough. They provide detailed information on the potential for surface water flooding, based on probabilistic 2-dimensional modelling. This information improves greatly on data which has previously been provided at a national scale by the Environment Agency. In addition each SWMP contains an Action Plan that has been developed in conjunction with both the borough and relevant other Risk Management Authorities. This data and actions and associated policy interventions will feed directly into the operational level of the borough across many departments, in particular into spatial and emergency planning policies and designations and into the management of local authority controlled land.

**Strategic Flood Risk Assessments (SFRA)**

1.7.8 Each local planning authority is required to produce a SFRA under Planning Policy Statement 25 (PPS25). This provides an important tool to guide planning policies and land use decisions. Current SFRAs have a strong emphasis on flooding from main rivers and the sea and are relatively weak (due to past priorities and a lack of data) in evaluating flooding from other local sources including surface water, groundwater and ordinary watercourses. The information from Drain London will improve this understanding.

1.7.9 The LB of Waltham Forest is included in the North London SFRA, drafted in August 2008. This report covers the London Boroughs of Barnet, Camden, Enfield, Haringey, Hackney, Haringey, Islington and Waltham Forest. The North London SFRA was commissioned based on the existing collaboration between the seven boroughs on the North London Waste Plan.

1.7.10 The LB of Waltham Forest is is also covered by the East London SFRA, which was drafted in June 2005. This report covers the London Boroughs of Lewisham, Greenwich, Bexley, Havering, Barking and Dagenham, Newham, Waltham Forest, Redbridge, Hackney and Tower Hamlets. The East London SFRA was commissioned by Thames Gateway London Partnership and includes the collaboration between the ten boroughs in East London and the London Corporation. This document was drafted to meet the requirements of PPG25 and is now considered out of date as it does not meet the requirements in PPS25.

1.7.11 The LB of Waltham Forest are intending to produce their own SFRA as part of the Local Development Framework in the near future.

**Local Development Documents (LDD)**

1.7.12 LDDs including the Core Strategy and relevant Area Action Plans (AAPs) will need to reflect the results from Drain London. This may include policies for the whole borough or for specific parts of boroughs, for example Critical Drainage Areas. There may also be a need to review Area Action Plans where surface water flood risk is a particular issue. The updated SFRA will assist with this as will the reviewed RFRA and any updated London Plan policies. In producing Opportunity Area Planning Frameworks, the GLA and boroughs will also examine surface water flood risk more closely.

**Local Flood Risk Management Strategies**

1.7.13 The Flood and Water Management Act 2010 (FWMA) requires each LLFA to produce a Local Flood Risk Management Strategy by December 2012. Whilst Drain London will not directly deliver a LFRMP, the SWMPs, PFRAs and their associated risk maps will provide the necessary evidence base to support the development of LFRMS and it is anticipated that no, or limited new modelling will be necessary to produce these strategies.

1.7.14 The schematic diagram (Figure 1-6 below) illustrates how the CFMP, PFRA, SWMP and SFRA link to and underpin the development of a Local Flood Risk Management Strategy.

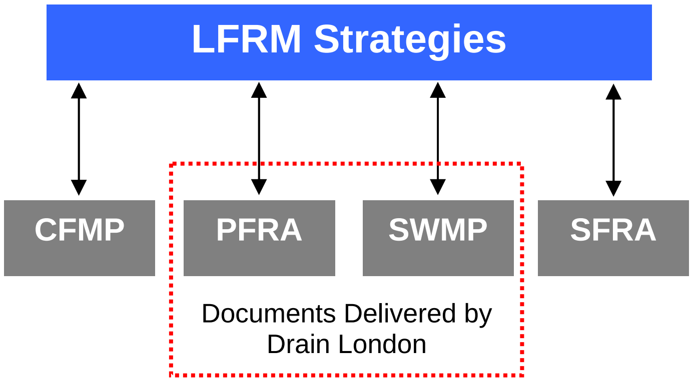



**Figure 1-6 Linkages of LFRM Strategy Reports**

## 1.8 Existing Legislation

1.8.1 The Flood and Water Management Act 2010 (FWMA) presents a number of challenges for policy makers and the flood and coastal risk management authorities identified to co-ordinate and deliver local flood risk management (surface water, groundwater and flooding from ordinary water courses). 'Upper Tier' local authorities have been empowered to manage local flood risk through new responsibilities for flooding from surface and groundwater.

1.8.2 The FWMA reinforces the need to manage flooding holistically and in a sustainable manner. This has grown from the key principles within Making Space for Water (Defra, 2005) and was further reinforced by the summer 2007 floods and the Pitt Review (Cabinet Office, 2008). It implements several key recommendations of Sir Michael Pitt's Review of the Summer 2007 floods, whilst also protecting water supplies to consumers and protecting community groups from excessive charges for surface water drainage.

1.8.3 The FWMA must also be considered in the context of the EU Floods Directive, which was transposed into law by the Flood Risk Regulations 2009 (the Regulations) on 10 December 2009. The Regulations requires three main types of assessment / plan to be produced:

a) Preliminary Flood Risk Assessments (maps and reports for Sea, Main River and Reservoirs flooding) to be completed by Lead Local Flood Authorities and the Environment Agency by the 22 December 2011. Flood Risk Areas, at potentially significant risk of flooding, will also be identified. Maps and management plans will be developed on the basis of these flood risk areas.

b) Flood Hazard Maps and Flood Risk Maps. The Environment Agency and Lead Local Flood Authorities are required to produce Hazard and Risk maps for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2013.

c) Flood Risk Management Plans. The Environment Agency and Lead Local Flood Authorities are required to produce Flood Risk Management Plans for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2015.

1.8.4 Figure 1-7, below, illustrates how this SWMP fits into the delivery of local flood and coastal risk management, and where the responsibilities for this lie.

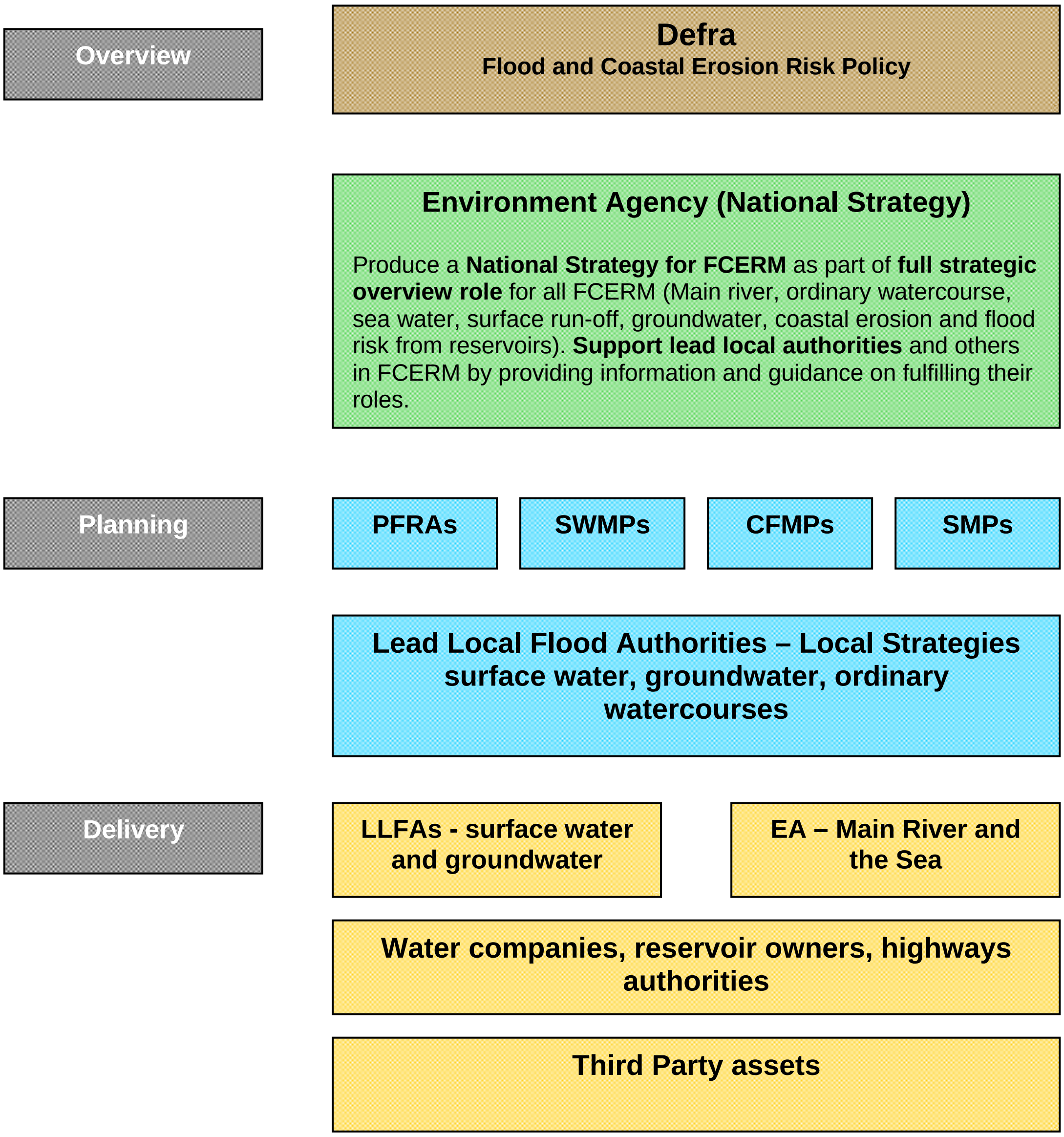



**Figure 1-7 Where the SWMP is located within the delivery of local flood and coastal risk management**

## 1.9 Peer Review

1.9.1 It is essential for the Drain London Project that SWMPs are consistent and comparable across Greater London. This is to facilitate:

- Fair, transparent and rapid allocation of funds to identified high priority flood risk areas within London;
- Collaborative working practices between stakeholders; and
- Building of local capability (Council officers and consultants doing work in the future will be able to make use of outputs regardless of who produced them for each borough).

1.9.2 To ensure consistency and comparability between London Borough SWMPs produced, a Peer Review process has been used. The process involved the four consultant teams who are working on the Drain London SWMPs independently reviewing each other's work. This has ensured that all outputs result from a consistent technical approach, are of a high technical quality and are communicated in the specified formats. The peer review report for this SWMP is included in Appendix F.

## 1.10 LLFA Responsibilities

1.10.1 Aside from forging partnerships and coordinating and leading on local flood management, there are a number of other key responsibilities that have arisen for Local Lead Flood Authorities from the Flood & Water Management Act 2010, and the Flood Risk Regulations 2009. These responsibilities include:

- **Investigating flood incidents** – LLFAs have a duty to investigate and record details of significant flood events within their area. This duty includes identifying which authorities have flood risk management functions and what they have done or intend to do with respect to the incident, notifying risk management authorities where necessary and publishing the results of any investigations carried out. .
- **Asset Register** – LLFAs also have a duty to maintain a register of structures or features which are considered to have an effect on flood risk, including details on ownership and condition as a minimum. The register must be available for inspection and the Secretary of State will be able to make regulations about the content of the register and records.
- **SuDS Approving Body** – LLFAs are designated the SuDS Approving Body (SAB) for any new drainage system, and therefore must approve, adopt and maintain any new sustainable drainage systems (SuDS) within their area. This responsibility is anticipated to commence from April 2012.
- **Flood risk management strategies** – LLFAs are required to develop, maintain, apply and monitor a strategy for local flood risk management in its area. The local strategy will build upon information such as national risk assessments and will use consistent risk based approaches across different local authority areas and catchments.
- **Works powers** – LLFAs have powers to undertake works to manage flood risk from surface runoff and groundwater, consistent with the local flood risk management strategy for the area.

- **Designation powers** – LLFAs, as well as district councils and the Environment Agency have powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management.

1.10.2 These LLFA requirements have been considered in the production of this document. The SWMP will assist the LLFA in providing evidence for points 1, 2 and 3.

# 2 Phase 1: Preparation

## 2.1 Partnership

2.1.1 The Flood and Water Management Act 2010 defines the Lead Local Flood Authority (LLFA) for an area as the unitary authority for the area, in this case LB of Waltham Forest. As such, the LB of Waltham Forest is responsible for leading local flood risk management including establishing effective partnerships with stakeholders such as the Environment Agency, Thames Water Utilities Ltd, Transport for London, Network Rail and London Underground as well as others. Ideally these working arrangements should be formalised to ensure clear lines of communication, mutual co-operation and management through the provision of Level of Service Agreements (LoSA) or Memorandums of Understanding (MoU). It is recommended that the partnerships created as part of the Drain London Tier 1 work are maintained into perpetuity.

2.1.2 As mentioned in section 1.5.15 of this report, the LB of Waltham Forest forms part of the Drain London 'Group 4' group of boroughs, established as part of the Drain London programme. Group 4 are currently represented on the Thames Regional Flood Defence Committee (RFDC) by Councillor Chris Bond, Cabinet Member for Environment from the LB of Enfield.

2.1.3 Members of the public may also have valuable information to contribute to the SWMP and to an improved understanding and management of local flood risk within the borough. Public engagement can afford significant benefits to local flood risk management including building trust, gaining access to additional local knowledge and increasing the chances of stakeholder acceptance of options and decisions proposed in future flood risk management plans.

## 2.2 Data Collection

2.2.1 The collection and collation of strategic level data was undertaken as part of the Drain London Tier 1 work and disseminated to Tier 2 consultants by the GLA. Data was collected from each of the following organisations:

- LB of Waltham Forest
- British Airports Authority
- British Geological Survey
- British Waterways
- Environment Agency
- Greater London Authority
- Highways Agency
- London Underground
- Network Rail
- Thames Water
- Transport for London

2.2.2 A comprehensive data set was provided to the Tier 2 consultants.

2.2.3 Table 2-1 provides a summary of the data sources held by partner organisations and provides a description of each dataset, and how the data was used in preparing the SWMP. This data was collated centrally by the Greater London Authority through the Drain London project, including centralising relevant data sharing agreements and licensing. This data was then disseminated to consultants Capita Symonds with Scott Wilson for the preparation of the LB of Waltham Forest SWMP.

**Table 2-1 Data Sources and Use**

| | Dataset | Description | Use in this SWMP |
|---|---|---|---|
| Environment Agency | Main River centre line | GIS dataset identifying the location of Main Rivers across London | To define waterway locations within the borough. |
| | Environment Agency Flood Map (Flood Zones) | Shows extent of flooding from rivers during a 1 in 100yr flood and 1 in 1000yr return period flood. Shows extent of flooding from the sea during 1 in 200yr and 1 in 1000yr flood events. Ignores the presence of defences. | To identify the fluvial and tidal flood risk within the borough and areas benefiting from fluvial and tidal defences. |
| | Areas Susceptible to Surface Water Flooding | A national outline of surface water flooding held by the EA and developed in response to Pitt Review recommendations. | To assist with the verification of the pluvial modelling |
| | Flood Map for Surface Water | A second generation of surface water flood mapping which was released at the end of 2010. | To assist with the verification of the pluvial modelling |
| | Groundwater Flooding Incidents | Records of historic incidents of groundwater flooding as recorded by the Environment Agency. | To identify recorded groundwater flood risk – assist with verifying groundwater flood risk |
| | National Receptors Dataset | A nationally consistent dataset of social, economic, environmental and cultural receptors including residential properties, schools, hospitals, transport infrastructure and electricity substations. | Utilised for property/infrastructure flood counts and to determine CDA's. |
| | Indicative Flood Risk Areas | National mapping highlighting key flood risk areas, based on the definition of 'significant' flood risk agreed with Defra and WAG. | Initial review to determine national view on flood risk areas within the borough. |
| | Historic Flood Outline | Attributed spatial flood extent data for flooding from all sources. | Used to assist with the verification of modelling results and CDA locations (where available) |
| | Rainfall Data | 15 minute and daily rainfall gauge records from approximately 1990 – 2010 for gauge sites across London. | Used in the initial stages of rainfall modelling to determine appropriate model durations and hyetographs. |
| | Source protection zones | Show zones around important groundwater sources which may be impacted by contamination that might cause pollution in the area. The maps show three main zones (inner, outer and total catchment). | Within the assessment of groundwater flooding to determine permeable geology |
| | Asset data | Details on the location and extent of flood defences across Group 4 as well as a system asset management plans. | To determine asset locations within the pluvial modelling process. |
| London Borough of Waltham Forest | Strategic Flood Risk Assessments (SFRA) | SFRAs may contain useful information on historic flooding, including local sources of flooding from surface water, groundwater and flooding from canals. | Provide a background to the flood risk in the borough. |
| | Historical flooding records | Historical records of flooding from surface water, groundwater and ordinary watercourses (in the form of insurance claims and call centre records). | Where available used to assist with the verification of modelling results and CDA locations. |

| | Dataset | Description | Use in this SWMP |
|---|---|---|---|
| | Anecdotal information relating to local flood history and flood risk areas | Anecdotal information from authority members regarding areas known to be susceptible to flooding from excessive surface water, groundwater or flooding from ordinary watercourses. | Assist with CDA confirmation but not necessarily used as verification evidence. |
| | Highways Flooding Reports | Highways Flooding Reports, including analysis of the flood risk at each location. | Verification of pluvial model results. |
| | Core Strategy Development Plans | Local Development Scheme, details on Area Action Plans and Place Shaping Priority Areas. | Understanding of areas of future development. |
| **Thames Water** | DG5 Register for Thames Water Utilities areas | DG5 Register logs and records of sewer flooding incidents in each area. | Mapping sewer flooding incidents. |
| | Sewer pipe network | GIS dataset providing the geo-referenced location of surface water, foul and combined sewers across Group 1. Includes pipe size and some information on invert levels. | Verifying CDA locations and Phase 3:Options Assessment |
| | Basements | GIS dataset showing Thames Water Utilities recording of basement locations. | Defining CDAs and utilised within the property count information |
| **British Waterways** | British Waterway's canal network | Detailed GIS information on the British Waterway's canal network, including the location of canal centrelines, sluices, locks, culverts, etc. | Centrelines have been incorporated within modelling to define canal locations |
| **British Geological Society** | Geological datasets | Licensed GIS datasets including:<br>Geological indicators of flooding;<br>Susceptibility to groundwater flooding;<br>Permeability;<br>Bedrock and superficial geology. | Understanding the geology of the borough |
| **GLA** | Deprived Areas | Index of Multiple Deprivation, ranking all London Ward's. | Used within the prioritisation matrix and for property counts |
| | Administrative boundaries | Greater London Borough boundaries | Providing study boundaries |
| | Ordnance Survey Mapping, MasterMap | Vector mapping of the London area | Utilised within the pluvial modelling to determine "roughness" within the borough |
| **London Fire Brigade** | Historic flooding records | London Fire Brigade call outs to incidents of flooding between January 2000 and December 2009. Does not specify the source of flooding. | Understanding of possible flood locations within the borough – records do not indicate what type of flooding occurred at each location. |

| | Dataset | Description | Use in this SWMP |
|---|---|---|---|
| London Underground and Network Rail | Historic flooding records | Recorded incidents of flooding to London Underground and National Rail infrastructure | Verification of pluvial modelling results and CDA designations |
| Transport for London | Pump Station Locations | Pdf mapping identifying the location of road underpass pump station owned and maintained by TfL. | Understanding which assets include pumping stations and to assist in the verification of pluvial outputs and the optioneering exercise |
| Infoterra | LiDAR topographical data | High resolution elevation data derived from airborne sources – at a 1m grid. A laser is used to measure the distance between the aircraft and ground and between the aircraft and the vegetation canopy or building tops. Typical (unfiltered) accuracy ranges are +/- 0.15m. | Filtered LiDAR was utilised within the creation of the pluvial models to define the ground surface of the catchment and to understand the general topography of the catchment and wider borough. |

## 2.3 Data Review

2.3.1 The most significant data gap across the LB of Waltham Forest relates to records of past ‘local’ flooding incidents. This is a common issue across the UK as record keeping of past floods has historically focussed on flooding from rivers or the sea. Records of past incidents of surface water, sewer, groundwater or ordinary watercourse flooding have been sporadic.

2.3.2 Thames Water have provided postcode linked data on records of sewer flooding, (known as the DG5 register) however more detailed data on the location and cause of sewer flooding is not currently available.

2.3.3 Some incidents have been digitised into GIS from postcodes entered into a spreadsheet provided by the LB of Waltham Forest, however there is very little information on the probability, hazard or consequence of flooding.

2.3.4 Similarly, the London Fire Brigade have recorded incidents of call outs related to flooding, however there is no information on the source of flooding (e.g. pipe bursts or rainfall), or probability, hazard or consequence of the flooding.

**Future Groundwater Flooding**

2.3.5 Groundwater flooding is dependent on local variations in topography, geology and soils. The causes of groundwater flooding are generally understood however it is difficult to predict the actual location, timing and extent of groundwater flooding without comprehensive datasets.

2.3.6 There is a lack of reliable measured datasets to undertake flood frequency analysis and even with datasets this analysis is complicated due to the non-independence of groundwater level data. Surface water flooding incidents are sometimes mistaken for groundwater flooding incidents, e.g. where runoff via infiltration seeps from an embankment, rather than locally high groundwater levels.

2.3.7 Drain London have commissioned specific groundwater emergence maps, known as increased Potential for Elevated Groundwater (iPEG) maps, to assist in determining the areas within Greater London that are possibly at risk of groundwater flooding.

**Future Surface Water Flooding**

2.3.8 The Environment Agency data sets ‘Areas Susceptible to Surface Water Flooding’ and second generation ‘Flood Map for Surface Water’ are national scale assessments suitable for broadly identifying surface water flood risk. The datasets are of a resolution suitable for assessments such as the PFRA, however are limited in their use in addressing the next stages of the Flood Risk Regulations (2009), e.g. Hazard Maps and in producing SWMPs and useful Action Plans The outputs from Drain London will assist in addressing this data limitation. These EA data sets were utilised in the model validation phase.

**Flooding Consequences**

2.3.9 The National Receptors Database (NRD), version 1.0 data set, was provided for all London Boroughs in December 2010. This data set was provided to allow property counts to be undertaken for all SWMPs. Version 1.1 of the NRD has subsequently been issued and contains modifications and corrections since version 1.0. However, in order to avoid repetition of work, and ensure consistency between the SWMP, PFRA and the EA Pluvial flooding (Areas Susceptible to Surface Water Flooding and Flood Map for Surface Water), it was decided to complete the SWMP using NRD version 1.0.

## 2.4 Security, Licensing and Use Restrictions

2.4.1 A number of datasets used in the preparation of this SWMP are subject to licensing agreements and use restrictions.

2.4.2 The following national datasets provided by the Environment Agency are available to lead local flood authorities for local decision making:

- EA Flood Zone Map;
- Areas Susceptible to Surface Water Flooding;
- Flood Map for Surface Water; and
- National Receptor Database.

2.4.3 A number of the data sources used are publicly available documents, such as:

- Strategic Flood Risk Assessment;
- Catchment Flood Management Plan;
- Preliminary Flood Risk Assessment; and
- Index of Multiple Deprivation.

2.4.4 The use of some of the datasets made available for this SWMP has been restricted. These include:

- Records of property flooding held by the Council and by Thames Water Utilities Ltd;

- British Geological Society geology datasets; and
- London Fire Brigade call outs for flooding.

2.4.5 Necessary precautions must be taken to ensure that all restricted information given to third parties is treated as confidential. The information must not be used for anything other than the purpose stated in the terms and conditions of use accompanying the data. No information may be copied, reproduced or reduced to writing, other than what is necessary for the purpose stated in the agreement.

## 2.5 LLFA Asset Register Requirements

2.5.1 As indicated in Section 2.5, the FWMA requires that the LLFA maintains an asset register which records information about structures and features that are likely to have a significant impact on flood risk within the LLFAs jurisdictional boundary.

2.5.2 As of the 6th April 2011, all LLFAs will need to maintain a register. Defra have determined the legal characteristics of the register and records, this is provided in Table 2-2:

**Table 2-2 Asset Register (source: Defra, 2011 Lead Local Flood Authority Duty to Maintain a Register)**

| | Register | Record |
|---|---|---|
| **a.** | Must be made available for inspection at all reasonable times. | Up to the LLFA to decide if they wish to make it available for inspection |
| **b.** | Must contain a list of structures or features which in the opinion of the authority, are likely to have a significant effect on a local flood risk. | For each structure or feature listed on the register, the record must contain information about its ownership and state of repair. |
| **c.** | s.21 (2) of the Act allows for further regulations to be made about the content of the register and record. There is currently no plan to provide such regulations therefore their content should be decided on by the LLFA depending on what information will be useful to them. | |
| **d.** | There is no legal requirement to have a separate register and record although as indicated above, only the register needs to be made available for public inspection. | |

2.5.3 A template and guidance documentation was provided to the LLFAs in March 2011. Although these templates were not designed to be a working tool, they do demonstrate what information could be contained within the register and how it could be structured.

2.5.4 The creation of the asset register was not within the scope of the Drain London project and is the responsibility of the LLFA. It is recommended that the LLFAs utilise a risk-based approach when creating the asset register, and begin recording structures or features which are considered the have the greatest influence on flooding first.

2.5.5 It is important to note that the register will be a "live" document, and is expected to be updated over time as more structures and features are identified and added.

## 2.6 Review of Asset Management Systems

2.6.1 Criteria to assess the existing asset management system of all London Boroughs was developed as part of the Drain London Tier 2 exercise to ensure consistency over the Greater London study area. This criteria is listed below:

- Level 1 – The borough knows where their assets are, what they look like and what condition they are in. Register system may take the form of a spreadsheet or hard copy records.

- Level 2 – The borough is aware of the 'Local Authority Flood Risk Asset Tool' currently being produced by the EA / Defra. Their register is GIS based (basic proprietary system only) or uses a highways based asset management system database. Their register captures information generally aligned with guidance provide by the Tool and the EA NFCDD system where practical. They know where their assets are and carry out reactive maintenance of significant structures as required.

- Level 3 – The borough has a detailed understanding of Asset Registers as required by the Flood and Water Management Act. Their register system accurately replicates the 'Local Authority Flood Risk Asset Tool' data standards and related NFCDD structures to an attribute level. Their register is GIS based (advanced proprietary or bespoke system) or is completely integrated with an existing asset management system. They know where their assets are and carry out periodic maintenance on the structures using a risk based priority system.

2.6.2 LB Waltham Forest provided some asset information as part of the Drain London Tier 1 'data collection' exercise and based on the current review of the asset register appears to be Level 1. Table 2-3 provides a summary of the actions required to meet the full level 3 status as defined above.

**Table 2-3 LLFA Asset Register Recommendations**

| Data | Format | Recommendations |
|---|---|---|
| Highway flooding and drainage records – including location and serviceability of road gullies. | GIS | Compile:<br>• GIS layer of Highway flooding<br>• GIS Layers of drainage network flooding.<br>• GIS layer of gullies with serviceability state |
| Drainage network information – sewers (surface, foul, combined), culverts, drains (surface water, highway), gullies, ditches, other open drainage channels | GIS | Compile GIS layers of:<br>• Sewers (surface, foul, combined)<br>• Culverts from PDFs<br>• Drains (surface water, highway)<br>• Gullies<br>• Ditches<br>• Other open drainage channels |
| Local Authority led flood risk improvement schemes | Database | Keep a live document which records all such scheme details and contact details. |
| SuDS schemes information (Council adopted SuDS) | Database | Going forward keep a live document which records all such scheme details and contact details. |
| Balancing pond and lake information | Database and GIS | Keep a live document which records all such scheme details along with a GIS layer detailing asset and location information. |
| Critical local asset records (assets which are known to, or have the potential to flood) | GIS | Compile:<br>• GIS layer of Critical local asset records |
| Historic sewer records (if any) | GIS | Inquire if any records are available from Thames Water etc. |

| | | |
|---|---|---|
| | | If available as drawings/photos compile GIS layer of historic sewer records available. |
| Historic construction records of drainage assets | GIS | Locate and create GIS layer of plans and drawings relating to foul and surface water drainage |
| Capacity and condition of 'ordinary' watercourses essential to operation of the urban drainage systems, including culverted watercourses and flow models (where they exist). | GIS | Compile GIS layer of capacity and condition of 'ordinary' watercourses. |
| New development drainage studies and supporting information | Database | Start collecting new development drainage studies and supporting information. |
| Road gulley cleaning/maintenance records | Database | Create record |
| Maintenance regimes and records of all assets | Database | Create record |

2.6.3 Appendix B of this report contains further information on the Asset Register recommendations for the LB of Waltham Forest.

# 3 Phase 2: Risk Assessment

## 3.1 Intermediate Assessment

**Aims**

3.1.1 The aim of the Phase 2 Intermediate Risk Assessment is to *identify the sources and mechanisms of surface water flooding across the study area* which will be achieved through an intermediate assessment of pluvial flooding, sewer flooding, groundwater flooding and flooding from ordinary watercourses along with the interactions with main rivers and the sea. The modelling outputs will then be mapped using GIS software.

3.1.2 SWMPs can function at different geographical scales and therefore necessarily at differing scales of detail. Table 3-1 defines the potential levels of assessment within a SWMP. This SWMP has been prepared at the 'borough' scale and fulfils the objectives of a second level 'Intermediate Assessment'.

**Table 3-1: SWMP Study Levels of Assessment [Defra 2010]**

| Level of Assessment | Appropriate Scale | Outputs |
|---|---|---|
| 1. Strategic Assessment | Greater London | Broad understanding of locations that are more vulnerable to surface water flooding.<br>Prioritised list for further assessment.<br>Outline maps to inform spatial and emergency planning. |
| 2. Intermediate Assessment | Borough wide | Identify flood hotspots which might require further analysis through detailed assessment.<br>Identify immediate mitigation measures which can be implemented.<br>Inform spatial and emergency planning. |
| 3. Detailed Assessment | Known flooding hotspots | Detailed assessment of cause and consequences of flooding.<br>Use to understand the mechanisms and test mitigation measures, through modelling of surface and sub-surface drainage systems. |

3.1.3 As shown in Table 3-1 above, the intermediate assessment is applicable across a large town, city or borough. In the light of extensive and severe historical flooding and the results from the over-arching national pluvial modelling suggesting that there are 32,400 properties at risk across the borough during a 1 in 200 year return period rainfall event, it is appropriate to adopt this level of assessment to further quantify the risks.

3.1.4 The purpose of this intermediate assessment will be to further identify those parts of the borough that are likely to be at greater risk of surface water flooding and require more detailed assessment. The methodology used for this SWMP is summarised below. Further detail of the methodology is provided in Appendix C.

- A Direct Rainfall modelling approach using TuFLOW software has been selected whereby rainfall events of known probability are applied directly to the ground surface and water is routed by the model over a representation of the ground surface to provide an indication of potential flow path directions and velocities and areas where surface water may pond.

- The direct rainfall modelling has been supported by hydraulic field visits and has been undertaken in conjunction with the LB of Waltham Forest staff and/or EA staff.
- The outputs from the pluvial modelling have been verified (where possible) against historic surface water flood records.

## 3.2 Risk Overview

3.2.1 The following sources of flooding have been assessed and are discussed in detail in the following sections of this report:

- Pluvial flooding: runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or a watercourse. Figures 13 to 22 in Appendix D present mapped results of the surface water modelling;
- Sewer flooding; flooding which occurs when the capacity of the underground drainage system is exceeded, resulting in flooding inside and outside of buildings. Normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters as a result of wet weather or tidal conditions;
- Flooding from ordinary watercourses: flooding which occurs as a result of the capacity of the watercourse being exceeded resulting in out of bank flow (water coming back out of rivers and streams); and
- Flooding from groundwater sources: occurs when the water level within the groundwater aquifer rises to the surface.

3.2.2 The identification of areas at risk of flooding has been dominated by the assessment of surface water and ordinary watercourse flooding as these sources are expected to result in the greater consequence (risk to life and damage to property), as well as the quality of the information available for informing the assessment.

**Mapping Limitations**

3.2.3 The mapping shown within this report is suitable to identify broad areas which are more likely to be vulnerable to surface water flooding. This allows the LB of Waltham Forest and its partners to undertake more detailed analysis in areas which are most vulnerable to surface water flooding.

3.2.4 In addition, the maps can also be used as an evidence base to support spatial planning. This will ensure that surface water flooding is appropriately considered when allocating land for future development. The maps can be used to assist emergency planners in preparing their Multi-Agency response plans.

3.2.5 Please note that these maps only show the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall in urban areas) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses. Individual properties therefore may not always face the same chance of flooding as the areas that surround them.

3.2.6 There may also be particular occasions when flooding occurs and the observed pattern of flooding does not in reality match the predicted patterns shown on these maps. We have done all we can to ensure that the maps reflect all the data available to us and have applied our expert knowledge to create conclusions that are as reliable as possible. It is essential that anyone using these maps fully understands the complexity of the data utilised in production of the maps, is aware of the limitations and does not use the maps in isolation.

3.2.7 We will not be liable if the maps by their nature are not as accurate as might be desired or are misused or misunderstood despite our warnings. For this reason we are not able to promise that the maps will always be completely accurate or up to date. We are also not liable for any future flooding that is not highlighted in this report.

## 3.3 Surface Water Flooding

**Description**

3.3.1 Surface water flooding is the term used to describe flooding which occurs when intense, often short duration rainfall is unable to soak into the ground or to enter drainage systems and therefore runs over the land surface causing flooding. It is most likely to occur when soils are saturated so that they cannot infiltrate any additional water or in urban areas where buildings tarmac and concrete prevent water soaking into the ground. The excess water can pond (collect) in low points and result in the development of flow pathways often along roads but also through built up areas and open spaces. This type of flooding is usually short lived and associated with heavy downpours of rain.

3.3.2 The potential volume of surface runoff in catchments is directly related to the size and shape of the catchment to that point. The amount of runoff is also a function of geology, slope, climate, rainfall, saturation, soil type, urbanisation and vegetation.

**Causes and classifications**

3.3.3 Surface water flooding can occur in rural and urban areas, but usually causes more damage and disruption in the latter. Flood pathways include the land and water features over which floodwater flows. These pathways can include drainage channels, rail and road cuttings. Developments that include significant impermeable surfaces, such as roads and car parks may increase the volume and rate of surface water runoff.

3.3.4 Urban areas which are close to artificial drainage systems, or located at the bottom of hill slopes, in valley bottoms and hollows, may be more prone to surface water flooding. This may especially be the case in areas that are down slope of land that has a high runoff potential including impermeable areas and compacted ground.

**Impacts of surface water flooding**

3.3.5 Surface water flooding can affect all forms of the built environment, including:

- Residential, commercial and industrial properties;
- Infrastructure, such as roads and railways, telecommunication systems and sewer systems;

It can also impact on:

- Agriculture; and
- Amenity and recreation facilities.

3.3.6 Flooding from land is usually short-lived and may only last as long as the rainfall event. However occasionally flooding may persist in low-lying areas where ponding occurs. Due to the typically short duration, flooding from land tends not to have as serious consequences as other forms of flooding, such as flooding from rivers or the sea however it can still cause significant damage and disruption on a local scale.

**Historic Records – Surface Water Flooding**

3.3.7 Past records of surface water flooding within Waltham Forest have been gathered from sources such as the Environment Agency, London Underground as well as the LB of Waltham Forest. These incidents have been mapped as part of the SWMP and are presented in figure 5 in Appendix D. Table 3-2 provides a summary of the previous records of flooding attributed to surface water in the LB of Waltham Forest.

**Table 3-2: Records of Surface Water Flooding**

| Date | Location | Recorded Impacts |
|---|---|---|
| 29/05/2007 | Sanderstead Road, Leyton E10 7PW | The pavement opposite no. 5 and 7 was flooded during heavy rain. |
| 20/07/2007 | Hale End Road, Hale End E4 9PB | Approximately 8 inches of ponding water was observed along the garden path. |
| 11/01/2008 | Chingford Avenue, Chingford E4 6RP | Gully observed to be flooded along Chingford Avenue, opposite Ingrebourne Court. |
| 21/01/2008 | Marshall Road, Leyton E10 5NH | Flooding observed by the entrance to Asda on Marshall Road. |
| 27/02/2008 | Forest Road, Walthamstow E17 6JQ | Flooding occurred across the whole of the westbound bus lane on Forest Road, in the dip beyond Blackhorse Road Station. |
| 29/04/2008 | Lea Bridge Road, Leyton E10 7LD | Due to the angling in the road, flood water ponded opposite the crossing on Lea Bridge Road (270) as well as opposite the bus stop and the Hare and Hounds pub and the E10 night club. |
| 25/06/2008 | Maud Road, Leyton E10 5QG | Alexandra Road and York Road into Ruckholt Road flooded and regularly does when it rains. |
| 12/08/2008 | Old Church Road, Chingford E4 6SE | Deep flooding occurred at the junction of Chingford Avenue and Old Church Road. |
| 05/09/2008 | Hall Lane, South Chingford E4 8PT | North circular underpass at Hall Lane flooded. |
| 19/01/2009 | Warwick Road, Higham Hill E17 5NP | Warwick Road flooded |
| 10/02/2009 | Holly Road, Wanstead E11 2PF | Holly Road subway underneath the Greenman roundabout experienced heavy flooding and is observed to flood regularly. |
| 15/06/2009 | Farnley Road, Chingford Green E4 7AD | Serious flooding into the property through the front door |
| 15/06/2009 | Frankland Road, South Chingford E4 8JY | Flood waters observed to rise up through the floorboards. |
| 20/07/2009 | Raglan Road, Walthamstow E17 9HX | The junction of Raglan Road, Shernhall Street and Eastern Road observed to flood during rainfall affecting all the residencies and businesses in the area. |

| Date | Location | Recorded Impacts |
|---|---|---|
| 12/08/2009 | Whipps Cross Road, Leytonstone E11 1NL | Underpass at Whipps Cross Road entering Tesco flooded. |
| 23/11/2009 | Heathcote Grove, Chingford E4 6SB | No. 77 and neighbours on Heathcote Grove had flooded front gardens and water coming into the airbricks and garage. |
| 03/12/2009 | Lea Valley Viaduct/Southend Road, South Chingford A406 | Reported at least 20 inches of water ponded in the underpass at Hall Lane and Southend Road (A406). |
| 22/02/2010 | Hitcham Road, Leyton E17 8HL | Flooding on Hitcham Road near Emmanuel Forest Church. |

**Methodology for Surface Water Flooding**

3.3.8 As part of the SWMP process hydraulic modelling has been undertaken. Several 2-dimensional direct rainfall models were created, using the TUFLOW software, to determine the causes and consequences of surface water flooding within the LB of Waltham Forest. The results of the models provide an indication of key flowpaths, velocities and areas where water is likely to pond.

3.3.9 As the extents of the models have been based upon catchment boundaries, and not borough boundaries, several models were required to cover the area occupied by the LB of Waltham Forest. This was carried out to appropriately represent cross-boundary interaction and allow for Drain London Tier 2 consultants to undertake a collaborative modelling approach. Figure 3-1 below indicates the extent of the models utilised within the assessment of the LB of Waltham Forest.

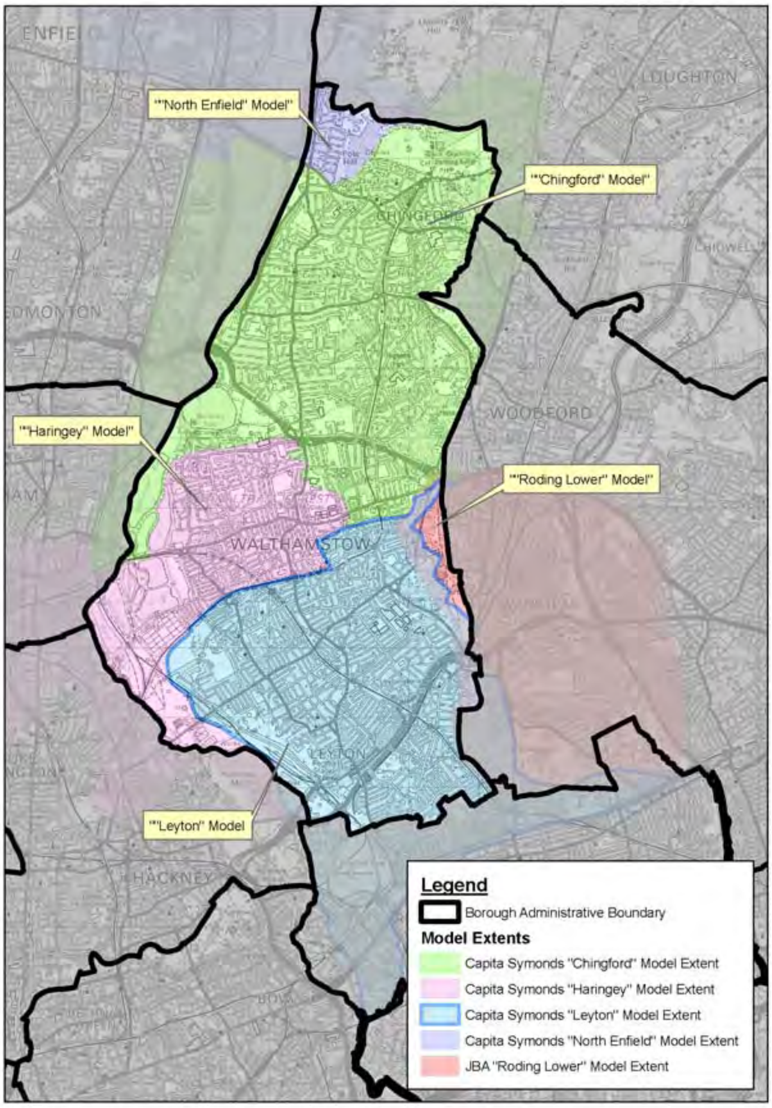



**Figure 3-1: Model coverage for the London Borough of Waltham Forest**

3.3.10 The hydraulic models were run for the following return periods:

- 1 in 30 year event;
- 1 in 75 year event;
- 1 in 100 year event;
- 1 in 100 year event with allowance for climate change (30% increase in rainfall); and
- 1 in 200 year event

3.3.11 As part of this study, maps of maximum water depth and hazard for each of the return periods above have been prepared and are presented in Appendix D of this report. When viewing the maps, it is important that the limitations of the modelling are considered. The key assumptions include the use of a continuous loss (6.5mm/hr) to represent the presence of the underground drainage network. The model does not take into account any capacity issues associated with the drainage network such as surcharging of manholes leading to backing up of surface water, blocked outfalls etc. Refer to Appendix C for a more detailed discussion on the hydraulic modelling methodology.

3.3.12 Figures 13 to 17 in Appendix D indicates that water is predicted to pond over a number of roads, railways and residential properties. These generally occur at low points in the topography or where water is constricted behind an obstruction or embankment. An example of this flooding mechanism within the borough is within the sports grounds in Highams Park where water is observed to back up behind the North Circular (A406).

3.3.13 Overland flowpaths have been observed to follow natural valleys within the borough such as one that begins in Walthamstow flowing in a southerly direction and ending in Leyton, adjacent to the Orient football ground. In the north of the borough, flowpaths are observed to the north of Highams Park. The flow routes begin near Larks Wood and flow in a westerly direction, cumulating in ponding water at Cabinet Way.

3.3.14 Railway lines with 'cuttings' may also be particularly susceptible, such as the stretch of track between Walthamstow Central and Wood Street stations.

3.3.15 Some of the records of surface water flooding in the LB of Waltham Forest (Figure 5) have been used to verify the modelling results. Discussions with Council staff at Waltham Forest have also provided anecdotal support for several of the locations identified as being susceptible.

3.3.16 The results of the assessment have been used to identify 'Local Flood Risk Zones' (LFRZs) and 'Critical Drainage Areas' (CDAs) across the LB of Waltham Forest. These critical CDAs are identified in Figure 23 of Appendix D. Section 3.8 provides a short summary of the risk of flooding within each CDA.

**Uncertainty in flood risk assessment – Surface Water Modelling**

3.3.17 The surface water modelling provides the most detailed information to date on the mechanisms, extent and hazard which may result from high intensity rainfall across the LB of Waltham Forest. However, due to the strategic nature of this study and the limitations of some data sets, there are limitations and uncertainties in the assessment approach that the reader should be aware of.

3.3.18 There is a lack of reliable measured datasets and the estimation of the return period (probability) for flood events is therefore difficult to verify. The broad scale mapping provides an initial guide to areas that may be at risk, however there are a number of limitations to using the information:

- The mapping does not include underground sewerage and drainage systems;
- The mapping should not be used in a scale to identify individual properties at risk of surface water flooding. It can be used as a general indication of areas potentially at risk.
- Whilst modelled rainfall inputs has been modified to reflect the possible impacts of climate change it should be acknowledged that this type of flooding scenario is uncertain and likely to be very site specific. More intense short duration rainfall and higher more prolonged winter rainfall are likely to exacerbate flooding in the future.

## 3.4 Ordinary Watercourse Flooding

**Description**

3.4.1 All watercourses in England and Wales are classified as either 'Main Rivers' or 'Ordinary Watercourses'. The difference between the two classifications is based largely on the perceived importance of a watercourse, ad in particular it's potential to cause significant and widespread flooding. However this is not to say watercourses classified as Ordinary Watercourses cannot cause localised flooding. The Water Resources Act (1991) defines a 'Main River' as "a watercourse shown as such on a Main River Map". The Environment Agency keep and maintain information on the spatial extent of the Main River designations. The Floods and Water Management Act (2010) defines any watercourse that is not a Main River an Ordinary Watercourse – including ditches, dykes, rivers, streams and drains (but not public sewers).

3.4.2 The Environment Agency have duties and powers in relation to Main Rivers. Local Authorities, or in some cases Internal Drainage Boards, have powers and duties in relation to Ordinary Watercourses.

3.4.3 Flooding from Ordinary Watercourses occurs when water levels in the stream or river channel rise beyond the capacity of the channel, causing floodwater to spill over the banks of the watercourse and into the adjacent land. The main reasons for water levels rising in ordinary watercourses are:

- Intense or prolonged rainfall causing flow to increase in watercourses, exceeding the capacity of the channel. This can be exacerbated by wet antecedent (the preceding time period) conditions and where there are significant contributions of groundwater;
- Constrictions/obstructions within the channel causing flood water to backup;
- Blockage/obstructions of structures causing flood water to backup and overtop the banks; and
- High water levels preventing discharge at the outlet of the ordinary watercourse (often into a Main River).

3.4.4 Table 3.3, overleaf, summaries the watercourses present in the borough and the classification.

**Table 3-3: Watercourses in the London Borough of Waltham Forest**

| Watercourse | Classification | Responsibility under the FWMA |
|---|---|---|
| The Ching Brook | Main River | EA |
| River Lee | Main River | |
| River Lee Flood Relief Channel | Main River | |
| Dagenham Brook | Main River | |
| Coopermill Stream | Ordinary Watercourse | LB Waltham Forest |
| Numerous unnamed ditches | Ordinary Watercourse | |

**Impacts of Flooding from Ordinary Watercourse**

3.4.5 The consequence of ordinary watercourse flooding is dependent upon the degree of hazard generated by the flood water (as specified within the Defra/Environment Agency research on Flood Risks to People - FD2321/TR2) and what the receptor is (e.g. the consequence of a hospital flooding is greater than that of a commercial retailer). The hazard posed by flood water is related to the depth and velocity of water, which, in Ordinary Watercourses, depends on:

- Constrictions in the channel causing flood water to backup;
- The magnitude of flood flows;
- The size, shape and slope of the channel;
- The width and roughness of the adjacent floodplain; and
- The types of structures that span the channel.

3.4.6 The hazard posed by floodwater is proportional to the depth of water, the velocity of flow and the speed of onset of flooding. Hazardous flows can pose a significant risk to exposed people, property and infrastructure.

3.4.7 Whilst low hazard flows are less of a risk to life (shallow, slow moving/still water), they can disrupt communities, require significant post-flood clean-up and can cause costly and possibly permanent structural damage to property.

**Historic Records – Ordinary Watercourse Flooding**

3.4.8 There were no historical records of flooding from ordinary watercourses available from the LB of Waltham Forest. This is not to say that no such incidents have occurred or that there is no future flood risk to the borough from ordinary watercourses.

**Methodology for Assessing Ordinary Watercourses**

3.4.9 Ordinary watercourses have been included in the surface water flood modelling. Watercourses have been defined by digitising breaklines along the centre line of each watercourse. Elevations of watercourses have been determined from LiDAR to represent a “bank full” scenario.

3.4.10 Structures along the watercourse have been modelled as either 1D or 2D elements, depending on the length and location of the structure. The dimensions of structures have been determined from asset information obtained in the data collection stage where available or inferred from site visits or LiDAR data.

3.4.11 The assessment of flood risk from ordinary watercourses in Waltham Forest has been based on outputs from the Drain London surface water modelling described in Appendix C and presented in Figures 13 to 17 in Appendix D. The figures indicate that the LB of Waltham Forest is at a low risk of flooding from ordinary watercourses with little to no standing water observed in the floodplain. This is found to be consistent with the Environment Agency Flood Zone Maps (figure 6) and increases confidence in the outputs of the surface water model.

3.4.12 Please note that the risk of flooding from fluvial and tidal sources are covered within the North London SFRA (August, 2008).

**Uncertainties and Limitations – Ordinary Watercourse Modelling**

3.4.13 As with any hydraulic model, these models have been based on a number of assumptions which may introduce uncertainties into the assessment of risk. The assumptions within the models should be noted and understood such that informed decisions can be made when using model results.

3.4.14 In relation to ordinary watercourses, the limits of the modelling include (but are not limited to):

- Modelling of structures has not been based on detailed survey data;
- The watercourses are assumed to be bank full at the start of the rainfall event, hence river flows and channel capacities have not been taken into account; and
- Only one storm duration was considered for this study.

3.4.15 Taking these uncertainties and constraints into consideration, the estimation of risk of flooding from rivers presented in this report is considered robust for the level of assessment required in the SWMP.

## 3.5 Groundwater Flooding

**Description**

3.5.1 Groundwater flooding is caused by the emergence of water originating from sub-surface permeable strata. In short groundwater flooding is water which emerges from the ground from either a specific point (such as a spring) or over a wide diffuse location. A groundwater flood event results from a rise in groundwater level sufficient for the water table to intersect the ground surface and inundate low lying land. Groundwater floods tend to be long in duration developing over weeks or months and prevailing for days or weeks.

3.5.2 There are many mechanisms associated with groundwater flooding, which are linked to high groundwater levels, and can be broadly classified as:

- Direct contribution to channel flow.
- Springs erupting at the surface.
- Inundation of drainage infrastructure.
- Inundation of low-lying property (basements).

**Impacts of Groundwater Flooding**

3.5.3 The main impacts of groundwater flooding are:

- Flooding of basements of buildings below ground level – in the mildest case this may involve seepage of small volumes of water through walls, temporary loss of services etc. In more extreme cases larger volumes may lead to the catastrophic loss of stored items and failure of structural integrity;
- Overflowing of sewers and drains – surcharging of drainage networks can lead to overland flows causing significant but localised damage to property. Sewer surcharging can lead to inundation of property by polluted water. Note: it is complex to separate this flooding from other sources, notably surface water or sewer flooding;
- Flooding of buried services or other assets below ground level – prolonged inundation of buried services can lead to interruption and disruption of supply;
- Inundation of roads, commercial, residential and amenity areas – inundation of grassed areas can be inconvenient, however the inundation of hard-standing areas can lead to

structural damage and the disruption of commercial activity. Inundation of agricultural land for long durations can have financial consequences; and

- Flooding of ground floors of buildings above ground level – can be disruptive, and may result in structural damage. The long duration of flooding can outweigh the lead time which would otherwise reduce the overall level of damages.

3.5.4 In general terms groundwater flooding rarely poses a risk to life.

**Historical Records**

3.5.5 Table 3-4 provides a summary of the previous records of flooding attributed to groundwater in the LB of Waltham Forest. Figure 10 in Appendix D shows the geographical locations on these incidents within the borough.

**Table 3-4: Records of Groundwater Flooding**

| Date | Location | Recorded Impacts |
|---|---|---|
| 02/02/2001 | TQ38988743 | Standing Water |
| 11/06/2002 | TQ38729289 | Standing Water |
| 30/09/2002 | TQ38168848 | Standing Water |
| 06/11/2002 | TQ36918931 | Standing Water |
| 12/11/2002 | TQ39228708 | Standing Water |
| 11/09/2003 | TQ38399410 | Seepage |
| 30/01/2004 | TQ37698702 | Standing Water |
| 09/03/2004 | TQ39118769 | Standing Water |
| 29/03/2004 | TQ38038853 | Standing Water |
| 14/05/2004 | TQ38018901 | Seepage |
| 25/10/2004 | TQ36989344 | Standing Water |
| 29/11/2004 | TQ37618949 | Standing Water |
| 15/01/2005 | TQ38769206 | Waterlogged |
| 09/02/2005 | TQ38928702 | Standing Water |
| 17/06/2005 | TQ38939037 | Seepage |
| 20/09/2005 | TQ39098713 | Standing Water |
| 10/04/2006 | TQ36208891 | Standing Water |
| 02/06/2006 | TQ38919201 | Standing Water |
| 13/10/2006 | TQ38428824 | Standing Water |
| 20/02/2007 | TQ36968928 | Standing Water |
| 17/04/2007 | TQ38979249 | Standing Water |
| 07/11/2007 | TQ37338884 | Standing Water |
| 23/11/2007 | TQ36918970 | Flowing Water |
| 06/05/2008 | TQ38338837 | Standing Water |
| 24/06/2008 | TQ36498908 | Standing Water |
| 30/09/2008 | TQ39098731 | Flowing Water |
| 11/02/2009 | TQ38799065 | Flowing Water |

**Methodology used for Groundwater Mapping**

3.5.6 As part of the Drain London project Drain London Tier 1 consultants commissioned a dataset referred to as the Increased Potential Elevated Groundwater (iPEG) maps. The iPEG mapping assists in identifying areas which have an increased potential to experience groundwater flooding. The iPEG map shows those areas within the borough where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2 m of the ground surface. The assessment was carried out at a Greater London scale.

3.5.7 The four data sources listed below have been utilised to produce the 'increased Potential for Elevated Groundwater' (iPEG) map:

- British Geological Survey (BGS) Groundwater Flood Susceptibility Map;
- Jacobs Groundwater Emergence Maps (GEMs);
- Jeremy Benn Associates (JBA) Groundwater Flood Map; and
- Environment Agency/Jacobs Thames Estuary 2100 (TE2100) groundwater hazard maps.

3.5.8 More information on the production of the iPEG map is discussed in Appendix C.

3.5.9 The iPEG mapping is presented in Figure 10 of Appendix D together with historic records of flooding which have been identified as related to groundwater. The mapping shows an increased potential for ground water to rise most noticeably in the south of the borough – south-east of Walthamstow and in parts of Leyton. Past records of flood incidents attributed to groundwater are located throughout the borough, with a concentration of incidents occurring in the south. These incidents are located in the vicinity of the areas identified as having an increased potential however generally do not overlap.

3.5.10 The discrepancy between recorded historic incidents and potential areas of future incidents may be attributed to the following:

- Past incidents may be a result of localised flooding mechanisms (or other flooding mechanisms) which have not been assessed as part of the production of the iPEG mapping.
- The iPEG mapping does not represent local geological features and artificial influences (e.g. structures or conduits) which have the potential to heavily influence the local rise of groundwater.
- The iPEG map only shows areas that have the greatest potential for elevated groundwater and does not necessarily include all areas that are underlain with permeable geology.
- The flood source attributed to some past incidents may not be accurate.

**Uncertainties and Limitations – Groundwater Flooding**

3.5.11 Not all areas underlain by permeable geology are shown on the iPEG maps. Only where there is the highest degree of confidence in the assessment are the areas delineated as areas where groundwater may be an issue. This ensures resources are focused on the most susceptible areas. In all areas underlain by permeable substrate, groundwater should still be considered in planning developments.

3.5.12 Within the areas delineated, the local rise of groundwater will be heavily controlled by local geological features and artificial influences (e.g. structures or conduits) which cannot currently be represented. This localised nature of groundwater flooding compared with, say, fluvial flooding suggests that interpretation of the map should similarly be different. The map shows the area within which groundwater has the potential to emerge but it is unlikely to emerge uniformly or in sufficient volume to fill the topography to the implied level. Instead, groundwater emerging at the surface may simply runoff to pond in lower areas.

3.5.13 For this reason within iPEG areas, locations shown to be at risk of surface water flooding are also likely to be most at risk of runoff/ponding caused by groundwater flooding. Therefore the iPEG map should not be used as a “flood outline” within which properties at risk can be counted. Rather it is provided, in conjunction with the surface water mapping, to identify those areas where groundwater may emerge and if so what would be the major flow pathways that water would take.

3.5.14 It should be noted that this assessment is broad scale and does not provided a detailed analysis of groundwater, it only aims to provide an indication of where more detailed consideration of the risks may be required.

3.5.15 The causes of groundwater flooding are generally understood. However groundwater flooding is dependent on local variations in topography, geology and soils. It is difficult to predict the actual location, timing and extent of groundwater flooding without comprehensive datasets.

3.5.16 There is a lack of reliable measured datasets to undertake flood frequency analysis on groundwater flooding and even with datasets this analysis is complicated due to the non-independence of groundwater level data. Studies therefore tend to analyse historic flooding which means that it is difficult to assign a level of certainty.

3.5.17 The impact of climate change on groundwater levels is highly uncertain. More winter rainfall may increase the frequency of groundwater flooding incidents, but drier summers and lower recharge of aquifers may counteract this effect.

## 3.6 Sewers

**Description**

3.6.1 Flooding from foul and combined sewers occurs when rainfall exceeds the capacity of networks or when there is an infrastructure failure. In the LB of Waltham Forest the sewer network is a largely separated foul and surface water system.

**Causes of sewer flooding**

3.6.2 The main causes of sewer flooding are:

- Lack of capacity in the sewer drainage networks due to original under-design;
- Lack of capacity in sewer drainage networks due to an increase in flow (such as climate change and/or new developments connecting to the network);
- Exceeded capacity in sewer drainage networks due to events larger than the system designed event;
- Loss of capacity in sewer drainage networks when a watercourse has been fully culverted and diverted or incorporated into the formal drainage network (lost watercourses);
- Lack of maintenance or failure of sewer networks which leads to a reduction in capacity and can sometimes lead to total sewer blockage;
- Failure of sewerage infrastructure such as pump stations or flap valves leading to surface water or combined foul/surface water flooding;

- Groundwater infiltration into poorly maintained or damaged pipe networks; and
- Restricted outflow from the sewer systems due to high water or tide levels in receiving watercourses ('tide locking').

**Impacts of Sewer Flooding**

3.6.3 The impact of sewer flooding is usually confined to relatively small localised areas but flooding is associated with blockage or failure of the sewer network, flooding can be rapid and unpredictable. Flood waters from this source are also often contaminated with raw sewage and pose a health risk. The spreading of illness and disease can be a concern to the local population if this form of flooding occurs on a regular basis.

3.6.4 Drainage systems often rely on gravity assisted dendritic systems, which convey water in trunk sewers located at the lower end of the catchment. Failure of these trunk sewers can have serious consequences, which are often exacerbated by topography, as water from surcharged manholes will flow into low-lying urban areas.

3.6.5 The diversion of "natural" watercourses into culverted or piped structures is a historic feature of the London drainage network. Where it has occurred, deliberately or accidentally it can result in a reduced available capacity in the network during rainfall events when the sewers drain the watercourses catchment as well as the formal network. Excess water from these watercourses may flow along unexpected routes at the surface (usually dry and often developed) as its original channel is no longer present and the formal drainage system cannot absorb it.

**Historic Records – Sewer Flooding**

3.6.6 Table 3-5 provides a summary of the historic records of flooding attributed to the sewerage network in the LB of Waltham Forest.

**Table 3-5: Records of Sewer Flooding**

| Date | Location | Recorded Impacts |
|---|---|---|
| 24/05/2008 | Waltham Forest Town Hall, Forest Road | Wastewater flooded basement |
| 29/11/2007 | Wilowfield School, Clifton Avenue, Walthamstow | Flooding following blocked drain |
| 10/03/2009 | Boundary Road, Walthamstow E17 8NE | Blocked gully reported opposite property, causing rain to flow into front garden |
| 13/03/2009 | Marshall Road, Leyton E10 5NH | Gully in the underpass in Marshall Road, underneath Ruckholt Road caused flooding in the approach road to Leyton Mills Retail Park |
| 11/05/2009 | Blackhorse Lane, Higham Hill E17 6DJ | Blocked gully opposite 113 Blackhorse Lane causing flooding |
| 15/06/2009 | Chingford Avenue, Chingford E4 6RP | Blocked drains |
| 15/06/2009 | 28-30 Larkswood Road, Chingford E4 9DT | Overflowing manhole in main drain in alleway between properties |
| 16/11/2009 | Green Man Roundabout, Leytonstone E11 2PF | Pedestrian underpass at Green Man Roundabout was flooded and impassable for a couple of days. Ponding is approximately 1.5ft nearest Whipps Cross Road exit |

| Date | Location | Recorded Impacts |
|---|---|---|
| 25/11/2009 | Manor Way, Chingford E4 6NW | 1ft of water in the road. Outside no. 13, 22 and 35 |

3.6.7 The risk of flooding from sewers is increasing due to the increasing urbanisation of areas and rising rainfall intensities. Several recent flood events across the country have been attributed to the inability of the drainage network to contain runoff during severe storm events and the occurrence of events which exceed the design capacity of the drainage network may be increasing.

3.6.8 The data provided by Thames Water for use in this SWMP shows postcodes where properties are known to have experienced sewer flooding prior to June 2010. Figure 9 in Appendix D displays this data along with other known records of sewer flooding. The data provides a broad overview of flood incidents in the borough as it is not property specific, instead providing information in postcode sectors (a four digit postcode). As some of these sectors extend into other London Boroughs, it is not possible to determine the exact number of properties that have experienced a sewer flooding incident. The Thames Water dataset is summarised for the LB of Waltham Forest in Table 3-6.

3.6.9 The majority of the incidents of sewer flooding are clustered in the south of the borough in Upper Walthamstow - post code area E17 9. High incidents of sewer flooding are also observed in Leytonstone, and in the north of the borough, south of Chingford – post code areas E10 6, E11 1, E11 4, E4 8 and E4 9.

3.6.10 The large number of incidents recorded near Chingford could be a result of “locking” of surface water sewer outfalls as these areas appear to outfall to the River Lee. Around Walthamstow and Leytonstone, the high number of incidents may be a result of an undersized, ageing or poorly functioning surface water system.

**Table 3-6: Number of Thames Water sewer flood records within the London Borough of Waltham Forest**

| Post Code Sector | 2 in 10 external | 2 in 10 internal | 1 in 10 external | 1 in 10 internal | 1 in 20 external | 1 in 20 internal | Severe | Total Properties |
|---|---|---|---|---|---|---|---|---|
| E10 5 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 3 |
| E10 6 | 0 | 2 | 3 | 3 | 0 | 7 | 4 | 19 |
| E10 7 | 0 | 0 | 2 | 1 | 2 | 1 | 0 | 6 |
| E11 1 | 0 | 0 | 3 | 1 | 1 | 13 | 1 | 19 |
| E11 3 | 0 | 3 | 1 | 4 | 0 | 4 | 0 | 12 |
| E11 4 | 0 | 3 | 2 | 5 | 1 | 2 | 1 | 14 |
| E15 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 4 |
| E15 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 |
| E17 3 | 0 | 0 | 1 | 0 | 1 | 0 | 2 | 4 |
| E17 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| E17 5 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 4 |
| E17 6 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 |
| E17 9 | 3 | 7 | 47 | 3 | 0 | 0 | 1 | 61 |
| E4 6 | 0 | 0 | 3 | 1 | 2 | 2 | 0 | 8 |
| E4 7 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 5 |
| E4 8 | 4 | 3 | 15 | 2 | 0 | 1 | 0 | 25 |
| E4 9 | 4 | 0 | 16 | 9 | 4 | 0 | 0 | 33 |
| IG8 9 | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 5 |
| **Total** | **11** | **19** | **101** | **31** | **14** | **41** | **52** | **269** |

**Methodology for Drainage Network Modelling**

3.6.11 Consultation with Thames Water determined that the sewer system across London could be assumed to have an approximate capacity of 6.5mm/hr. This was represented in the surface water modelling by removing 6.5mm/hr from the rainfall totals for the duration of the model.

3.6.12 The sewer system was not modelled explicitly hence interaction between the sewer system and surface water modelling is not investigated. This was beyond the scope of the borough wide study but in specific areas where the sewer network has been identified to be of particular relevance to flood risk more detailed integrated modelling may be required at a later date.

**Uncertainties in Flood Risk Assessment – Sewer Flooding**

3.6.13 Assessing the risk of sewer flooding over a wide area is limited by the lack of data and the quality of data that is available. Furthermore, flood events may be a combination of surface water, groundwater and sewer flooding.

3.6.14 An integrated modelling approach is required to assess and identify the potential for sewer flooding but these models are complex and require detailed information. Obtaining this information can be problematic as datasets held by stakeholders are often confidential, contain varying levels of detail and may not be complete. Sewer flood models require a greater number of parameters to be input and this increases the uncertainty of the model predictions.

3.6.15 Existing sewer models are generally not capable of predicting flood routing (flood pathways and receptors) in the above ground network of flow routes - streams, dry valleys, highways etc.

3.6.16 Use of historic data to estimate the probability of sewer flooding is the most practical approach, however does not take account of possible future changes due to climate change or future development. Nor does it account for improvements to the network, including clearance of blockages, which may have occurred.

## 3.7 Other Influences of Flooding

**Main River Fluvial Flooding**

3.7.1 Interactions between surface water and tidal/fluvial flooding are generally a result of watercourses unable to store excess surface water runoff. Where the watercourse in question is defended, surface water can pond behind defences. This may be exacerbated in situations where high water levels in the watercourse prevent discharge via flap valves through defence walls.

3.7.2 Main rivers have been considered in the surface water modelling by assuming a ‘bank full’ condition, in the same way that ordinary watercourses have been modelled. Structures such as weirs, locks and gates along watercourses have not been explicitly modelled.

3.7.3 Figure 7 in Appendix D shows the Environment Agency flood zone maps mapped alongside historical records of flood events. The outlines show that the risk of fluvial flooding from Main Rivers is largely concentrated in the Lee Valley as well as along some stretches of the Ching Brook. The River Lee is also tidally influenced up until Lee Bridge near Leyton Marshes, hence the southern extent of the borough is within the tidal reach of the River Thames. Much of the River Lee and its tributaries are defended. In addition, the Thames Barrier also currently provides protection from a tidal event in excess of the 0.1% annual probability event. The presence of these defences and the Thames Barrier may reduce the probability of flooding, however does not eliminate the risk entirely. There is still a residual risk of flooding resulting from overtopping or a breach of the defences during a tidal or fluvial event. This could result in deep and fast flowing water entering Waltham Forest potentially resulting in significant consequences.

3.7.4 Further information on fluvial (Main River) flooding can be found in the North London SFRA (August 2008).

**Artificial Drainage Bodies**

3.7.5 The Lee Flood Relief Channel is the only artificial watercourse located within the LB of Waltham Forest, however it is part of the main river network. This channel was constructed to alleviate water levels on the River Lee.

3.7.6 There are a number of reservoirs located with the LB of Waltham Forest with the largest located in the west of the borough alongside the River Lee. The sudden failure of a dam could potentially have catastrophic consequences, due to a surge in water being released into the downstream catchment. The enforcement of the Reservoirs Act is the responsibility of the Environment Agency, however the maintenance and regular inspection of the reservoirs is the responsibility of the owners. Through the enforcement of regular inspection and maintenance, the risk of flooding as a result of reservoir failure is considered low.

3.7.7 The production of reservoir flood maps was commissioned by the Environment Agency in 2009 for all large raised reservoirs in England and in Wales. These maps show the likely consequences should a reservoir failure occur. The maps may be viewed on the Environment Agency's website.

## 3.8 Critical Drainage Areas

3.8.1 A critical drainage area (CDA) is defined by the Drain London Tier 2 Technical Specification as *"a discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer and/or river) often cause flooding in a Flood Risk Area during severe weather thereby affecting people, property or local infrastructure."*

3.8.2 Within these CDAs, Local Flood Risk Zones have been identified. These are defined as *"the actual spatial extent of predicted flooding in a single location. LFRZs are discrete areas of flooding that do not exceed the national criteria for a 'Flood Risk Area' but still affect houses, businesses or infrastructure."* Local Flood Risk Zones (LFRZs) across the LB of Waltham Forest have been identified based on both the probability and consequence of flooding from the above 'local' sources. The approach taken has therefore considered the local circumstances in defining and agreeing with each borough its LFRZs, whilst seeking to maintain consistency in the overall level of risk to people and property.

3.8.3 Figure 3-3 below shows an example of a CDA and LFRZ. Note that the LFRZ has not been delineated with a boundary to prevent implying properties not shown at risk to be within a flood risk "zone". This approach has been adopted across the whole of the Drain London study area.

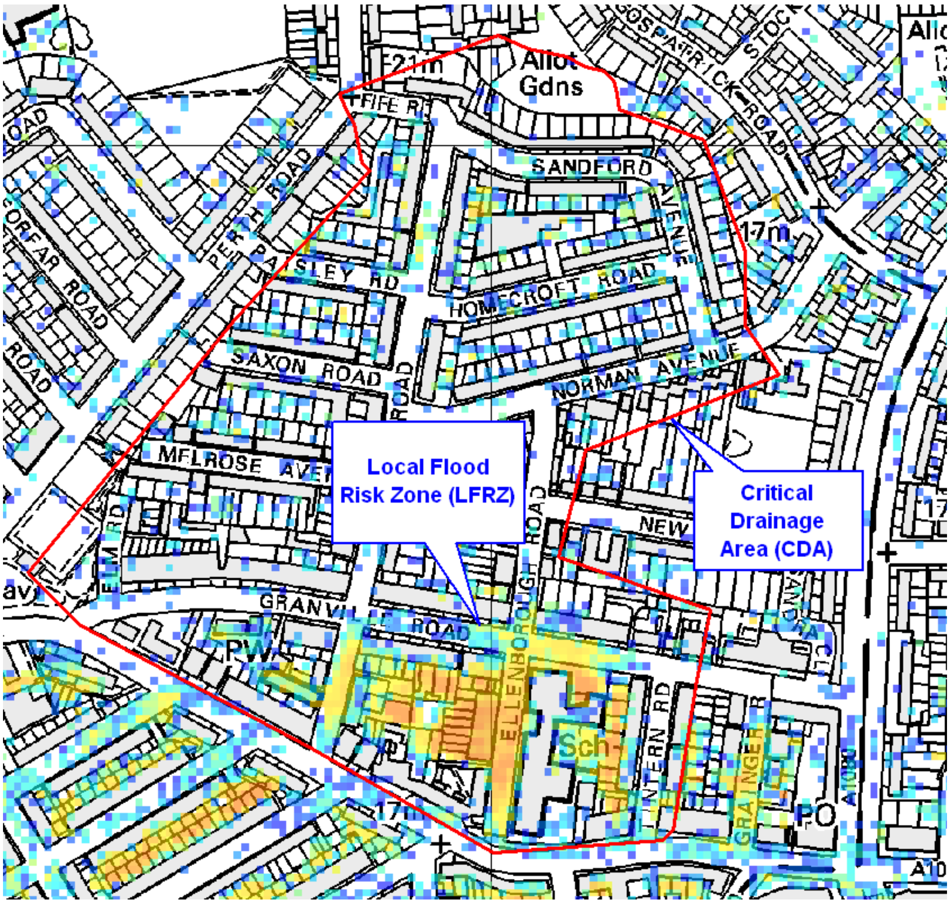



**Figure 3-2 Example Critical Drainage Area (CDA) and Local Flood Risk Zone (LFRZ)**

3.8.4 75 critical drainage areas have been identified across Group 4, including 13 within the LB of Waltham Forest. Figure 1 in Appendix D shows the location of these 13 CDAs within the borough. Figures 23 to 24 indicate the flood depth and flood hazard in each CDA for the 1 in 100 year rainfall event. The naming of the CDAs has been carried out across the entire Group this are not necessarily sequential across individual boroughs.

3.8.5 Guidance on the depths and velocities (hazard) of floodwater that can be a risk to people is shown within Figure 3-3.

d * (v+0.5) + DF

| Velocity \ Depth | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.13 | 0.25 | 0.38 | 0.50 | 0.63 | 0.75 | 0.88 | 1.00 | 1.13 | 1.25 |
| 0.50 | 0.25 | 0.50 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 |
| 1.00 | 0.38 | 0.75 | 1.13 | 1.50 | 1.88 | 2.25 | 2.63 | 3.00 | 3.38 | 3.75 |
| 1.50 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 |
| 2.00 | 0.63 | 1.25 | 1.88 | 2.50 | 3.13 | 3.75 | 4.38 | 5.00 | 5.63 | 6.25 |
| 2.50 | 0.75 | 1.50 | 2.25 | 3.00 | 3.75 | 4.50 | 5.25 | 6.00 | 6.75 | 7.50 |
| 3.00 | 0.88 | 1.75 | 2.63 | 3.50 | 4.38 | 5.25 | 6.13 | 7.00 | 7.88 | 8.75 |
| 3.50 | 1.00 | 2.00 | 3.00 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 | 9.00 | 10.00 |
| 4.00 | 1.13 | 2.25 | 3.38 | 4.50 | 5.63 | 6.75 | 7.88 | 9.00 | 10.13 | 11.25 |
| 4.50 | 1.25 | 2.50 | 3.75 | 5.00 | 6.25 | 7.50 | 8.75 | 10.00 | 11.25 | 12.50 |
| 5.00 | 1.38 | 2.75 | 4.13 | 5.50 | 6.88 | 8.25 | 9.63 | 11.00 | 12.38 | 13.75 |

Categories of flood hazard:

| | From | To | |
|---|---|---|---|
| Class 1 | 0.75 | 1.50 | Danger for some |
| Class 2 | 1.50 | 2.50 | Danger for most |
| Class 3 | 2.50 | 20.00 | Danger for all |

Note: The table gives values of flood hazard (= d*(v+0.5) +DF)

**Figure 3-3 Combinations of flood depth and velocity that cause danger to people (Source: Defra/Environment Agency research on Flood Risks to People - FD2321/TR2)**

3.8.6 This information has been converted into a hazard rating (defined within Table 3-7) which can be seen within all hazard related figures within Appendix D, figures 18 to 22.

**Table 3-7 Legend for Hazard Rating Figures**

| Degree of Flood Hazard | Hazard Rating (HR) | | Description |
|---|---|---|---|
| **Low** | <0.75 | Caution | Flood zone with shallow flowing water or deep standing water |
| **Moderate** | 0.75b – 1.25 | Dangerous for some (i.e. children) | Danger: Flood zone with deep or fast flowing water |
| **Significant** | 1.25 -2.5 | Dangerous for most people | Danger: Flood zone with deep fast flowing water |
| **Extreme** | >2.5 | Dangerous for all | Extreme danger: Flood zone with deep fast flowing water |

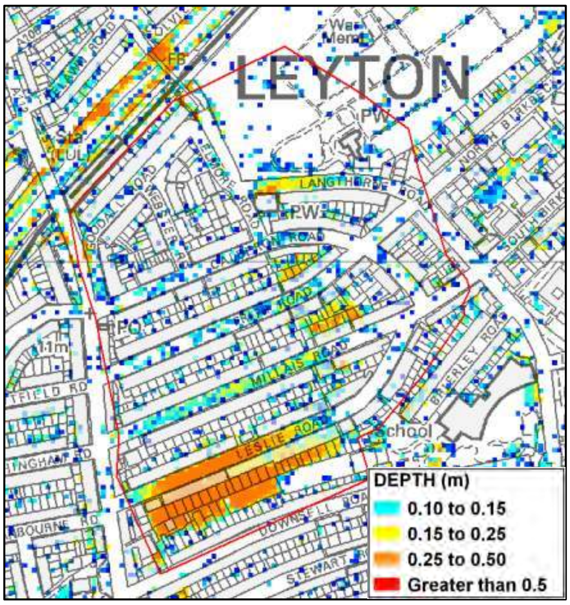
3.8.7 The following sections of the report provide a summary of the location, probability, consequences and mechanisms of flooding in each CDA within the borough. Each accompanying figure shows the extent of the CDA displayed with the 1 in 100 year maximum depth results.

**CDA: Group4_046**

Location: Leslie Road, Leyton

Description: Surface water is observed to flow along Leslie Road in a westerly direction, ponding at the lowest point.

Validation: Generally good correlation with EA Surface Water Map. There are no other recorded incidents of flooding in the area.

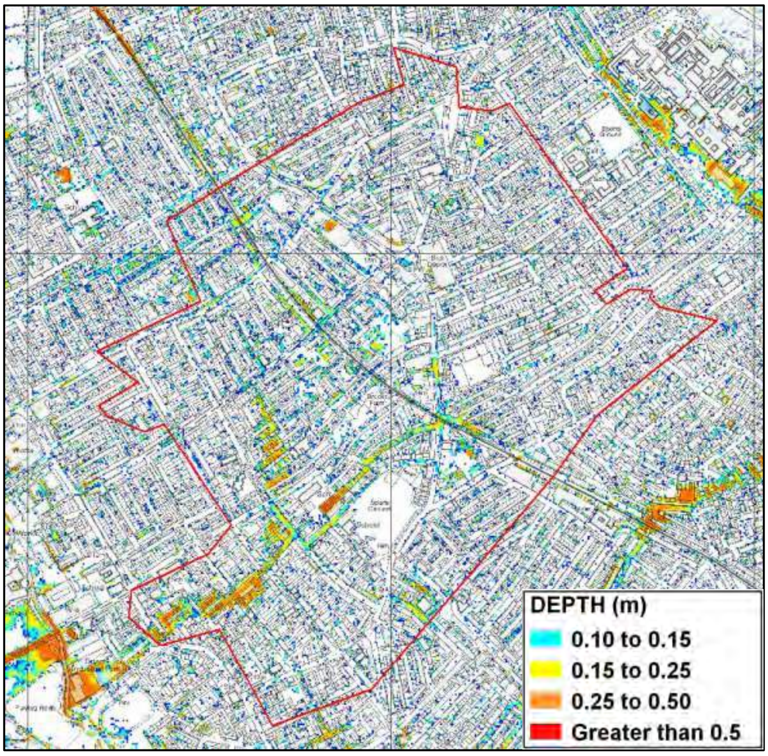



**CDA: Group4_047**

Location: Leyton Grange and Primrose Road, Leyton

Description: Surface water runoff is observed to flow along a natural valley within the CDA. The route begins at the corner of Capworth Street and Clyde Place and flows in a south-westerly direction along Primrose Road and Leyton Grange.

Validation: Good correlation with EA Surface Water Map for 200 year event. A Waltham Forest Call Centre record just to the south of the flooding hotspot notes that Church Road is flooded every time it rains. No other supporting flood records.

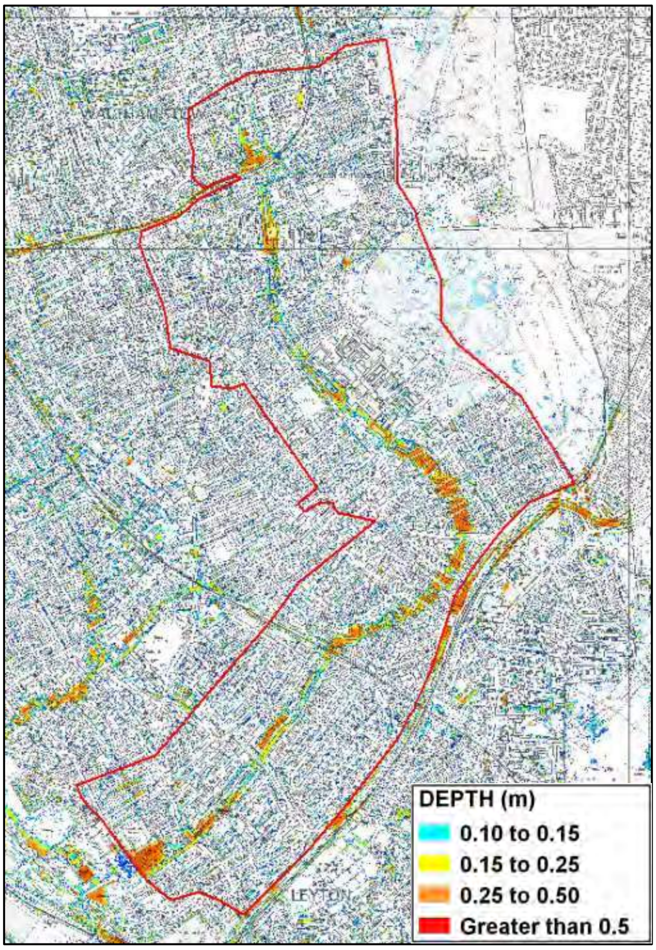


**CDA: Group4_048**

Location: Extensive drainage catchment beginning in Upper Walthamstow through to Leyton

Description: This is a large subcatchment where historic flood routes/watercourses have been integrated into the drainage network and overland flow routes have been lost. This creates significant overland flow routes during extreme rainfall events from the north east to the south west towards the Dagenham Brook and River Lea. The highly urbanised catchment creates 'pockets' of flooding where overland flow is restricted by infrastructure such as roads and buildings. Reduction of surface water runoff in the upper catchment could have a direct benefit to fluvial flood risk from the Dagenham Brook.

Validation: Generally good correlation with EA Surface Water Map. There are a lot of flood incidents reported in the area (in particular London Fire Brigade records), however only a few correlate well to identified Local Flood Risk Zones.

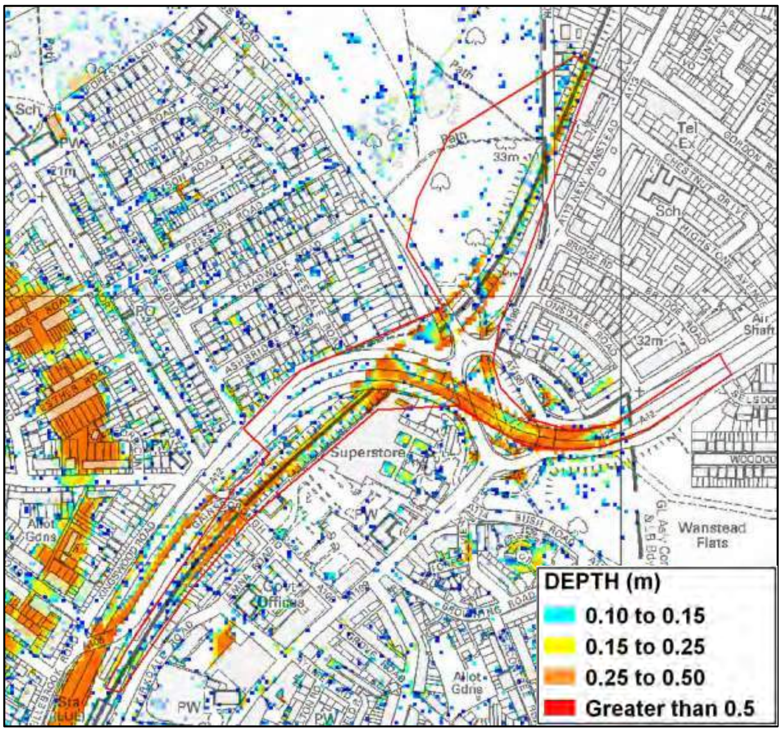



**CDA: Group4_049**

Location: The A12 underpass at Green Man Roundabout

Description: Surface water runoff flowing from the east and west along the A12 and ponding at the lowest point.

Validation: Not validated. The EA Surface Water Map does not show any flooding in the underpass. It may not have been modelled in the EA Surface water Map.

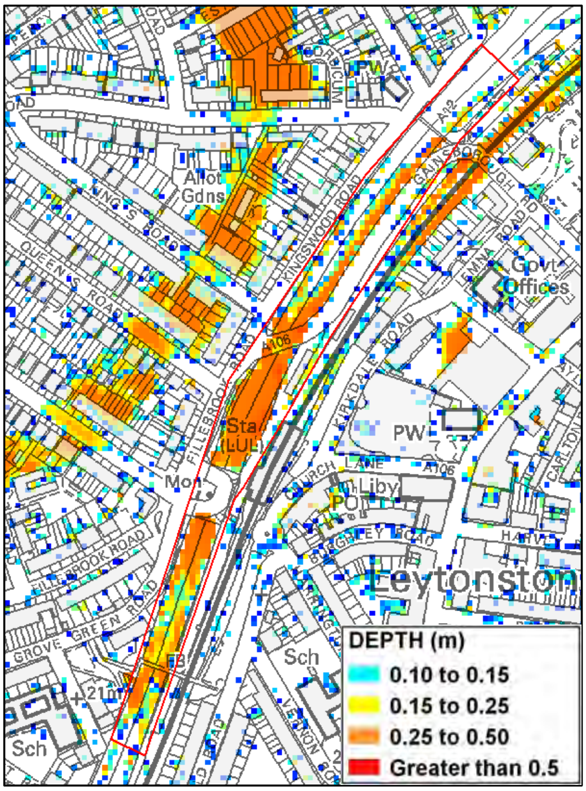


**CDA: Group4_052**

Location: The A12 underpass at Leytonstone Underground Station

Description: Surface water runoff flowing from the north and south along the A12 and ponding at the lowest point.

Validation: Reasonable correlation with EA Surface Water Map for both 30 year and 200 year event. The EA Surface Water Map has not modelled a continuous link in the underpass therefore underestimated the catchment size and extent of flooding. There are no recorded incidents of flooding at this location.

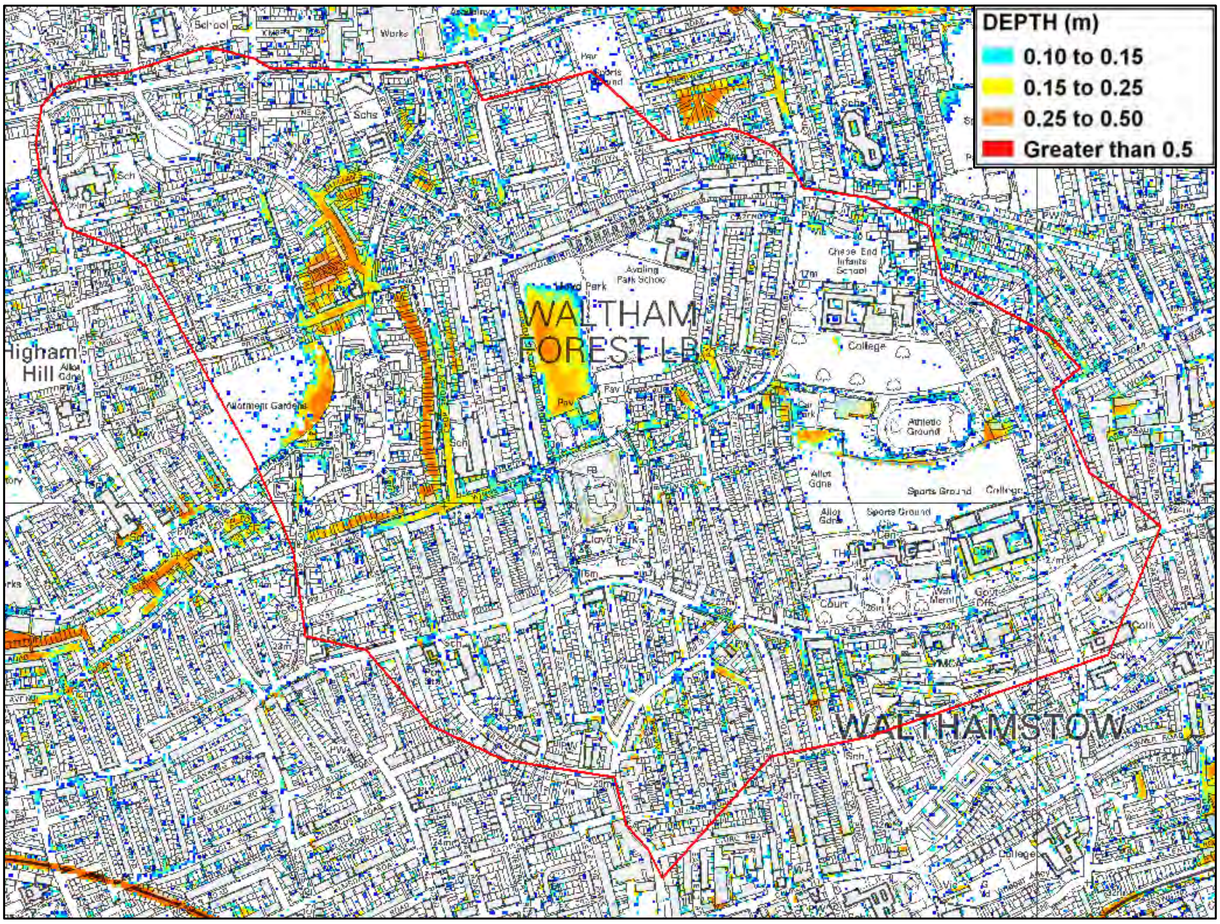



**CDA: Group4_054**

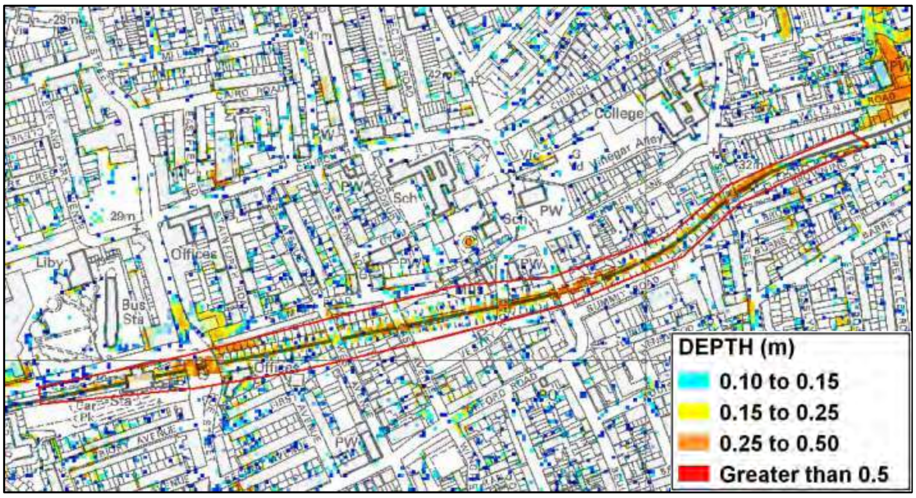
Location: Residential areas near Heron Close and Elphinstone Road, Waltham Forest

Description: The Local Flood Risk Zone is at a low point in the catchment and surface water is prevented from flowing further downhill by high ground around Priory Court. Ponding water in around Heron Close and Elphinstone Road is as a result of overland flow from surrounding high ground in the north, east and west.

Validation: Generally good correlation with EA Surface Water Map for both 30 year and 200 year event. Difference in flood extent for the 30 year event on Elphinstone Road. This could be a result of differences in how buildings have been modelled in Drain London. Anecdotal evidence from LB Waltham Forest staff of flooding in Priors Court. Limited additional clear correlation between historic flood records and modelled flood extents.




**CDA: Group4_058**




Location: Railway line between Walthamstow Central and Wood St stations, Walthamstow

Description: Railway is in a cutting at this location. The track slopes from the east to the west continuously.

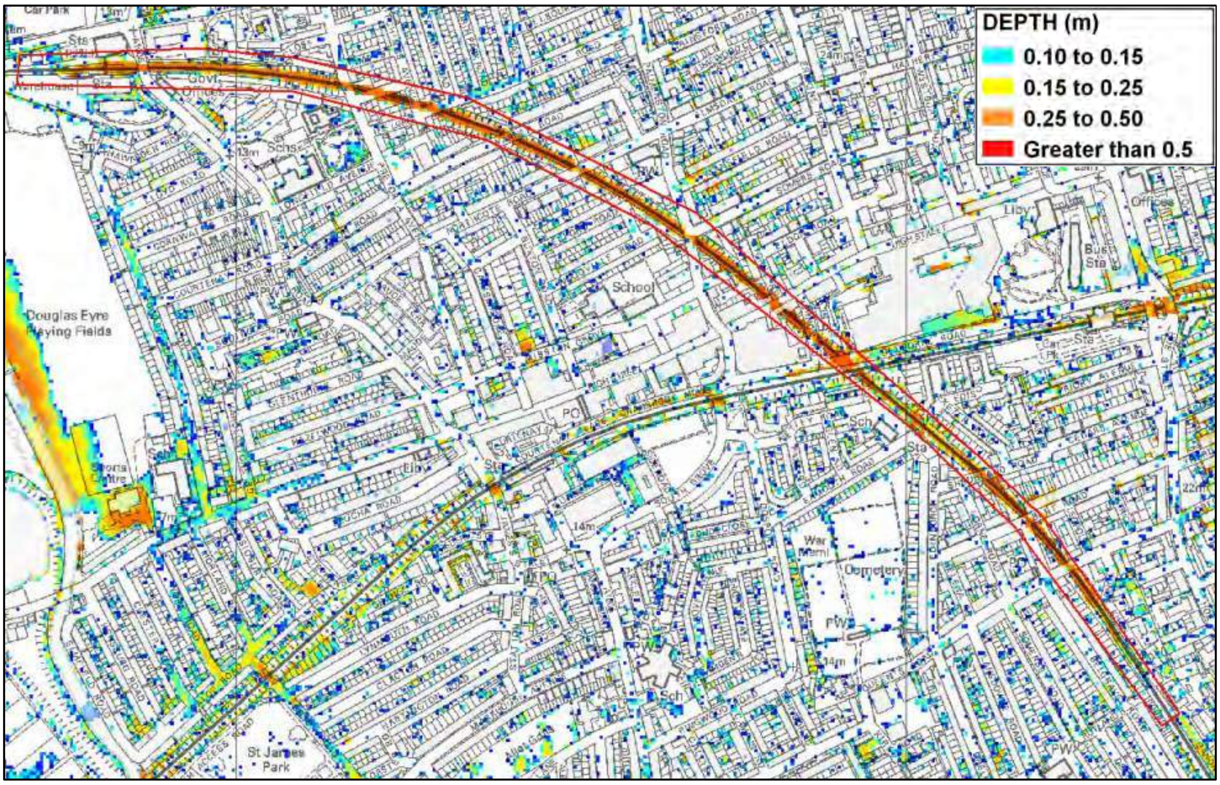
Validation: Good correlation with EA Surface Water Map for 30 year and 200 year event. London Fire Brigade have been called to two incidents of flooding at Walthamstow Central Station, however it is not known whether this was flooding of the railway line or the underground.

**CDA: Group4_059**

Location: Blackhorse Road Station and Overground Railway line to the east

Description: Railway is in a cutting at this location. There is a low point in the track to the east of Blackhorse Road Station. Surface water runoff is observed to flow along the railway track and pond at this low point.

Validation: Good correlation with EA Surface Water Map for the 200 year event. Drain London modelling shows worse flooding for the 30 year event. No other supporting records of historic flooding.

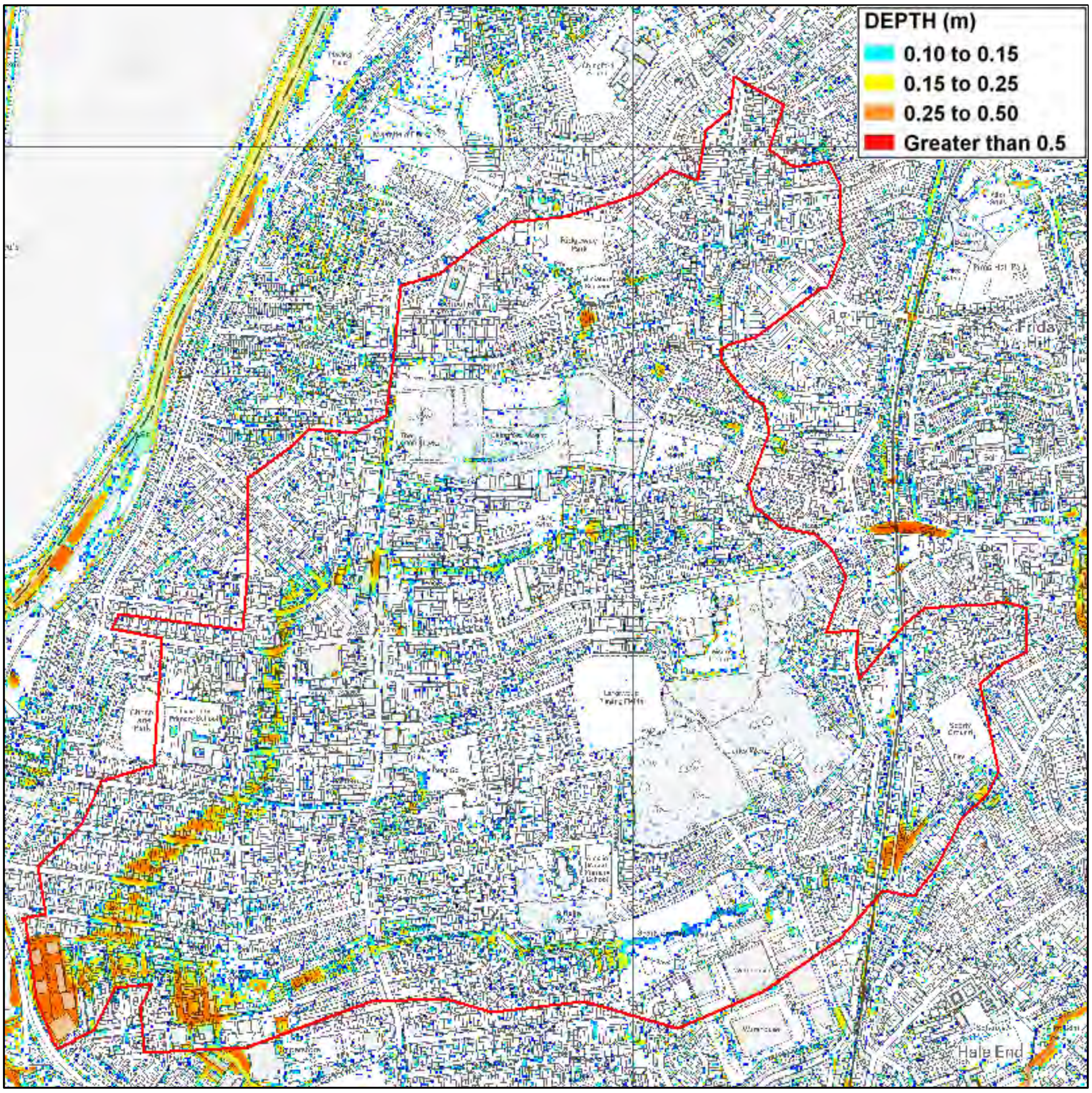


**CDA: Group4_064**

Location: Large catchment area in North Waltham Forest from Hale End in the east through to the River Lea in the west

Description: This is a large sub-catchment where historic flood routes/watercourses have been integrated into the drainage network and overland flow routes have been lost. This creates substantial overland flow routes from the east towards the confluence of the River Ching and River Lea, culminating in deep flooding predicted at Cabinet Way, upstream of the North Circular. Flooding is predominantly a result of surface water runoff, however after the peak of the surface water flooding event has passed water flowing down the River Ching may exceed its banks near Burnside Ave and exacerbates flooding in the Cabinet Way area.

Validation: Generally good correlation with EA Surface Water Map. There are clusters of flooding incidents recorded by the London Fire Brigade in two of the identified Local Flood Risk Zones - Marmion Ave and at Chingford Ave.

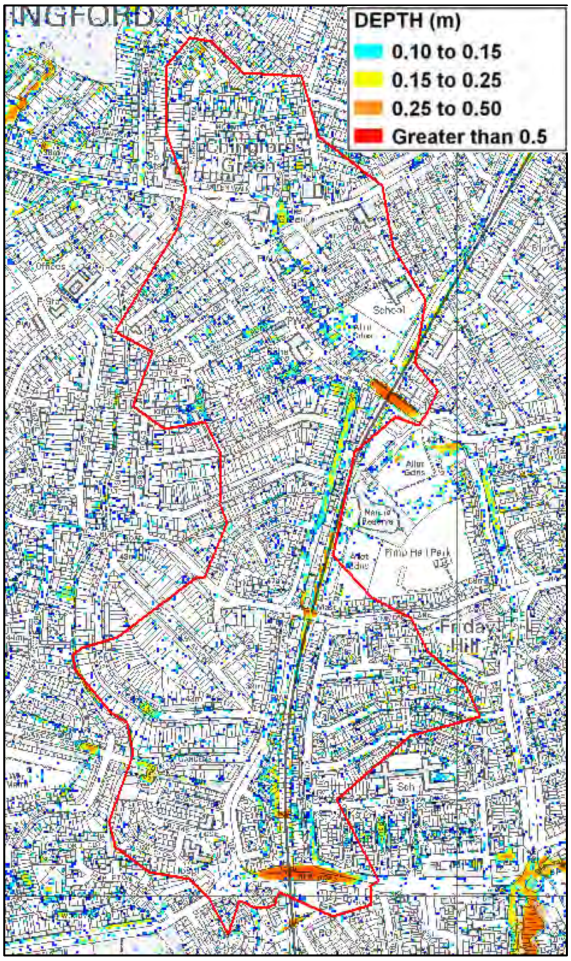


**CDA: Group4_065**

Location: The transport corridor between Chingford Green in the north and Friday Hill in the south

Description: The National Express East Anglia railway is partially in a cutting in this area. The track slopes continuously downwards from north to south. Overland flow from the catchment to the west is likely to contribute to flooding in the railway cutting, which flows north to south and can run off the track where the railway comes out of cutting and is raised above the surrounding ground.

Validation: Good correlation with EA Surface Water Map for 30 year and 200 year event. Flooding is not predicted at properties in these areas. No flooding records have been provided for these locations by Waltham Forest, Network Rail or TfL.

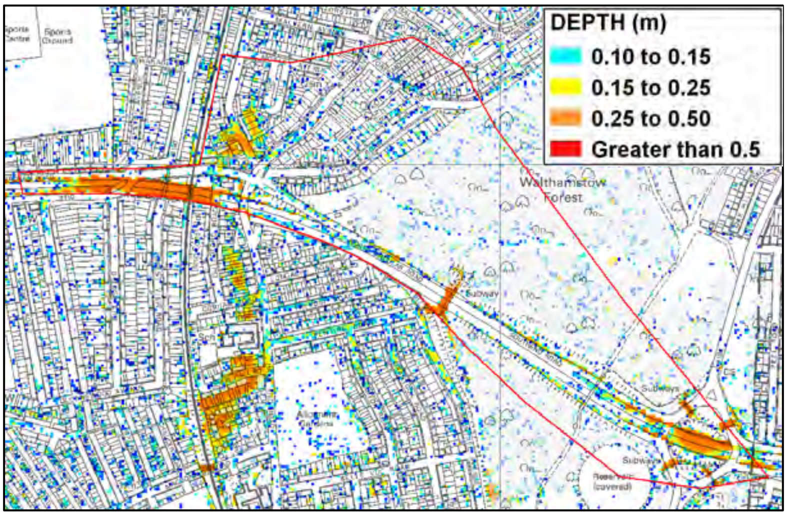



**CDA: Group4_066**

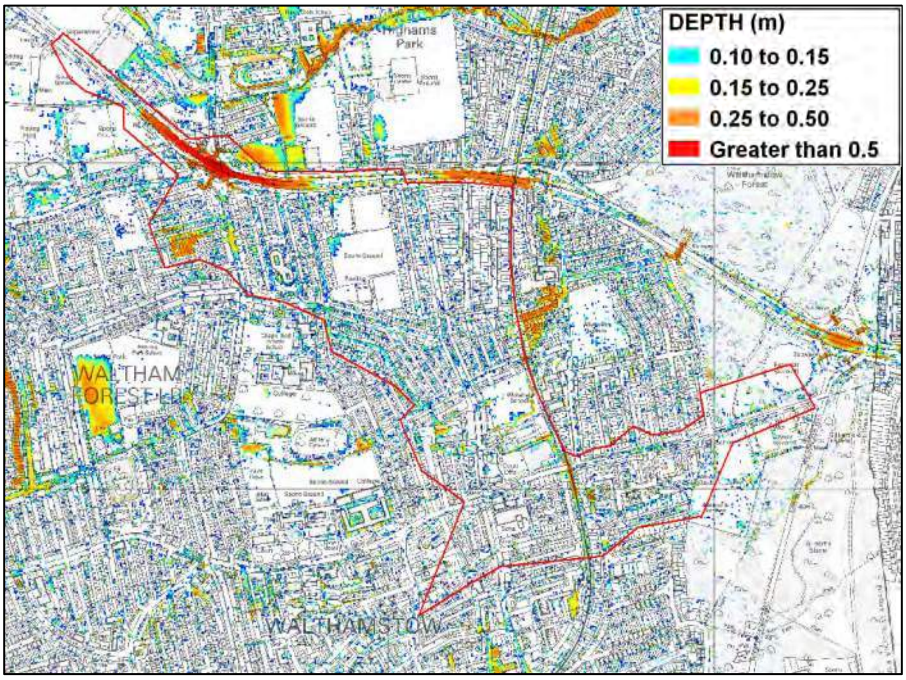
Location: North circular underpasses through Waltham Forest at Forest View and Woodford Road/A104.

Description: Surface water observed to pond at the underpasses. Overland flow is predominantly from the A406.

Validation: Good correlation with EA Surface Water Map for both 30 year and 200 year event.



**CDA: Group4_067**

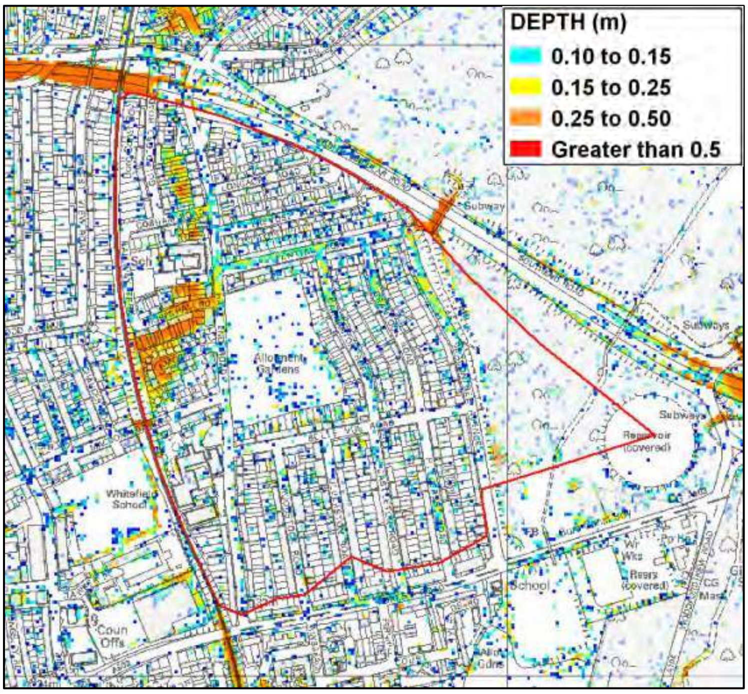



Location: The A406 North Circular at the Crooked Billet Roundabout

Description: Surface water observed to flow from the south, entering the A406 and ponding at the underpass beneath the Crooked Billet Roundabout.

Validation: Good correlation with EA Surface Water Map for both 30 year and 200 year event. Waltham Forest Call Centre have registered flooding and blocked drains at the Crooked Billet Roundabout in July 2009.

**CDA: Group4_068**




Location: Lamorna Crescent, Waltham Forest

Description: Surface water from surrounding higher ground flows in a westerly direction and ponds behind the railway embankment between Highams Park and Wood Street rail stations. Key flow routes are along Carnantion Road, Pentire Road, and through the allotment gardens. Residential properties along Thorpe Hall Road and Lamorna Close are shown to flood. The local Thames Water drainage network discharges to a small watercourse between Thorpe Hall Road and Lamorna Close.

Validation: Good correlation with EA Surface Water Map, however no other supporting records of historic flooding.

## 3.9 Summary of Risk

3.9.1 Table 3-8 (below) identifies the surface water flood risk to infrastructure, households and commercial/industrial receptions. The table is a summary of the information submitted to the Drain London Board of Prioritisation Matrices for each CDA.

**Table 3-8: Summary of Surface Water Flood Risk in CDAs in the London Borough of Waltham Forest**

| CDA ID | Scheme Location | Moderation | | Infrastructure | | | | | | Households | | | | | | | | Commercial / Industrial | | | | Validation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Primary | Secondary | Essential | | Highly Vulnerable | | More Vulnerable | | Non-Deprived (All) | | Non-Deprived (Basements) | | Deprived (All) | | Deprived (Basements) | | All | | Basements Only | | |
| | | | | All | > 0.5m Deep | All | > 0.5m Deep | All | > 0.5m Deep | All | > 0.5m Deep | All | > 0.5m Deep | All | > 0.5m Deep | All | > 0.5m Deep | All | > 0.5m Deep | All | > 0.5m Deep | |
| Group4_046 | Leslie Road, Leyton | Synergy | Combination of two or more of the above | 0 | 0 | 0 | 0 | 0 | 0 | 245 | 8 | 0 | 0 | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Non-Validated |
| Group4_047 | Leyton Grange and Primrose Road, Leyton | Synergy | Combination of two or more of the above | 7 | 1 | 6 | 0 | 5 | 0 | 609 | 0 | 0 | 0 | 1061 | 0 | 2 | 0 | 114 | 0 | 0 | 0 | Validated |
| Group4_048 | Extensive drainage catchment beginning in Upper Walthamstow through to Leyton. | Synergy | Combination of two or more of the above | 4 | 1 | 7 | 1 | 11 | 0 | 2691 | 68 | 2 | 1 | 1480 | 9 | 2 | 0 | 140 | 2 | 0 | 0 | Validated |
| Group4_049 | The A12 underpass at Green Man Roundabout. | Nationally / strategically important infrastructure | Combination of two or more of the above | 2 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Non-Validated |
| Group4_052 | The A12 underpass ay Leytonstone Underground Station | Nationally / strategically important infrastructure | None | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | Validated |
| Group4_054 | Residential area at Heron Close near the intersection of Priors Croft and North Countess Road. | Health and Safety | Environmental | 4 | 3 | 6 | 0 | 6 | 0 | 1477 | 6 | 0 | 0 | 615 | 0 | 0 | 0 | 69 | 0 | 0 | 0 | Validated |
| Group4_058 | Walthamstow Railway and St Mary's Road | Regionally Important Infrastructure | Combination of two or more of the above | 1 | 1 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | Validated |
| Group4_059 | Blackhorse Road Station and Overground Railway line to the east. | Regionally Important Infrastructure | Combination of two or more of the above | 1 | 1 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 24 | 1 | 0 | 0 | 10 | 4 | 0 | 0 | Non-Validated |
| Group4_064 | Cabinet Way, Waltham Forest | Synergy | Combination of two or more of the above | 4 | 3 | 3 | 0 | 8 | 0 | 2180 | 1 | 0 | 0 | 284 | 5 | 0 | 0 | 99 | 9 | 0 | 0 | Validated |
| Group4_065 | The transport corridor between Chingford Green in the north and Friday Hill in the south. | Regionally Important Infrastructure | None | 3 | 0 | 2 | 0 | 3 | 0 | 440 | 0 | 0 | 0 | 200 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | Validated |
| Group4_066 | North circular underpasses through Waltham Forest at Forest View and Woodford Road/A104.. | Regionally Important Infrastructure | Health and Safety | 2 | 2 | 1 | 0 | 0 | 0 | 113 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Validated |
| Group4_067 | The A406 North Circular at the Crooked Billet Roundabout. | Regionally Important Infrastructure | Combination of two or more of the above | 4 | 2 | 2 | 0 | 2 | 0 | 543 | 0 | 0 | 0 | 371 | 0 | 0 | 0 | 41 | 0 | 0 | 0 | Validated |
| Group4_068 | Small section of ordinary watercourse behind Lamorna Crescent, Waltham Forest | Health and Safety | Environmental | 0 | 0 | 0 | 0 | 1 | 0 | 442 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | Validated |

# 4 Phase 3: Options

## 4.1 Objectives

4.1.1 The purpose of Phase 3 is to identify a range of structural and non-structural measures (options) with the potential to alleviate flood risk and to then assess each option in order to eliminate those that are not feasible or do not make economic sense. The remaining options are then developed and tested against their relative effectiveness, benefits and costs. The target level of flood protection from surface water flooding has been set at 1 in 75 years. This aligns with the likely level of flood protection necessary to enable commercial insurance cover to be provided to the general public.

4.1.2 The option identification has taken place on an area-by-area (site-by-site) basis following the process established in Phase 2. The options assessment assesses and short-lists the measures for each CDA in turn..

4.1.3 Phase 3 delivers a high level option assessment for each of the Critical Drainage Areas (CDAs) identified in Phase 2. No monetised damages have been calculated and flood mitigation costs have been determined using engineering judgement rather than through detailed analysis. Costs should therefore be treated at an order of magnitude level of accuracy. The options assessment presented here follows the process described in the Defra SWMP Guidance but is focussed on highlighting areas for further detailed analysis and immediate ‘quick win’ actions. Further detailed analysis may occur for high priority CDAs, as defined by the Prioritisation Matrix, within the next Tier (Tier 3) of the Drain London project.

## 4.2 Measures

4.2.1 Surface water flooding is often highly localised and complex. Its management is therefore highly dependent upon the characteristics of the critical drainage area and there are few solutions which will provide benefits in all locations. This section outlines potential measures which have been considered for mitigating the surface water flood risk within LB of Waltham Forest.

4.2.2 The SWMP Plan Technical Guidance (Defra 2010) identifies the concept of Source, Pathway and Receptor as an appropriate basis for understanding and managing flood risk. Figure 4-1 identifies the relationship between these different components, and how some components could be considered within more than one category.

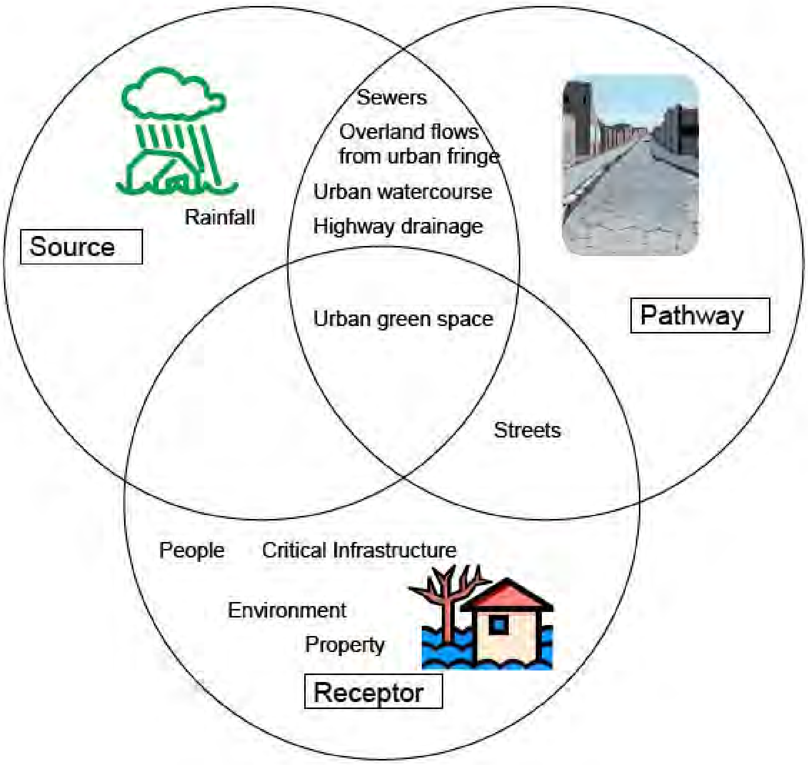



**Figure 4-1 Illustration of Sources, Pathways & Receptors (extracted from SWMP Technical Guidance, Defra 2010)**

4.2.3 When identifying potential measures it is useful to consider the source, pathway, receptor approach (refer to Figure 4-1 and Figure 4-2). Both structural and non-structural measures were considered in the optioneering exercise undertaken for the identified CDAs. Structural measures can be considered as those which require fixed or permanent assets to mitigate flood risk (such as a detention basin, increased capacity pipe networks). Non-structural measures may not involve fixed or permanent facilities, and the benefits to of flood risk reduction is likely to occur through influencing behaviour (education of flood risk and possible flood resilience measures, understanding the benefits of incorporating rainwater reuse within a property, planning policies etc).

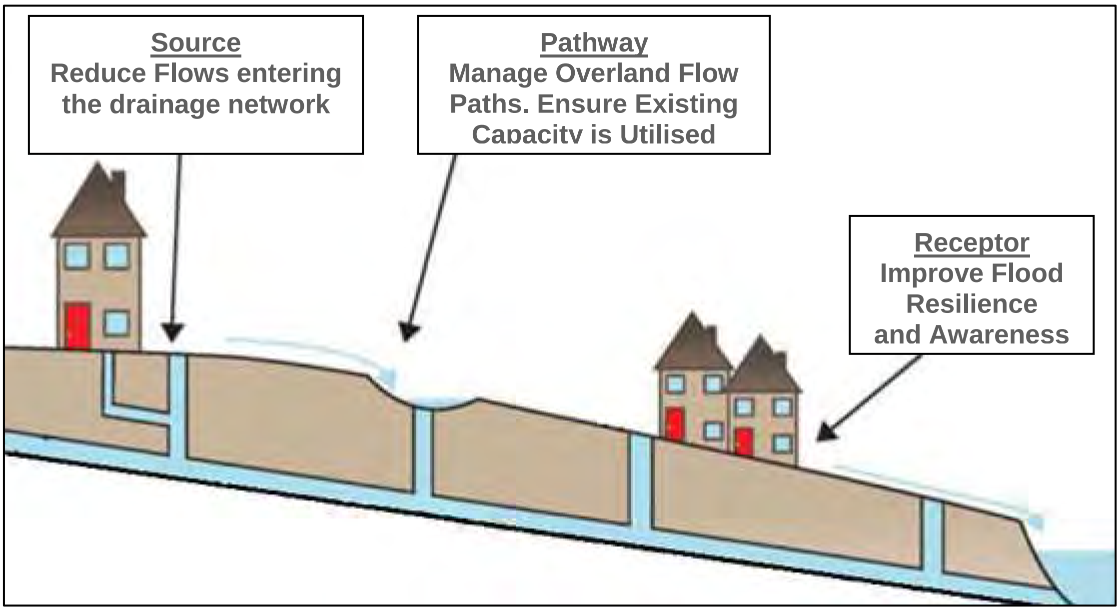



**Figure 4-2 Source, Pathway and Receptor Model (adapted from Defra SWMP Technical Guidance, 2010)**

4.2.4 Methods for managing surface water flooding can be divided into methods which influence either the Source, Pathway or Receptor, as described below, (refer to Table 4-1.):

- Source Control: Source control measures aim to reduce the rate and volume of surface water runoff through increasing infiltration or storage, and hence reduce the impact on receiving drainage systems. Examples include retrofitting SuDS (e.g. Bioretention basins, wetlands, green roofs etc) and other methods for reducing flow rates and volume.

- Pathway Management: These measures seek to manage the overland and underground flow pathways of water in the urban environment, and include: increasing capacity in drainage systems; separation of foul and surface water sewers etc.

- Receptor Management: This is considered to be changes to communities, property and the environment that are affected by flooding. Mitigation measures to reduce the impact of flood risk on receptors may include improved warning and education or flood resilience measures.

**Table 4-1 Typical Surface Water Flood Risk Management Measures**

| | Generic measures | Site specific measures |
|---|---|---|
| | • Do Nothing (do not continue maintenance)<br>• Do Minimum (continue current maintenance) | |
| **Source control** | • Bioretention carpark pods<br>• Soakaways, water butts and rainwater harvesting<br>• Green roofs<br>• Permeable paving<br>• Underground storage;<br>• Other 'source' measures | • Swales<br>• Detention basins<br>• Bioretention basins;<br>• Bioretention carpark pods;<br>• Bioretention street planting;<br>• Ponds and wetlands |
| **Pathway Management** | • Improved maintenance regimes<br>• Increase gulley assets | • Increase capacity in drainage system<br>• Separation of foul & surface water sewers<br>• Managing overland flows<br>• Land Management practices<br>• Other 'pathway' measures |
| **Receptor Management** | • Improved weather warning<br>• Planning policies to influence development<br>• Social change, education and awareness<br>• Improved resilience and resistance measures<br>• Raising Doorway/Access Thresholds'<br>• Other 'receptor' measures | • Temporary or demountable flood defences - collective measure |

**Excluded Measures**

4.2.5 Section 4.4 discusses the preferred options for each of the CDAs in turn (The CDAs are as described in Section 3). Two specific options were considered but generally excluded for all CDAs during the optioneering exercise, there were;

- Do Nothing: no longer undertaking maintenance (e.g. no longer maintaining gulley pits)
- Do Minimum: continuing the current maintenance regime (e.g. maintaining the current level of maintenance on a gulley pit).

4.2.6 The *Do Nothing* approach was excluded as a preferred option as it will provide no benefit to reducing the flood risk within a Local Flood Risk Zone (LFRZ) and wider CDA. Utilising this approach would in fact be likely to lead to an increase the probability and consequence of flooding in the borough

4.2.7 The *Do Minimum* approach was excluded as a preferred option due to the predicted effects of climate change increasing the intensity and volume of rainfall. Maintaining the proposed maintenance regime will only be beneficial to the CDAs and LFRZs whilst rainfall intensities and volumes remain at a level similar to that of current conditions. If intensities and volumes increase as a result of climate change (as is anticipated) then the standard of protection afforded by assets (e.g. gulley pits) will diminish over time.

## 4.3 Proposed Surface Water Drainage Policy

4.3.1 It should be acknowledged that the CDAs only account for a small portion of the areas that could be affected by surface water flooding. The CDAs are the areas where the impact of surface water flooding is expected to be greatest but it is recommended that the Council implement policies which will reduce the flood risk from surface water flooding throughout the borough and promote Best Management Practises to the implementations of SuDS and the reduction of runoff volumes.

4.3.2 The SWMP Action Plan (discussed in Section 5) which is a major output of this project recommends that the following policies are implemented within the boundaries of the LLFA to reduce the flood risk within the borough:

***Policy 1****: All developments across the borough (excluding minor house extensions less than 250m*$^2$*) which relate to a net increase in impermeable area are to include at least one 'at source' SuDS measure (e.g. waterbutt, rainwater harvesting tank, bioretention planter box etc). This is to assist in reducing the peak volume of runoff discharging from the site.*

***Policy 2****: Proposed 'brownfield' redevelopments greater than 0.1 hectare are required to reduce post development runoff rates for events up to and including the 1 in 100 year return period event with an allowance for climate change (in line with PPS25 and UKCIP guidance) to 50% of the existing site conditions. If this results in a discharge rate lower than the Greenfield conditions it is recommended that the Greenfield rate (calculated in accordance with IoH124*[1]*) are used.*

***Policy 3:*** *Developments located in Critical Drainage Areas (CDAs) and greater than 0.5 hectare are required to reduce runoff to that of a predevelopment Greenfield runoff rate (calculated in accordance with IoH124). It is recommended that a SuDS treatment train is utilised to assist in this reduction.*

4.3.3 The borough may also wish to consider the inclusion of the following policy to manage the pollutant loads generated from proposed development applications:

***Policy 4:*** *Best Management Practices (BMP) are required to be demonstrated for all development applications within the LB of Waltham Forest. The following load-reduction targets must be achieved when assessing the post-developed sites SuDS treatment train (comparison of unmitigated developed scenario versus developed mitigated scenario):*

*- 80% reduction in Total Suspended Sediment (TSS);*

*- 45% reduction in Total Nitrogen (TN);*

*- 60% reduction in Total Phosphorus (TP); and*

*- 90% reduction in litter (sized 5mm or greater).*

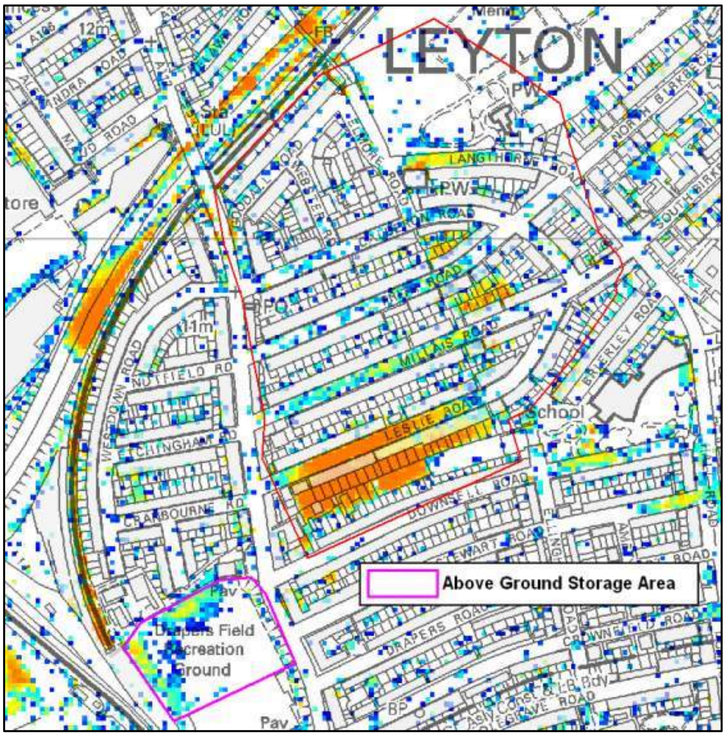
[1] Defra/Environment Agency, September 2005, Flood and Coastal Defence R&D Programme: Preliminary Rainfall Runoff Management for Developments (R&D Technical Report W5-074/A/TR/1 Revision D)

## 4.4 Preferred CDA Options

4.4.1 This section discusses the preferred option identified for each CDA based on the measures discussed in Table 4-1. A figure showing the preferred option has been provided where this is thought to enhance the description. The locations of the capital works shown in the figures are indicative only. It is strongly recommended that a feasibility assessment is carried out at each CDA prior to the commencement of any capital works.

4.4.2 Detailed option appraisal assessments were undertaken on a range of options for each CDA before the preferred option was chosen. This process was fully documented and details can be found within Appendix E.

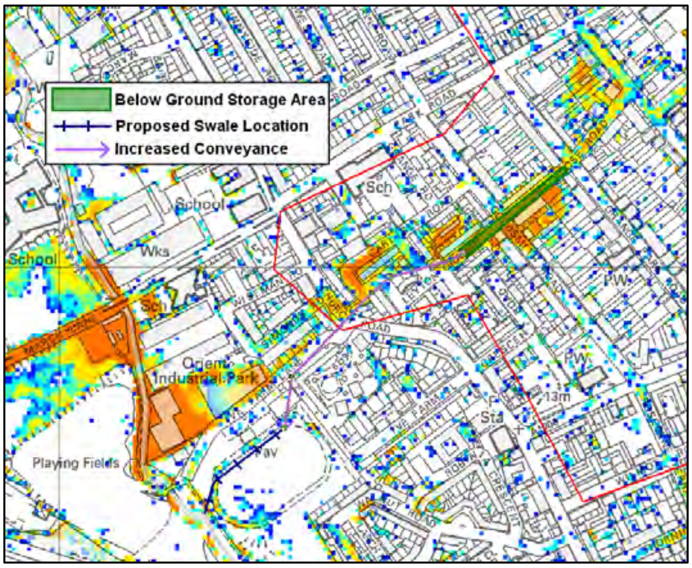
**CDA: Group4_046**




The preferred option for this CDA includes the creation of a pond/wetland to provide additional storage with new or diverted surface water drainage pipes in the road connecting into the storage area. Regular inspection of the syphon beneath the railway embankment is also recommended to minimise the likelihood of blockage. There is an opportunity to carry out these works alongside the reinstatement of Drapers Field as part of the Olympic Site redevelopment (Green Grid Project).

Other measures that were considered include increasing the capacity of the large pipe located beneath the back gardens of properties along Leslie Road. The increase in conveyance would need to be carried out to the outfall to ensure flood risk is not increased to others (approximately 700m away). This measure was disregarded as it is unlikely to be cost-beneficial considering the pipe runs through private properties and beneath the railway tracks.

**CDA: Group4_047**

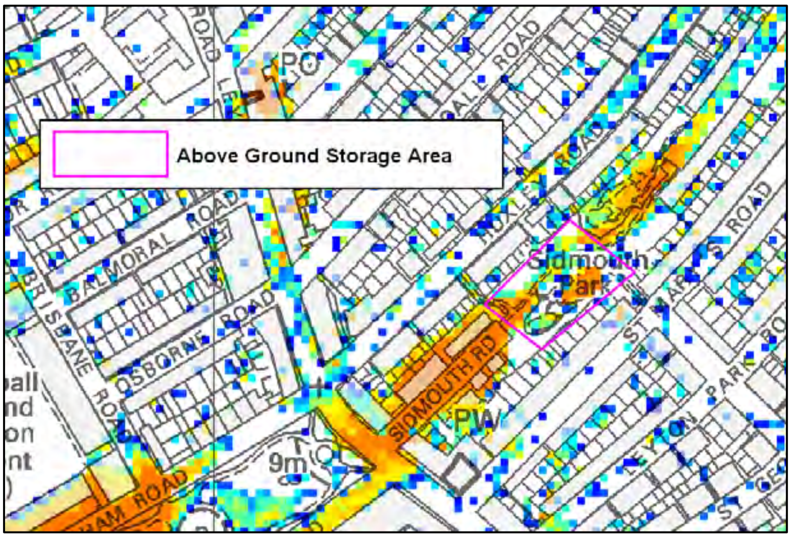



The preferred option for this CDA includes the construction of an underground storage unit beneath Leyton Grange/Primrose Road along with improved entry capacity. Partial deculverting of the surface water pipe beneath the athletic track is also recommended. In the longer term, the North Olympic Fringe redevelopment could be used as an opportunity to increase conveyance in the local drainage network.

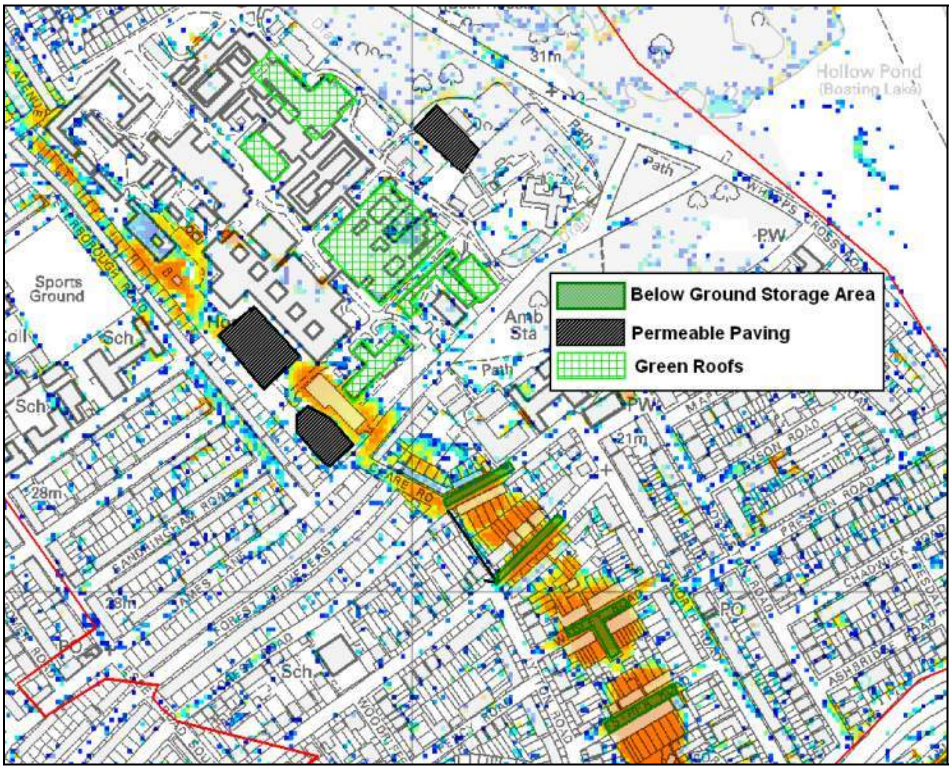
Other measures that were considered include increasing conveyance in the local drainage network. This is unlikely to be cost beneficial if carried out in isolation and in the short term.

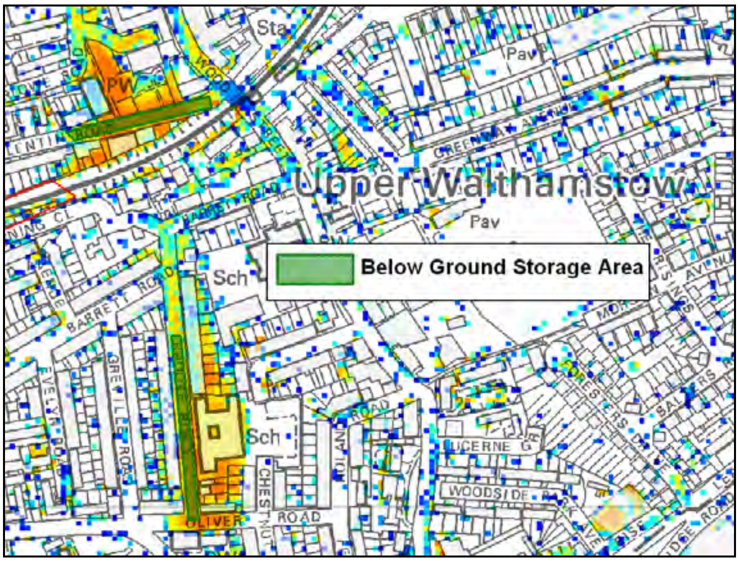
**CDA: Group4_048**

The preferred option for this CDA includes above ground storage in Sidmouth Park and below ground storage in Forest Rd, Hainault Rd, Wadley Rd, Esther Rd, Valentine Rd, Brooke Rd. The CDA would also benefit from retrofitting community resilience measures for those properties shown to be worst affected (those along Newport/Wadley/Esther/Wallwood Rd). Electricity sub-stations have been identified at Whipps Cross Hospital and at Warwick School. It is recommended that resilience measures are retrofitted to these sub-stations. The incorporating of SUDS measures at Whipps Cross Hospital, such as green roofs and permeable pavement, could help to reduce local runoff. Lastly, improving the entry capacity in the local road network could assist runoff in entering the drainage network. In the long term, the North Olympic Fringe development provides an opportunity to reduce runoff from large impermeable areas.




Other measures that were considered include increasing conveyance through the catchment. This may require upgrading the majority of the trunk sewer through the CDA with a length of up to 3km. This is unlikely to be cost effective and may be difficult to implement in a highly urbanised catchment.






**CDA: Group4_049**

The preferred option for this CDA includes increasing the capacity in the existing drainage system serving the A12 and improving entry capacity. A targeted response in the event of flooding in the form of a flood plan is also recommended to assist in reducing the consequences.

Other measures that were considered include construction of an underground storage unit beneath the carriage way with increased entry capacity. As it is likely that the A12 is currently serviced by an existing drainage network or pumping system the installation of a storage unit is unlikely to be cost-beneficial.

**CDA: Group4_052**

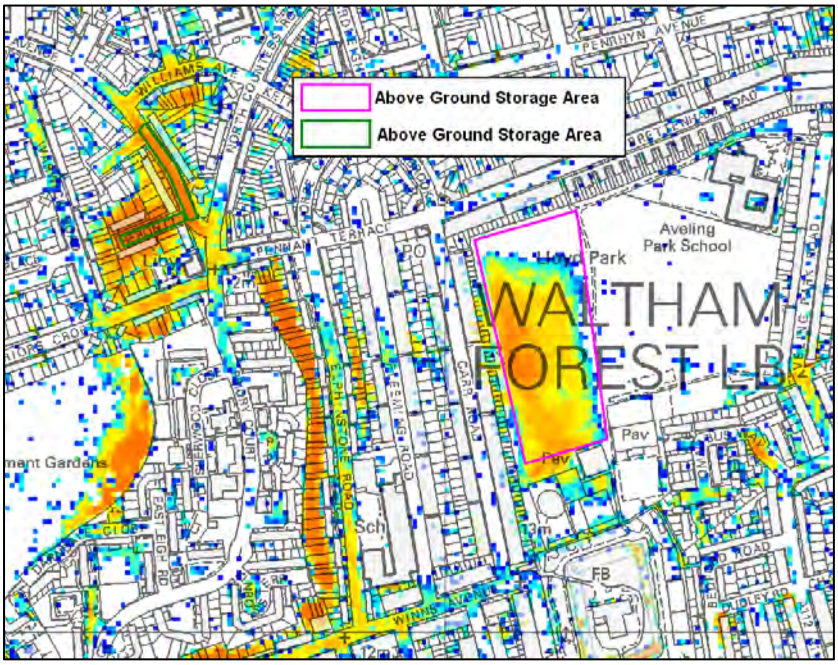
The preferred option for this CDA includes increasing the capacity in the existing drainage system serving the A12 and improving entry capacity. A targeted response in the event of flooding in the form of a flood plan is also recommended to assist in reducing the consequences.

Other measures that were considered include construction of an underground storage unit beneath the carriage way with increased entry capacity. As it is likely that the A12 is currently serviced by an existing drainage network or pumping system the installation of a storage unit is unlikely to be cost-beneficial.

**CDA: Group4_054**

The preferred option for this CDA includes the construction of above ground storage in Lloyd Park and below ground storage beneath Herons Close/Millfield Avenue. Retrofitting of flood resilience/resistance measures for the highest risk properties along Elphinstone Road are also recommended. Increasing the number of gullies in the local road network and improving the maintenance of the sewer system will help to ensure that the drainage network is used to full effect.

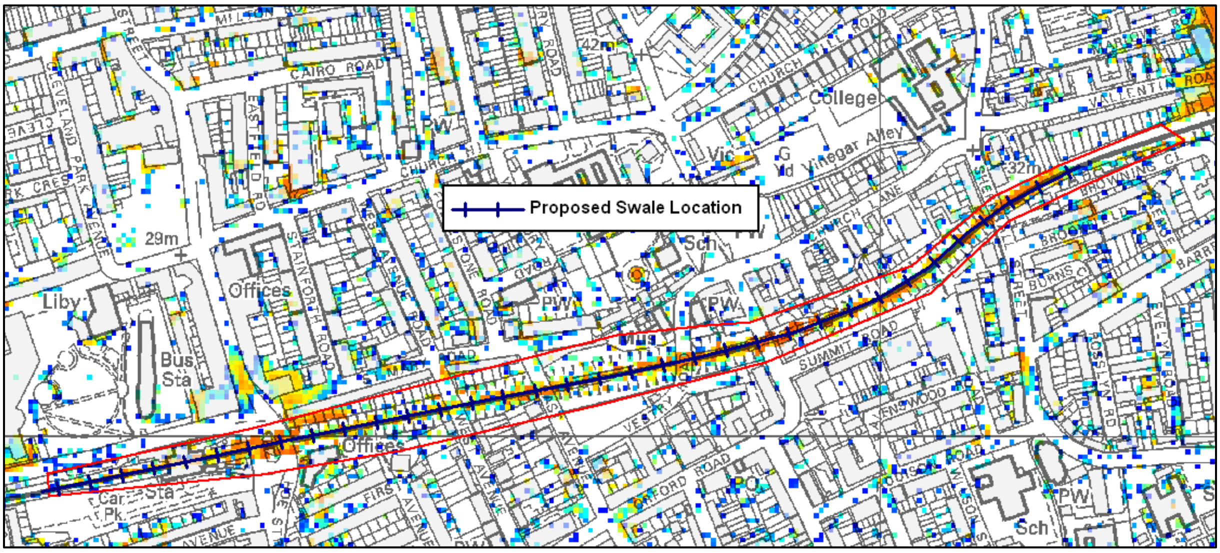
Other measures that were considered include increasing the capacity and realigning of the drainage system beneath North Countess Road in place of the above recommended above and below ground storage units. This measure was disregarded as there is the potential for an increase in flood risk to others downstream, unless the drainage network is increased to the outlet. Furthermore, this measure may not assist in alleviating flooding along Elphinstone Road and is therefore unlikely to be cost-beneficial.




**CDA: Group4_058**

The preferred option for this CDA includes the construction of a formalised swale running parallel to the railway line and the implementation of a regional transport flood plan.

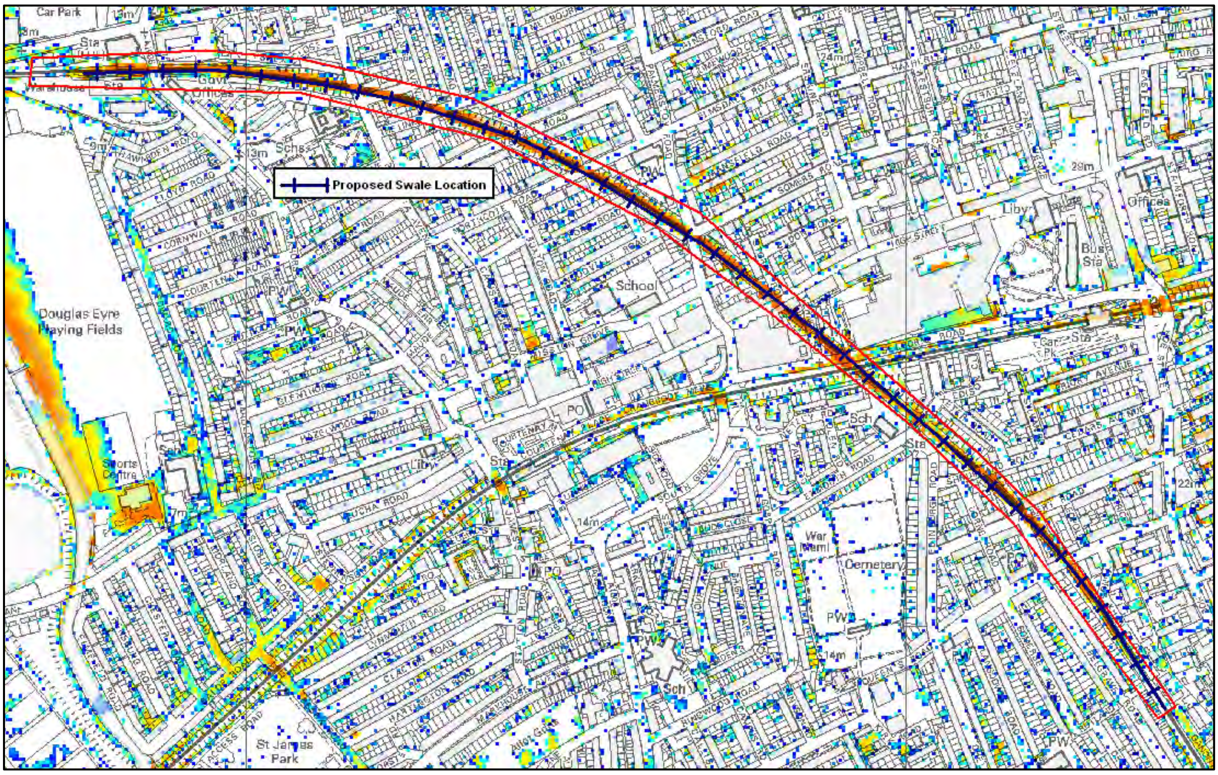
Other measures that were considered include increasing the capacity of the existing drainage system. This measure was disregarded as there is the potential to increase flood risk downstream if the existing drainage system that the railway drainage connects into does not have sufficient capacity.



**CDA: Group4_059**

The preferred option for this CDA includes the construction of a formalised swale running parallel to the railway line and the implementation of a regional transport flood plan.

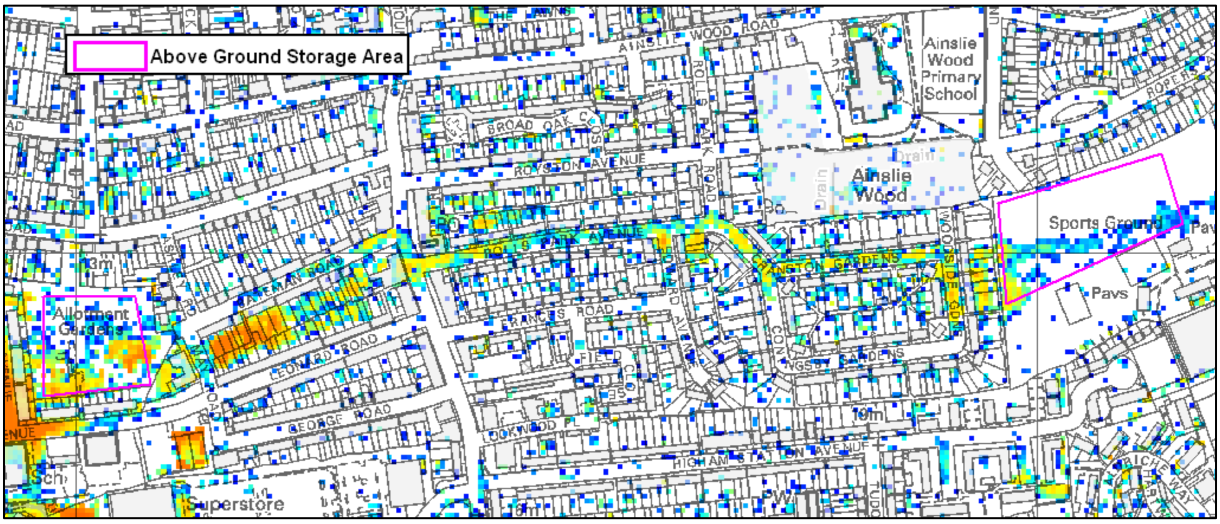
Other measures that were considered include increasing the capacity of the existing drainage system. This measure was disregarded as there is the potential to increase flood risk downstream if the existing drainage system that the railway drainage connects into does not have sufficient capacity.

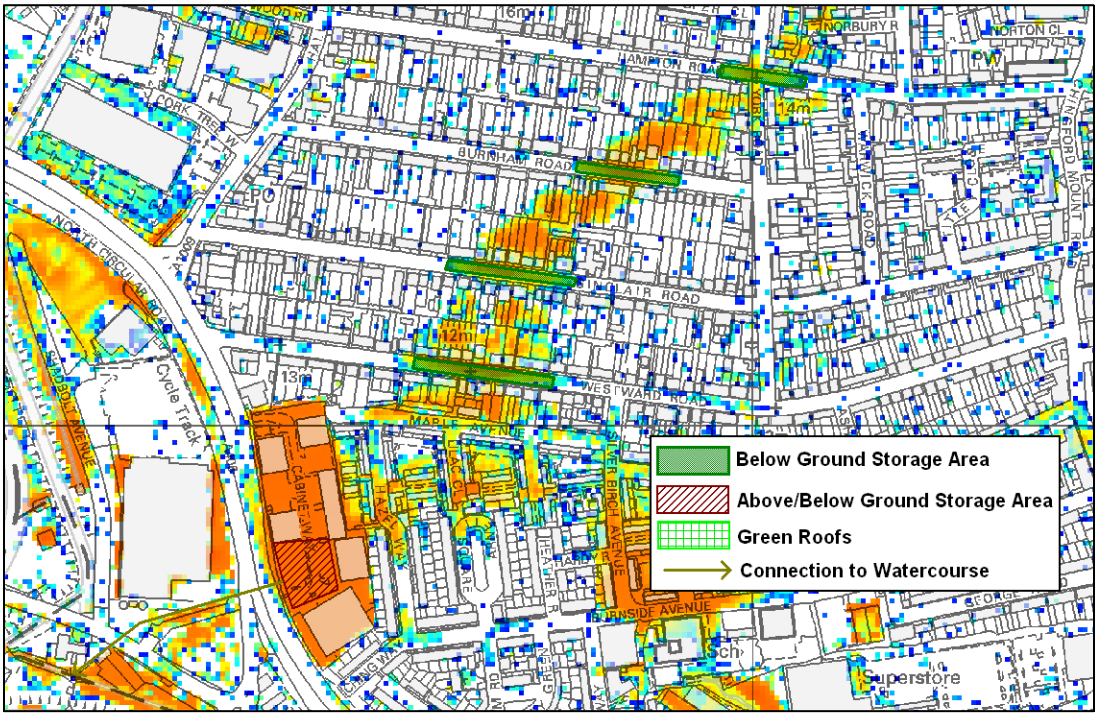



**CDA: Group4_064**

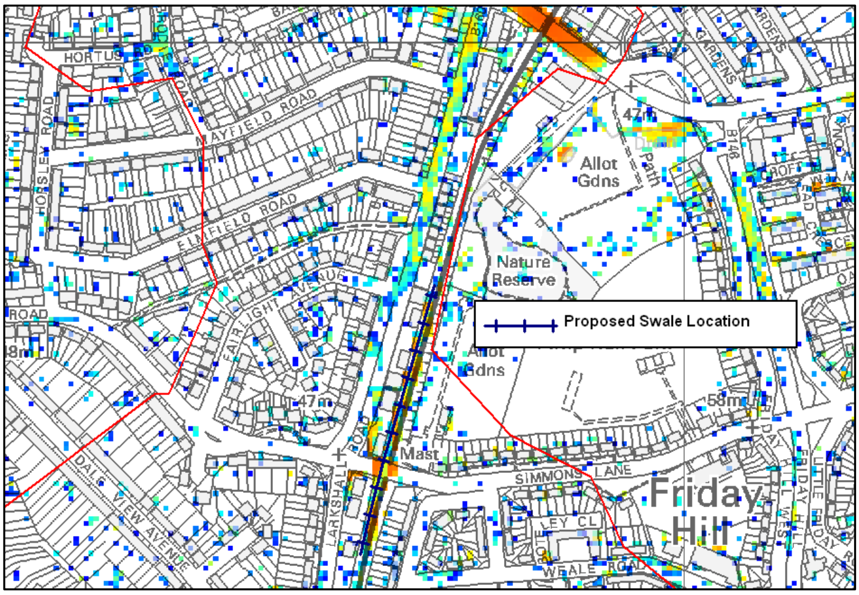
The preferred option for this CDA includes increasing capacity (e.g. wet well) of existing pumping station at Richmond Ave and include additional gullies in the local road network. The construction of above ground storage areas in Rolls Sports Ground (south of Lark Wood) and allotment gardens east of Rowan Avenue could assist in alleviating overland flow from the east. Underground storage incorporated beneath Hampton Road, Burnham Road, Sinclair Road, and Westward Road could attenuate flow from the north and reduce the amount of water ponding in Cabinet Way. Within Cabinet Way itself, storage facilities could be incorporated into paved areas and additional conveyance (large gullies and pipes) added between the low point in the Cabinet Way area to the River Ching upstream of the A406.

Other measures that were considered include retrofitting flood resistance/resilience measures to at risk properties and devising a community flood plan. This measure will reduce the consequences of flooding, but not the probability, hence the above approach is preferred.



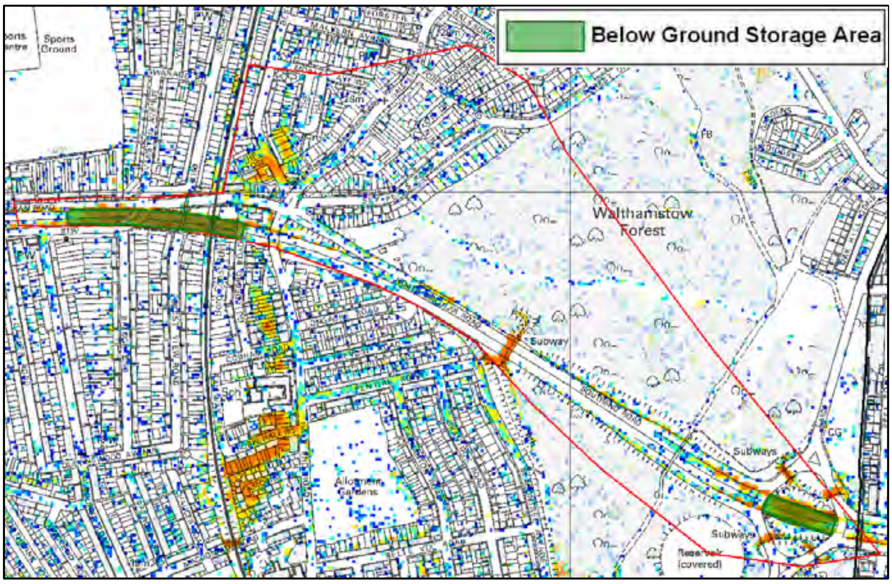
**CDA: Group4_065**




The preferred option for this CDA includes the construction of a swale parallel to the railway tracks. Improving entry capacities and increased maintenance regimes along New Road and Kings Road underpasses could help to reduce the amount of water ponding at these low points. The implementation of a regional transport flood plan will lessen the disruption to traffic should a flood event occur.

Other measures that were considered include constructing underground storage units beneath the railway line and beneath the road underpasses. This measure is unlikely to be cost-beneficial particularly for the roads. Another option considered was to carry out the preferred option without construction of the swale. This option was abandoned as it does not reduce the probability of flooding. As the railway line is of regional importance the above preferred option was favoured.

**CDA: Group4_066**

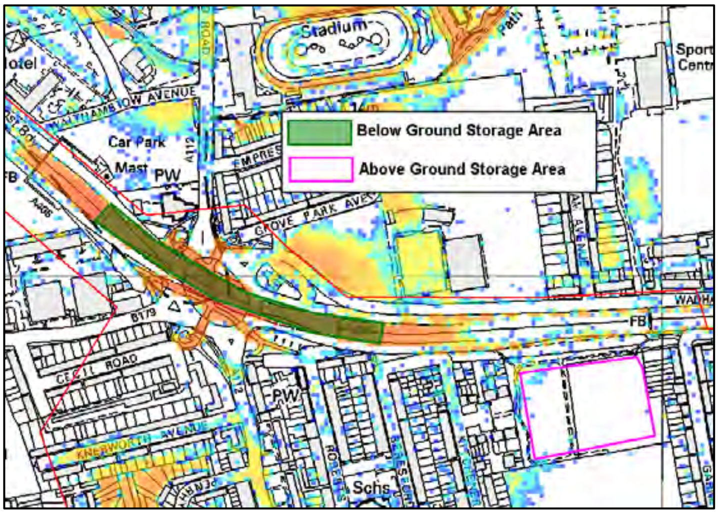



The preferred option for this CDA includes construction of underground storage beneath the North Circular at Woodford Road and Forest View underpasses along with increased entry capacities and maintenance regimes along Woodford View. The implementation of a regional transport flood plan will assist in minimising disruption to motorists during a flood event.

Another measure that was considered included increasing the conveyance of the existing drainage network in place of constructing underground storage units. This option was disregarded as there is the potential for the flood risk further downstream to increase as a result of these measures.

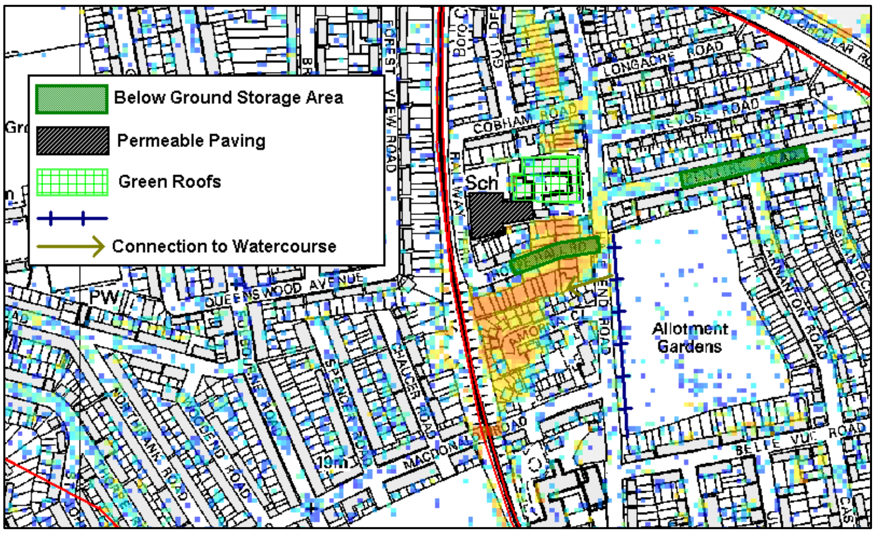
## CDA: Group4_067

The preferred option for this CDA includes the construction of additional storage beneath the A406 and in the adjacent playing fields. Increased maintenance regimes of gullies may assis in minimising the frequency of flooding. The implementation of a regional transport flood plan will assist in minimising disruption to motorists during a flood event.




Another measure that was considered included increasing the conveyance of the existing drainage network in place of constructing underground storage units. This option was disregarded as there is the potential for the flood risk further downstream to increase as a result of these measures.

## CDA: Group4_068




The preferred option for this CDA includes the construction of underground storage units beneath Pentire Road and Thorpe Hall Road along with localised entry capacity improvements in the road network.. The implementation of a swale along the western extent of the allotment gardens could capture surface water runoff before it enters the Local Flood Risk Zone. In addition, the retrofitting of SUDS measures such as green roofs and permeable paving at Thorpe Hall Primary School could assist in reducing local runoff.

Other measures that were considered include increasing the conveyance of the local drainage network. This option was disregarded as there is the potential to increase fluvial flood risk since the drainage network discharges to the watercourse behind Lamorna Close. Above ground storage in the allotment garden was considered in place of the swale however the option was abandoned as this is unlikely to be popular amongst residents.

## 4.5 Preferred Options Summary

4.5.1 It is recognised that numerous CDAs have been identified throughout the borough, and it may not be possible, with available resources and funds, to address identified surface water flood risk within all of these in the short to medium term. It is therefore important to prioritise those schemes that are deemed to be most beneficial and address those areas known to experience surface water flooding within the borough. Discussions with the LB of Waltham Forest through the Options Workshop and throughout the study have confirmed that priority should be assigned to addressing surface water flooding risk in those areas that:

- Experience regular or significant surface water / groundwater / sewer flooding;
- Contain basement properties;
- Contain critical infrastructure; and / or
- Through the pluvial modelling undertaken, are predicted to face significant surface water flooding depths (>0.5m) and hazard (high flow velocities and depth) for the 1 in 100 year rainfall event.

4.5.2 Table 4-2 provides an estimate of the percentage of surface water flood risk eliminated or mitigated as a result of implementing the preferred option. A capital cost band is also provided to give an indication as to the investment required. A band as opposed to a definitive figure has been provided to reflect the strategic nature of the SWMP study and options identification. All costs are indicative and should only be used for preliminary estimates due to the generalised nature of the information used to compile it. An estimated cost for the preferred flood mitigation option for each identified CDA has been calculated based on standard unit costs provided as part of Tier 1 of the Drain London Project to mitigate the 1 in 75 year event. No monetised damages have been calculated, and flood mitigation costs have been determined using engineering judgement, but have not undergone detailed analysis. The following standard assumptions have been applied, as determined in the Drain London Prioritisation Matrix Guidance:

- The costs are the capital costs for implementation of the scheme only.
- Costs do not include provisions for consultancy, design, supervision, planning process, permits, environmental assessment or optimum bias.
- No provision is made for weather (e.g. winter working).
- No provision is made for access constraints.
- Where required, it will be stated if costs include approximate land acquisition components.
- No operational or maintenance costs are included.
- No provision is made for disposal of materials (e.g. for flood storage or soakaway clearance).

## 4.6 Short – Medium Term Recommendations

4.6.1 Accounting for the nature of the surface water flooding in the LB of Waltham Forest, the options identified through the Phase 3 – Options Assessment, and requirements under the FWMA 2010 and Flood Risk Regulations 2009, it is considered that the following actions should be prioritised in the short to medium-term:

- Undertake a Surface Water Catchment Drainage Study for CDA's shown to be at highest risk in terms of number of receptors affected: Group4_048, Group4_054, and Group4_064. This assessment should be undertaken with the LB of Waltham Forest, Thames Water and TfL, to greater information on the flood risk within the CDAs along with obtaining a greater understanding of the drainage capacity within each area. It is recommended that the study continues the work undertaken as part of this SWMP and consider the following:
    - Determining the capacity in the existing sewer network, and likely spill volumes during the modelled return periods utilised in this study (refer to Section 3.3);
    - Update rainfall hyetographs utilised in the model so as to reflect the CDA area more accurately (only recommended for models which are trimmed to the CDA catchment);
    - Undertaking detailed pluvial modelling of the area, incorporating updated drainage capacity assumptions including sewer capacity information from Thames Water, where available;
    - Undertaking detailed pluvial modelling of the area, incorporating updated permeable area infiltration assumptions – ideally based on area/site specific permeability/percolation testing;
    - Identifying and recording surface water assets including their asset type, location and condition (required as part of the Asset Register);
    - Topographical survey of assets and structures which may influence flooding and overland flow paths – to be included in the 1D or 2D model element (as required) to provide a greater understanding of their influence;
    - Determining the current condition of gullies and carrier pipes;
    - Determining the capacity of gullies and carrier pipes;
    - Determining the connections to Thames Water surface water sewers and assets;
    - Undertaking CCTV surveys for those areas where there are known blockages in the local pipes and/or surface water sewers;
    - Clearing those gullies or pipes identified as blocked during investigations (as part of annual maintenance routine);
    - Determining upgrade requirements and costs for the local drainage infrastructure and seek funding opportunities to implement these; and
    - Providing updates to the Drain London pluvial models, to update the Flood Depth and Hazard maps for these areas with local drainage capacity information;

- Once updated modelling has been undertaken it is recommended that the preferred options for flood alleviation in the catchment (including the consideration of upgrades to the local and/or sewer drainage network, flood storage and/or source control SuDS) are reassessed through the detailed model, and that cost of implementing these are undertaken to identify the most cost-beneficial option(s) for mitigating surface water flood risk in the catchment.

- Undertake a feasibility study for providing source control and flow path management measures in all open space areas within the borough;

- Confirm the flood risk to all Network Rail, Transport for London and Highways Agency assets and agree a timeframe for the detailed assessment of areas of concern;

- Undertake a borough wide feasibility study to determine which roads may be retrofitted to include bioretention carpark pods;

- Improve maintenance regimes, and target those areas identified as having blocked gullies;

- Identify and record surface water assets as part of the Asset Register, prioritising those areas that are known to regularly flood and are therefore likely to require maintenance / upgrading in the short-term;

- Collate and review information on Ordinary Watercourses in the borough to gain an improved understanding of surface water flooding in the vicinity of these watercourses;

- Provide an 'Information Portal' via the LB of Waltham Forest website, for local flood risk information and measures that can be taken by residents to mitigate surface water flooding to / around their property. This could be developed in conjunction with the North London Strategic Flood Group and include:

    - A list of appropriate property-level flood risk resilience measures that could be installed in a property;

    - A list of 'approved' suppliers for providing local services, such as repaving of driveways, installation of rainwater tanks and water butts etc;

    - link to websites/information sources providing further information;

    - An update on work being undertaken in the borough by the Council and/or the Stakeholders to address surface water flood risk; and,

    - A calendar showing when gullies are to be cleaned in given areas, to encourage residents to ensure that cars are not parked over gullies / access is not blocked during these times.

- Production of a Communication Plan to effectively communicate and raise awareness of surface water flood risk to different audiences using a clearly defined process for internal and external communication with stakeholders and the public.

## 4.7 Option Prioritisation

4.7.1 The Prioritisation Matrix was developed out of the need for a robust, simple and transparent methodology to prioritise the allocation of funding for surface water management schemes across all the 33 London Boroughs by the Drain London Programme Board. As such, the prioritisation should be understood in the high-level decision-making context it was designed for. It is not intended to constitute a detailed cost-benefit analysis of individual surface water flood alleviation schemes nor to restrict the work that each LLFA may wish to seek funding for or commence.

4.7.2 The prioritisation methodology is primarily based upon existing Environment Agency and Defra guidance but has been tailored to the high-level prioritisation task at hand and is specific to the pan-London context.

4.7.3 The information within Table 4-2 was submitted for input into the Prioritisation Matrix by the Drain London Programme Board. The Board will then compare all Critical Drainage Area options across London and prioritise them for funding as part of Tier 3 works. Feedback will then be provided to all consultants at a London Borough level to influence the Action Plan prepared as part of Phase 4. CDA detailed investigations or 'quick win' measures receiving funding from Tier 3 will be identified as immediate actions, but others may require longer term planning and actions for implementation across relevant organisations.

4.7.4 Board feedback will be included in the final SWMP report.

**Table 4-2 Benefits and Costs of CDA Measures**

| CDA ID | Scheme Location | Scheme Category | Infrastructure | | | | | | Households | | | | Commercial / Industrial | | Capital Cost Band |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Essential | | Highly Vulnerable | | More Vulnerable | | Non-Deprived (All) | | Deprived (All) | | All | | |
| | | | Eliminated (%) | Mitigated (%) | Eliminated (%) | Mitigated (%) | Eliminated (%) | Mitigated (%) | Eliminated (%) | Mitigated (%) | Eliminated (%) | Mitigated (%) | Eliminated (%) | Mitigated (%) | |
| **Group4_046** | Leslie Road, Leyton | Other or combination of above | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 0 | 20 | 0 | 0 | **1m - 10m** |
| **Group4_047** | Leyton Grange and Primrose Road, Leyton | Other or combination of above | 0 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 10 | **1m - 10m** |
| **Group4_048** | Extensive drainage catchment beginning in Upper Walthamstow through to Leyton. | Other or combination of above | 0 | 25 | 15 | 0 | 0 | 25 | 0 | 5 | 0 | 0 | 0 | 30 | **1m - 10m** |
| **Group4_049** | The A12 underpass at Green Man Roundabout. | De-culvert / Increase conveyance | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **< 25k** |
| **Group4_052** | The A12 underpass ay Leytonstone Underground Station | De-culvert / Increase conveyance | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **< 25k** |
| **Group4_054** | Residential area at Heron Close near the intersection of Priors Croft and North Countess Road. | Other or combination of above | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 5 | 0 | 0 | 0 | 10 | **1m - 10m** |
| **Group4_058** | Walthamstow Railway and St Mary's Road | Other or combination of above | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **< 25k** |
| **Group4_059** | Blackhorse Road Station and Overground Railway line to the east. | Other or combination of above | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **26k - 50k** |
| **Group4_064** | Cabinet Way, Waltham Forest | Other or combination of above | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 5 | 0 | 0 | 0 | 15 | **1m - 10m** |
| **Group4_065** | The transport corridor between Chingford Green in the north and Friday Hill in the south. | Preferential / Designated Overland flow routes | 0 | 40 | 0 | 50 | 0 | 30 | 0 | 5 | 0 | 0 | 0 | 25 | **< 25k** |
| **Group4_066** | North circular underpasses through Waltham Forest at Forest View and Woodford Road/A104.. | Other or combination of above | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **101k - 250k** |
| **Group4_067** | The A406 North Circular at the Crooked Billet Roundabout. | Other or combination of above | 0 | 40 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | **101k - 250k** |
| **Group4_068** | Small section of ordinary watercourse behind Lamorna Crescent, Waltham Forest | Other or combination of above | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 20 | 0 | 0 | 0 | 0 | **251k - 500k** |

Note: The Drain London Prioritisation Matrix requires an estimation of the percentage of total number of units that have the potential to benefit from the proposed scheme. This has been determined by calculating the number of units within the LFRZ that the scheme has been designed to mitigate, as a percentage of the number of units within the CDA as a whole. The input is restricted to multiples of five percent (5%). It should be noted that the information within this table is purely for input into the Drain London Prioritisation Matrix and should be treated as such.

# 5 Phase 4: Implementation and Review

## 5.1 Action Plan

5.1.1 An Action Plan has been created for each LLFA within the Drain London area. The Action Plan is a simple summary spreadsheet that has been formulated by reviewing the previous phases of the SWMP in order to create a useful set of actions relating to the management and investigation of surface water flooding going forward. It is the intention that the Action Plan is a live document, maintained and regularly updated by the borough, as actions are progressed and investigated. It should be understood that following further detailed investigation the preferred option in each CDA, and even in some cases the need for any action other than basic investigation in a particular CDA may be discounted. Likewise new actions may be identified by the borough, or may be required by changing legislation and guidance overtime.

5.1.2 The Action Plan identifies (Table 5-1 outlines the Action Types used to categorise actions in the Action Plan):

- Actions required to satisfy the FWMA and FRR requirements, (these are common to all LLFAs);
- Future studies and consultations for investigation and confirming the level of flood risk within the borough;
- Who is responsible for delivery of each action, along with who might provide support;
- When actions should be undertaken, reviewed and updated.
- Linkages between actions;
- An estimation of costs for investigations and optioneering works – including possible sources of funding – for the CDAs within the borough;

**Table 5-1 Type of Actions within the Action Plan**

| Action Type | Abbreviation | Description |
|---|---|---|
| **Flood and Water Management Act / Flood Risk Regulations** | FWMA / FRR | Duties and actions as required by the FRR and FWMA - Refer to Appendix A of the LGG 'Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management' (February 2011) for minimum requirements |
| **Policy Action** | Policy | Spatial planning or development control actions |
| **Communication / Partnerships** | C + M | Actions to communicate risk internally or externally to LLFA or create / improve flood risk related partnerships |
| **Financial / Resourcing** | F + R | Actions to secure funding internally / externally to support works or additional resources to deliver actions |

| Action Type | Abbreviation | Description |
|---|---|---|
| **Investigation / Feasibility / Design** | I / F / D | Further investigation / feasibility study / Design of mitigation |
| **Flooding Mitigation Action** | FMA | Maintenance or capital works undertaken to mitigate flood risk |

## 5.2 Summary of Key Actions

5.2.1 The LB of Waltham Forest Action Plan has been delineated into the following themes:

- Actions for the Council to review with regard to the FWMA and FRR;
- General Actions and investigations that apply to the wider borough and can include the identified CDA's and consultation with the community; and
- CDA specific actions and investigations.

5.2.2

| ID | Action | | | Benefit |
|---|---|---|---|---|
| | What? | How? | Where? | |
| 1 | Take forward existing and future local actions in the SWMP | Continue to run a Flood Working Groups within the Council | Borough-wide | Co-ordinated delivery of local flood risk management within the borough |
| 2 | Take forward strategic existing and future actions in the SWMP that involve multiple boroughs or other flood risk management authorities | Continue to attend a working group similar to 'Drain London Group 4' | Sub-regional | Co-ordinated delivery of local flood risk management across the region |
| 3 | Develop, maintain, apply and monitor a Strategy for local flood risk management of the area. | Use the outcomes of the SWMP as the first stage of preparing a strategy. Refer to Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management 'A Living Document', February 2011, Local Government Association. | Borough-wide | Meeting obligations under the Floods and Water Management Act |
| 4 | Prepare a PFRA in relation to flooding in the LLFA's area. | Use the PFRA developed for Drain London as the basis for the next round of PFRAs in 2017 | Borough-wide | Meeting obligations under the Flood Risk Regulations |
| 5 | Prepare flood hazard maps and flood risk maps | In relation to each identified area of significant risk, a flood hazard map and a flood risk map need to be produced. The DL model results may be used as a starting point. Refer to Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management 'A Living Document', February 2011, Local Government Association. | Borough-wide | Meeting obligations under the Flood Risk Regulations |

| ID | Action | | | Benefit |
|---|---|---|---|---|
| | What? | How? | Where? | |
| 6 | Prepare flood risk management plans | A LLFA must prepare a flood risk management plan for each area of significant risk. | Borough-wide | Meeting obligations under the Flood Risk Regulations |
| 7 | Co-operation - Authorities must co-operate with each other in exercising functions under both the Act and the Regulations. | Regular sharing of data and expertise in addressing local flooding issues | Borough-wide | Meeting obligations under the Floods and Water Management Act |
| 8 | Duty to Maintain a Register | Establish and maintain a register of structures, including ownership which are believed to have a significant effect on a local flood risk. | Borough-wide | Meeting obligations under the Floods and Water Management Act. Improved understanding of local flood risk mechanisms and asset importance |
| 9 | Flood Incident Investigations | Investigate flooding incidents (where other risk management authorities do not respond and to the extent that it considers necessary or appropriate) to identify which authorities have relevant functions to deal with the flood and whether each of them intends to respond. | Borough-wide | Meeting obligations under the Floods and Water Management Act. Improved understanding of local flood risk issues. |
| 10 | Sustainable Development - contribute towards achievement of sustainable development. | Look for opportunities to integrate fluvial and surface water flood risk reduction measures | Borough-wide | Meeting obligations under the Floods and Water Management Act. Long term implementation of sustainable flood risk management. |
| 11 | Sustainable Drainage - LLFAs must establish a SuDS Approval Body (SAB) | SAB to potentially include representatives from Spatial Planning, Parks and Open Spaces, Highway Services, etc. Refer to Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management 'A Living Document', February 2011, Local Government Association. | Borough-wide | Meeting obligations under the Floods and Water Management Act. Long term implementation of sustainable flood risk management. |
| 12 | Investigate whether flooding incidents have occurred in Local Flood Risk Zones | Survey of local residents (e.g. mail drop, door knocking) | All Local Flood Risk Zones across the borough | Validate model outputs, resident 'buy in' |
| 13 | Record flooding incidents in a consistent manner | Use the standard data capture form developed as part of Drain London | Borough-wide | Consistency of data records across Greater London |
| 14 | Assess the accuracy of the standard Drain London drainage capacity assumptions to enable further local prioritisation of flood management options | Data sharing and meetings with Thames Water to discuss specific drainage capacity in CDAs using existing TWUL models (where available) | All CDAs across the borough | Refine understanding in CDAs |
| 15 | Ensure drainage systems are operating at capacity in Local Flood Risk Zones - maintenance of gullies | Review existing gully clearance/ maintenance schedules and if necessary revise/prioritise Local Flood Risk Zones | All Local Flood Risk Zones across the borough | Flooding isn't exacerbated |
| 16 | Ensure drainage systems are operating at capacity in Local Flood Risk Zones - maintenance of SW sewers | May require mapping of existing drainage infrastructure; Review existing maintenance schedules and if necessary revise/prioritise Local Flood Risk Zones | All Local Flood Risk Zones across the borough | Flooding isn't exacerbated |

| ID | Action | | | Benefit |
|---|---|---|---|---|
| | What? | How? | Where? | |
| 17 | Determine whether current emergency response to borough-wide surface water flooding are appropriate | Review the Multi-Agency Flood Plan in the context of the Drain London outputs, involving key transport providers such as TfL and Network Rail, as appropriate. | Borough-wide | Emergency response based no best available information |
| 18 | Review of the recorded incidents of basement flooding in the borough as well as groundwater borehole and geological conditions and develop a strategy to manage the problem. | Collate and investigate existing records of groundwater flooding reported by residents in basements. Use Drain London Potential Elevated Groundwater Map as an initial guide to target areas for improvement. Consider flood resilience/resistance measures that could be retrofitted to properties. | Borough-wide | Refine understanding of this borough wide problem and identify solutions and funding |
| 19 | Consider retrofitting flood resilience and resistance measures to basement properties where there is a history (and likely future risk) of groundwater ingress. | Impermeable membranes, additional drainage. | Borough-wide | Reduction in the probability of flooding |
| 20 | In Local Flood Risk Zones use SWMP mapped outputs to require developers to demonstrate compliance with PPS 25 by ensuring development will remain safe and will not increase risk to others, where necessary supported by more detailed integrated hydraulic modelling. | Development Control Policy | All Local Flood Risk Zones across the borough | Mid-long term reduction in the consequences of flooding |
| 21 | Developments in critical drainage areas to contribute to measures to reduce surface water flood risk in the CDA. | Section 106, Community Infrastructure Levy, Development Control Policy | All CDAs across the borough | Mid-long term reduction in the probability of flooding |
| 22 | Developments across the subcatchment to include at least one 'at source' SUDS measure, resulting in a net improvement in water quantity or quality discharging to sewer | Development Control Review and Monitoring of policy implementation | Borough-wide | Mid-long term reduce in flood risk and improvement in water quality |
| 23 | Developments across the borough greater than 0.5 hectares to reduce runoff from site by at least 50% | Development Control Review and Monitoring of policy implementation | Borough-wide | Mid-long term reduction in the probability of flooding |
| 24 | Developments greater than 0.5 hectare in Critical Drainage Areas to reduce runoff to predevelopment greenfield runoff rates | Development Control Review and Monitoring of policy implementation | All CDAs across the borough | Mid-long term reduction in the probability of flooding |

| ID | Action | | | Benefit |
|---|---|---|---|---|
| | What? | How? | Where? | |
| 25 | Determine capacity of existing drain system serving railway lines and the accuracy of the Drain London drainage capacity assumptions. | Detailed review of existing drainage information, survey and modelling if necessary | Stations and Railway lines on the Jubilee, District and Central Lines around Stratford and West Ham. National Rail East Anglia through Forest Gate and London Overground through Little Ilford. | Refine understanding of risk to critical infrastructure. Prioritise localised drainage improvements |
| 26 | Look for opportunities to reduce flood risk to critical transport infrastructure whilst upgrading the existing drainage network | Review the London Underground drainage catchments proposed for improvement against the Drain London outputs. | Borough-wide | Refine understanding of risk to critical infrastructure. Prioritise localised drainage improvements |
| 27 | Determine whether services (e.g. power, telecommunications) are resilient to surface water flooding | Provide outputs of Drain London to critical services providers and meet to discuss the overall resilience of service across the borough | Borough-wide | Community resilience to flooding |
| 28 | Installation of additional road gullies or alternative drainage systems to reduce standing water depth and duration in local flood risk zones | As part of highways improvement programme include additional construction task of installing additional gullies or alternative drainage systems where feasible. Consultation with Thames Water may be required. | In relevant CDAs across the borough | Reduction in the probability of flooding |
| 29 | Consider undertaking more detailed modelling particularly around critical underpasses and tunnels or where FAS exist | | CDAs of national importance | Refine understanding in CDAs |
| 30 | Determine standard of protection offered by pumps/drainage serving critical transport infrastructure underpasses - e.g. A12 | Discussions with TFL and Thames Water. Review of existing network models or design standard. Establish need for more detailed analysis and/or higher standard of protection. | The A12 underpass at Green Man Roundabout; The A12 underpass at Leytonstone underground station; Central line between Leyton and Stratford; Walthamstow Railway (near to Walthamstow Central); Richmond Ave, Hale End; North circular underpasses through Waltham Forest. | Refine understanding in CDAs |

| ID | Action | | | Benefit |
|---|---|---|---|---|
| | What? | How? | Where? | |
| 31 | Seek opportunities within all Masterplans and Area Action Plans to integrate fluvial and surface water flood risk reduction measures | Development Control Review and Monitoring of policy implementation | All Masterplans and Area Action Plans | Mid-long term reduce in flood risk and improvement in water quality |
| 32 | Ensure any development in a CDA falling within a Strategic Growth area/Area Action Plan to reduce runoff to predevelopment Greenfield runoff rates. | Area Action Plan | All Strategic Growth Areas and Area Action Plans | Long term reduction in flood risk in the CDA |
| 33 | Carry out a feasibility study including further investigation of the technical issues and consultation with local stakeholders | Feasibility investigation, including either use of Thames Water models or refined Drain London model. | All CDAs across the borough | Refine understanding in CDAs |
| 34 | Seek to include SUDS retrofitting policies to enhance or replace conventional drainage systems in LFRZs, or elsewhere as opportunities arise | Development Control Review and Monitoring of policy implementation | Borough-wide | Mid-long term reduce in flood risk and improvement in water quality |
| 35 | Investigate relationship between existing Foul Water pumping stations on the Surface Water system. | Map locations of existing FW pumping stations; assess standard of protection/vulnerability to storm flows | Borough-wide | Refine understanding of the relationship between both systems. |
| 36 | Determine areas within the Borough which are appropriate for retrofitting bioretention basins and carparking pods | Desktop study to determine feasibility of incorporating these SUDs within the Borough | Borough-wide | Findings will indicate areas appropriate within the Borough. Will assist in reducing runoff volumes and improving the water quality discharging to watercourses |

5.2.3 provides a summary of the Action Plan. The complete version of the Action Plan is held and maintained by the LB of Waltham Forest.

**Table 5-2 Action Plan Summary**

| ID | Action – What? | Action – How? | Action – Where? | Benefit | Potential Funding Source | Timing – Timeframe | Timing – Approx. Duration | Responsibility – Lead Organisation | Responsibility – LLFA Dept. | Responsibility – Primary Support | Other Stakeholders |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Take forward existing and future local actions in the SWMP | Continue to run a Flood Working Groups within the Council | Borough-wide | Co-ordinated delivery of local flood risk management within the borough | LB only | Short | Short | LB Waltham Forest | *Unknown* | Other members of working Group | |
| 2 | Take forward strategic existing and future actions in the SWMP that involve multiple boroughs or other flood risk management authorities | Continue to attend a working group similar to 'Drain London Group 4' | Sub-regional | Co-ordinated delivery of local flood risk management across the region | LB only | Short | Short | LB Waltham Forest | *Unknown* | Other Group 4 Boroughs | Environment Agency, Thames Water, TfL, Network Rail |
| 3 | Develop, maintain, apply and monitor a Strategy for local flood risk management of the area. | Use the outcomes of the SWMP as the first stage of preparing a strategy. Refer to Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management 'A Living Document', February 2011, Local Government Association. | Borough-wide | Meeting obligations under the Floods and Water Management Act | LB only | Medium | Short | LB Waltham Forest | *Unknown* | Environment Agency | |
| 4 | Prepare a PFRA in relation to flooding in the LLFA's area. | Use the PFRA developed for Drain London as the basis for the next round of PFRAs in 2017 | Borough-wide | Meeting obligations under the Flood Risk Regulations | LB only | Long | Short | LB Waltham Forest | *Unknown* | Environment Agency | |
| 5 | Prepare flood hazard maps and flood risk maps | In relation to each identified area of significant risk, a flood hazard map and a flood risk map need to be produced. The DL model results may be used as a starting point. Refer to Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management 'A Living Document', February 2011, Local Government Association. | Borough-wide | Meeting obligations under the Flood Risk Regulations | LB only | Medium | Short | LB Waltham Forest | *Unknown* | Environment Agency | |
| 6 | Prepare flood risk management plans | A LLFA must prepare a flood risk management plan for each area of significant risk. | Borough-wide | Meeting obligations under the Flood Risk Regulations | LB only | Medium | Short | LB Waltham Forest | *Unknown* | Environment Agency | |
| 7 | Co-operation - Authorities must co-operate with each other in exercising functions under both the Act and the Regulations. | Regular sharing of data and expertise in addressing local flooding issues | Borough-wide | Meeting obligations under the Floods and Water Management Act | LB only | Short | Long | LB Waltham Forest | *N/A* | Environment Agency, Thames Water | TfL, Network Rail |
| 8 | Duty to Maintain a Register | Establish and maintain a register of structures, including ownership which are believed to have a significant effect on a local flood risk. | Borough-wide | Meeting obligations under the Floods and Water Management Act. Improved understanding of local flood risk mechanisms and asset importance | LB only | Short | Long | LB Waltham Forest | *Unknown* | Environment Agency | |
| 9 | Flood Incident Investigations | Investigate flooding incidents (where other risk management authorities do not respond and to the extent that it considers necessary or appropriate) to identify which authorities have relevant functions to deal with the flood and whether each of them intends to respond. | Borough-wide | Meeting obligations under the Floods and Water Management Act. Improved understanding of local flood risk issues. | LB only | Short | Long | LB Waltham Forest | *Unknown* | | |
| 10 | Sustainable Development - contribute towards achievement of sustainable development. | Look for opportunities to integrate fluvial and surface water flood risk reduction measures | Borough-wide | Meeting obligations under the Floods and Water Management Act. Long term implementation of sustainable flood risk management. | LB only | Short | Long | LB Waltham Forest | *Development Control* | All other LLFA Departments | |

| ID | Action | | | Benefit | Potential Funding Source | Timing | | Responsibility | | | Other Stakeholders |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What? | How? | Where? | | | Timeframe | Approx. Duration | Lead Organisation | LLFA Dept. | Primary Support | |
| 11 | Sustainable Drainage - LLFAs must establish a SuDS Approval Body (SAB) | SAB to potentially include representatives from Spatial Planning, Parks and Open Spaces, Highway Services, etc. Refer to Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management 'A Living Document', February 2011, Local Government Association. | Borough-wide | Meeting obligations under the Floods and Water Management Act. Long term implementation of sustainable flood risk management. | LB only | Short | Long | LB Waltham Forest | *Unknown* | | |
| 12 | Investigate whether flooding incidents have occurred in Local Flood Risk Zones | Survey of local residents (e.g. mail drop, door knocking) | All Local Flood Risk Zones across the borough | Validate model outputs, resident 'buy in' | LB only | Short | 1 year | LB Waltham Forest | *Unknown* | | Local Residents |
| 13 | Record flooding incidents in a consistent manner | Use the standard data capture form developed as part of Drain London | Borough-wide | Consistency of data records across Greater London | LB only | Short | Long | LB Waltham Forest | *Unknown* | | |
| 14 | Assess the accuracy of the standard Drain London drainage capacity assumptions to enable further local prioritisation of flood management options | Data sharing and meetings with Thames Water to discuss specific drainage capacity in CDAs using existing TWUL models (where available) | All CDAs across the borough | Refine understanding in CDAs | LB only | Short | 1 year | LB Waltham Forest | *Unknown* | Thames Water | |
| 15 | Ensure drainage systems are operating at capacity in Local Flood Risk Zones - maintenance of gullies | Review existing gully clearance/ maintenance schedules and if necessary revise/prioritise Local Flood Risk Zones | All Local Flood Risk Zones across the borough | Flooding isn't exacerbated | LB only | Short | 1 year | LB Waltham Forest | *Unknown* | TfL | Thames Water |
| 16 | Ensure drainage systems are operating at capacity in Local Flood Risk Zones - maintenance of SW sewers | May require mapping of existing drainage infrastructure; Review existing maintenance schedules and if necessary revise/prioritise Local Flood Risk Zones | All Local Flood Risk Zones across the borough | Flooding isn't exacerbated | LB only | Short | 1 year | LB Waltham Forest | *Unknown* | Thames Water | |
| 17 | Determine whether current emergency response to borough-wide surface water flooding are appropriate | Review the Multi-Agency Flood Plan in the context of the Drain London outputs, involving key transport providers such as TfL and Network Rail, as appropriate. | Borough-wide | Emergency response based no best available information | LB only | Short | 1 year | LB Waltham Forest | *Emergency Planning / Civil Contingencies* | Local Resilience Forum | TfL, Network Rail |
| 18 | Review of the recorded incidents of basement flooding in the borough as well as groundwater borehole and geological conditions and develop a strategy to manage the problem. | Collate and investigate existing records of groundwater flooding reported by residents in basements. Use Drain London Potential Elevated Groundwater Map as an initial guide to target areas for improvement. Consider flood resilience/resistance measures that could be retrofitted to properties. | Borough-wide | Refine understanding of this borough wide problem and identify solutions and funding | LB only | Medium | 1 year | LB Waltham Forest | *Drainage Engineering* | | Local Residents |
| 19 | Consider retrofitting flood resilience and resistance measures to basement properties where there is a history (and likely future risk) of groundwater ingress. | Impermeable membranes, additional drainage. | Borough-wide | Reduction in the probability of flooding | Property Level Flood Protection (Defra) | Long | 10 years | LB Waltham Forest | *Drainage Engineering* | | Local Residents |

| ID | Action | | | Benefit | Potential Funding Source | Timing | | Responsibility | | | Other Stakeholders |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What? | How? | Where? | | | Timeframe | Approx. Duration | Lead Organisation | LLFA Dept. | Primary Support | |
| 20 | In Local Flood Risk Zones use SWMP mapped outputs to require developers to demonstrate compliance with PPS 25 by ensuring development will remain safe and will not increase risk to others, where necessary supported by more detailed integrated hydraulic modelling. | Development Control Policy | All Local Flood Risk Zones across the borough | Mid-long term reduction in the consequences of flooding | Private developer | Short | LDF Plan Period | LB Waltham Forest | *Development Control* | Environment Agency | |
| 21 | Developments in critical drainage areas to contribute to measures to reduce surface water flood risk in the CDA. | Section 106, Community Infrastructure Levy, Development Control Policy | All CDAs across the borough | Mid-long term reduction in the probability of flooding | Private developer | Short | LDF Plan Period | LB Waltham Forest | *Spatial Planning* | Environment Agency | |
| 22 | Developments across the subcatchment to include at least one 'at source' SUDS measure, resulting in a net improvement in water quantity or quality discharging to sewer | Development Control Review and Monitoring of policy implementation | Borough-wide | Mid-long term reduce in flood risk and improvement in water quality | Private developer | Short | LDF Plan Period | LB Waltham Forest | *Spatial Planning* | Environment Agency | |
| 23 | Developments across the borough greater than 0.5 hectares to reduce runoff from site by at least 50% | Development Control Review and Monitoring of policy implementation | Borough-wide | Mid-long term reduction in the probability of flooding | Private developer | Short | LDF Plan Period | LB Waltham Forest | *Spatial Planning* | Environment Agency | |
| 24 | Developments greater than 0.5 hectare in Critical Drainage Areas to reduce runoff to predevelopment greenfield runoff rates | Development Control Review and Monitoring of policy implementation | All CDAs across the borough | Mid-long term reduction in the probability of flooding | Private developer | Short | LDF Plan Period | LB Waltham Forest | *Spatial Planning* | Environment Agency | |
| 25 | Determine capacity of existing drain system serving railway lines and the accuracy of the Drain London drainage capacity assumptions. | Detailed review of existing drainage information, survey and modelling if necessary | Stations and Railway lines on the Jubilee, District and Central Lines around Stratford and West Ham. National Rail East Anglia through Forest Gate and London Overground through Little Ilford. | Refine understanding of risk to critical infrastructure. Prioritise localised drainage improvements | Network Rail/TfL | Medium | 1-2 years | Network Rail/TfL | *N/A* | Thames Water | |
| 26 | Look for opportunities to reduce flood risk to critical transport infrastructure whilst upgrading the existing drainage network | Review the London Underground drainage catchments proposed for improvement against the Drain London outputs. | Borough-wide | Refine understanding of risk to critical infrastructure. Prioritise localised drainage improvements | TfL | Medium | 1-2 years | TfL | *N/A* | LB Waltham Forest | Thames Water |
| 27 | Determine whether services (e.g. power, telecommunications) are resilient to surface water flooding | Provide outputs of Drain London to critical services providers and meet to discuss the overall resilience of service across the borough | Borough-wide | Community resilience to flooding | Service providers | Short | 1 year | Service Providers | *N/A* | LB Waltham Forest | |

| ID | Action | | | Benefit | Potential Funding Source | Timing | | Responsibility | | | Other Stakeholders |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What? | How? | Where? | | | Timeframe | Approx. Duration | Lead Organisation | LLFA Dept. | Primary Support | |
| 28 | Installation of additional road gullies or alternative drainage systems to reduce standing water depth and duration in local flood risk zones | As part of highways improvement programme include additional construction task of installing additional gullies or alternative drainage systems where feasible. Consultation with Thames Water may be required. | In relevant CDAs across the borough | Reduction in the probability of flooding | LB only | Short | Ongoing | LB Waltham Forest | *Transport / Highways* | TfL | Thames Water |
| 29 | Consider undertaking more detailed modelling particularly around critical underpasses and tunnels or where FAS exist | | CDAs of national importance | Refine understanding in CDAs | | Short | | LB Waltham Forest | *Drainage Engineering* | | |
| 30 | Determine standard of protection offered by pumps/drainage serving critical transport infrastructure underpasses - e.g. A12 | Discussions with TFL and Thames Water. Review of existing network models or design standard. Establish need for more detailed analysis and/or higher standard of protection. | The A12 underpass at Green Man Roundabout; The A12 underpass at Leytonstone underground station; Central line between Leyton and Stratford; Walthamstow Railway (near to Walthamstow Central); Richmond Ave, Hale End; North circular underpasses through Waltham Forest. | Refine understanding in CDAs | | Medium | 6 months | TfL | *N/A* | LB Waltham Forest/Thames Water | |
| 31 | Seek opportunities within all Masterplans and Area Action Plans to integrate fluvial and surface water flood risk reduction measures | Development Control Review and Monitoring of policy implementation | All Masterplans and Area Action Plans | Mid-long term reduce in flood risk and improvement in water quality | Private developer | Short | LDF Plan Period | LB Waltham Forest | *Spatial Planning* | | |
| 32 | Ensure any development in a CDA falling within a Strategic Growth area/Area Action Plan to reduce runoff to predevelopment Greenfield runoff rates. | Area Action Plan | All Strategic Growth Areas and Area Action Plans | Long term reduction in flood risk in the CDA | Private developer | Short | LDF Plan Period | LB Waltham Forest | *Spatial Planning* | Environment Agency | |
| 33 | Carry out a feasibility study including further investigation of the technical issues and consultation with local stakeholders | Feasibility investigation, including either use of Thames Water models or refined Drain London model. | All CDAs across the borough | Refine understanding in CDAs | LB only | Short | 5 years | LB Waltham Forest | *Unknown* | Thames Water | Environment Agency |
| 34 | Seek to include SUDS retrofitting policies to enhance or replace conventional drainage systems in LFRZs, or elsewhere as opportunities arise | Development Control Review and Monitoring of policy implementation | Borough-wide | Mid-long term reduce in flood risk and improvement in water quality | Private developer | Short | LDF Plan Period | LB Waltham Forest | *Spatial Planning* | | |
| 35 | Investigate relationship between existing Foul Water pumping stations on the Surface Water system. | Map locations of existing FW pumping stations; assess standard of protection/vulnerability to storm flows | Borough-wide | Refine understanding of the relationship between both systems. | Thames Water | Medium | 1-2 years | LB Waltham Forest | *Transport / Highways* | Thames Water | |

| ID | Action | | | Benefit | Potential Funding Source | Timing | | Responsibility | | | Other Stakeholders |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What? | How? | Where? | | | Timeframe | Approx. Duration | Lead Organisation | LLFA Dept. | Primary Support | |
| 36 | Determine areas within the Borough which are appropriate for retrofitting bioretention basins and carparking pods | Desktop study to determine feasibility of incorporating these SUDs within the Borough | Borough-wide | Findings will indicate areas appropriate within the Borough. Will assist in reducing runoff volumes and improving the water quality discharging to watercourses | LB only | Medium | 1-2 years | LB Waltham Forest | *Development Control* | Thames Water | Environment Agency and TfL |

## 5.3 Implementation Programme

5.3.1 Gantt chart to follow once Peer Review and Action Plan review complete.

## 5.4 Review Timeframe and Responsibilities

5.4.1 Proposed actions have been classified into the following categories:

- Short term; Actions to be undertaken within the next 12 months
- Medium term: Actions to be undertaken within the next 1 to 5 years.
- Long term. Actions to be undertaken beyond 5 years.

5.4.2 The Action Plan identifies the relevant internal departments and external partnerships that should be consulted and asked to participate when addressing an action. After an action has been addressed, it is recommended that the responsible department (responsible for completing the action) review the Action Plan and update it to reflect any issues (communication or stakeholder participation) which arose during the completion of an action and whether or not additional actions are required.

5.4.3 It is recommended that the Action Plan is reviewed and updated on a quarterly basis to reflect any necessary amendments. In order to capture the works undertaken by the Council and other stakeholders, it is recommended that the Action Plan review should not be greater than an annual basis. For clarity, it is noted that the FWMA places immediate or in some cases imminent new responsibilities on Lead Local Flood Authorities, of which LB Waltham Forest is one. The main actions required are contained in the Action Plan (Action ID Numbers 3 - 13) but are also summarised below:

- Develop, maintain, apply and monitor a Strategy for local flood risk management of the area.
- Duty to maintain a local flood risk asset register.
- Investigate flood incidents and record in a consistent manner.
- Establish a SuDS Approval Body (SAB).
- Contribute towards achievement of sustainable development.
- On-going responsibility to co-operate with other authorities through sharing of data and expertise.
- Preparation of flood risk management plans

## 5.5 Ongoing Monitoring

5.5.1 The partnership arrangements established as part of the SWMP process (e.g. LB of Waltham Forest, neighbouring boroughs, EA and TWUL, etc, working in collaboration) should continue beyond the completion of the SWMP in order to discuss the implementation of the proposed actions, review opportunities for operational efficiency and to review any legislative changes.

5.5.2 In addition, maintaining the working partnership between the 'Group 4' group of boroughs is recommended in order to gain an understanding of flood risk across the boroughs and to share best practice management procedures.

5.5.3 The SWMP Action Plan should be reviewed and updated annually as a minimum, but there may be circumstances which might trigger a review and/or an update of the Action Plan in the interim. In fact, Action Plan updates may be as frequent as every few months. Examples of something which would be likely to trigger an Action Plan review include:

- Occurrence of a surface water flood event;
- Additional data or modelling becoming available, **which may alter the understanding of risk within the study area**;
- Outcome of investment decisions by partners is different to the preferred option, which may require a revision to the action plan, and;
- Additional (**major**) development or other changes in the catchment which may affect the surface water flood risk.

5.5.4 It is in the interest of LB of Waltham Forest that the SWMP Action Plan remains current and up-to-date. To help facilitate this, it would be useful for the LB of Waltham Forest to liaise with other flood risk management authorities and monitor progress.

## 5.6 Incorporating new datasets

5.6.1 The following tasks should be undertaken when including new datasets in the LB of Waltham Forest SWMP:

- Identify new dataset.
- Save new dataset/information.
- Record new information in log so that next update can review this information.

## 5.7 Updating SWMP Reports and Figures

5.7.1 In recognition that the SWMP will be updated in the future, the report has been structured in chapters according to the SWMP guidance provided by Defra. By structuring the report in this way, it is possible to undertake further analyses on a particular source of flooding and only have to supersede the relevant chapter, whilst keeping the remaining chapters unaffected.

5.7.2 In keeping with this principle, the following tasks should be undertaken when updating SWMP reports and figures:

- Undertake further analyses as required after SWMP review
- Document all new technical analyses by rewriting and replacing relevant chapter(s) and appendices.
- Amend and replace relevant SWMP Maps.

- Reissue to departments within the LB of Waltham Forest and other stakeholders.

# 6 References

Cabinet Office, June 2008, The Pitt Review - Learning Lessons from the 2007 Floods

Capita Symonds Ltd, 2011, Preliminary Flood Risk Assessment for London Borough of Waltham Forest

Defra, March 2005, Making Space for Water - Taking forward a new Government strategy for Flood and Coastal Erosion Risk Management in England

Defra/Environment Agency, September 2005, Flood and Coastal Defence R&D Programme: Preliminary Rainfall Runoff Management for Developments (R&D Technical Report W5-074/A/TR/1 Revision D)

Defra, 2006, Flood and Coastal Defence Appraisal Guidance, FCDPAG3 Economic Appraisal, Supplementary Note to Operating Authorities – Climate Change Impacts October 2006. http://www.defra.gov.uk/environment/flooding/documents/policy/guidance/fcdpag/fcd3climate.pdf

Defra, 2008, The Government's Response to Sir Michael Pitt's Review of the Summer 2007 Floods http://www.defra.gov.uk/environment/flooding/documents/risk/govtresptopitt.pdf

Defra, March 2010, Surface Water Management Plan Technical Guidance

Defra, March 2010, Surface Water Management Plan Technical Appendices

Environment Agency, December 2010, Preliminary Flood Risk Assessment (PFRA) Final Guidance, Report GEHO1210BTGH-E-E

Environment Agency, December 2010, Preliminary Flood Risk Assessment (PFRA) Annexes to the Final Guidance, Report GEHO1210BTHF-E-E

Greater London Authority, 2010, Drain London: Data and Modelling Framework

Greater London Authority, 2010, Drain London: Data and Modelling Framework Appendices

Local Government Group, February 2011, Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management 'A Living Document'
http://www.lga.gov.uk/lga/aio/17064046

Mouchel, August 2008, North London Strategic Flood Risk Assessment

WSP, February 2010, Thatcham Surface Water Management Plan Volume One

# Appendix A Data Review

Currently being drafted

# Appendix B Asset Register Recommendation

Currently being drafted

# Appendix C Risk Assessment: Technical Details

Appendix C consists of the following subsections:

C1 – Surface Water Modelling
C2 – Groundwater

# Appendix C1 Surface Water Modelling

Refer to separate report “Waltham Forest SWMP Appendix C1: Surface Water Modelling Technical Report”

# Appendix C2 Groundwater

Refer to separate report "Waltham Forest SWMP Appendix C2: Groundwater Assessment Report"

# Appendix D Maps

The following maps are referenced as figures in the text of this SWMP report:

| Figure Number | Description |
|---|---|
| Figure 24: CDA_068 | CDA_068 – 1 in 100 year rainfall event Flood Hazard |

# Appendix E Option Assessment Details

To be provided following Peer Review

# Appendix F Peer Review

To be provided following Peer Review

# Appendix G Spatial Planner Information Pack

Awaiting from GLA/Tier 1 - DL agreeing London wide approach

# Appendix H Resilience Forum and Emergency Planner Information Pack

Awaiting from GLA/Tier 1 - DL agreeing London wide approach

# Appendix I

Ground Investigation

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# DRAFT

## Evolve Norse Ltd

## Ground Investigation

**Yardley Primary School**
**Hawkwood Crescent**
**London**
**E4 7PH**

**Report Ref: 24.09.031-dr01**
**January 2025**

MAIN OFFICE & LABORATORIES
Slapton Hill Barn, Blakesley Road, Slapton, Towcester, Northamptonshire. NN12 8QD
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# DOCUMENT RECORD

| | |
|---|---|
| **Report Title** | Ground Investigation Report |
| **Project Address** | Yardley Primary School, Hawkwood Crescent, London, E4 7PH |
| **Project Ref** | 24.09.031 |
| **Client** | Evolve Norse Ltd |

| | <u>**Signature**</u> | <u>**Name and Qualifications**</u> |
|---|---|---|
| **Prepared By:** | | **Benjamin Lee**<br>**Senior Geotechnical Engineer**<br>BSc (Hons), FGS |
| **Checked and Approved By:** | | **Tom Johnson**<br>**Associate Director**<br>BSc (Hons), MSc, FGS, CGeol |

**For and on behalf of ListersGeo, trading name of Listers Geotechnical Consultants Ltd**

| Issue No | Date | Status |
|---|---|---|
| **dr01** | 17th January 2025 | Draft Report |
| | | |

## EXECUTIVE SUMMARY

| | |
|---|---|
| **Project Reference** | 24.09.031 |
| **Site Location** | Yardley Primary School, Hawkwood Crescent, London, E4 7PH |
| **OS Grid Reference** | 537962, 195506 |
| **Development Proposals** | New two-storey education facility building with associated access road, car park and limited areas of soft landscaping. |
| **Current Site Use** | One- and two-storey building associated with the school with associated car park and areas of soft landscaping. |
| **Topography** | The site slopes down to the west. Slopes with retaining walls up to 1m high are present in the south-east of the site to accommodate steps and footpaths surrounding the building. A slope with a retaining wall up to approximately 2.0m high defines the western and north-western site boundary. |
| **Vegetation** | A few mature trees and bushes are present along the southern and eastern site boundary. Mature woodland extends on to the northern section of the site. |
| **Published Geology** | Artificial Ground: None recorded on-site, but thicknesses are anticipated beneath the site associated with the construction of the existing building and historical landscaping activities.<br>Superficial geology: None mapped on-site, but potential for Head.<br>Bedrock geology: London Clay Formation. |
| **Hydrology** | An unnamed tributary stream is located approximately 16m north of the site. |
| **Hydrogeology** | London Clay Formation: Unproductive Bedrock Aquifer.<br>The site is recorded within a Zone 2 Source Protection Zones (SPZ) for a potable groundwater abstraction. |
| **Site History** | Agricultural field with woodland to north from as early as 1863, until circa 1959 when the existing building is mapped, with sloping ground to the north. By 1999 the existing retaining walls and adjacent caretaker property are recorded. |
| **Potential Sources of Contamination** | Made Ground associated with the construction of the existing building and infrastructure and historical landscaping activities.<br>The London Clay Formation is known to contain pyrite, or iron sulphide, which, if allowed to oxidise, can provide an aggressive chemical environment for buried concrete. |
| **Ground Conditions Encountered** | Surface covering of Fill (asphalt-concrete) or Topsoil, although locally absent, over Made Ground (down to between 0.80m and 1.70m depth), above the London Clay Formation to the full depth of the investigation at 20.00m. |
| **Groundwater Encountered** | Locally struck during the fieldwork at depths between 1.25m and 1.30m; and slight seepages recorded at depths of 8.90m and 13.70m depth.<br>Monitoring recorded standing groundwater between some 1.00m and 2.00m depth, which may represent perched groundwater in the Made Ground pooling in the standpipes which are embedded in the relatively impermeable London Clay Formation. |
| **Risks to Human Health** | Asbestos fibres, asbestos containing materials (ACMs) and elevated PAHs recorded in the Made Ground soils at the site.<br>Mitigating measures should be employed to protect groundworkers and nearby land users during the construction phase. Developers will need to ensure that the Control of Asbestos Regulation 2012 are adhered to.<br>Remedial measures (such a clean cover system) will be required in areas of proposed soft landscaping to protect the future staff and pupils.<br>A Discovery Strategy should be prepared to cater for any unexpected contamination uncovered during the groundworks. |
| **Ground Gas Risks** | The current data set indicated that no special protection measures will be required for carbon dioxide and methane gases. This initial assessment will be updated on completion of the on-going monitoring.<br>No radon gas protection measures are necessary for buildings without underground rooms at this site. |

| | |
|---|---|
| **Risks to Controlled Waters** | No significant risk to Controlled Waters or the environment identified. |
| **Chemical Attack on Buried Concrete** | Design Sulphate Class DS-4<br>ACEC Class AC-4 |
| **Geotechnical Hazards** | Variable thicknesses of variable Made Ground soils, up to 1.70m depth<br>London Clay Formation: shrinkable soil of up to High volume change potential |
| **Potential Foundation Solutions** | Conventional spread foundations embedded at least 0.20m into the top of the London Clay Formation, at no less than 1.00m depth, design and constructed in accordance with NHBC standards. However, given the thickness of Made Ground in addition to the volume change potential of the London Clay Formation and the proximity to mature trees, foundation excavations may locally be required to extend to depth in excess of 2.50m.<br>Piled foundations may therefore offer the most assured foundation solution. |
| **Floor Slabs** | On account of the deep variable Made Ground and presence of shrinkable soils suspended floor slabs with an under floor void are recommended. |
| **Roads and Hardstanding Design** | Made Ground is likely to be exposed at formation level. A CBR value of less than 2% should be adopted and geogrids or similar soil reinforcement techniques be employed to provide a subgrade with a known CBR value.<br>The Made Ground is likely to be frost susceptible and the pavement thickness will need to accommodate this effect. |
| **Infiltration Measures** | Testing indicates that the London Clay Formation has very poor infiltration potential and unsuitable for traditional soakaways. Alternative drainage measures will need to be considered. |
| **Waste Soil Classification** | Topsoil: Likely non-hazardous due to organic content<br>Made Ground (brick and concrete): May classify as Inert under 17 01 07<br>Made Ground (disturbed clay): Inert<br>London Clay Formation: Inert under 17 05 04 |
| **Limitations and Recommendations** | A Discovery Strategy should be implemented during demolition and groundworks, and should suspicious soils be encountered, work should cease immediately, and the soils be assessed by a suitably qualified engineer.<br>Developers undertaking construction works on the site will have a duty of care to its employees to ensure that the Control of Asbestos Regulation 2012 are adhered to. Waste Made Ground soils should be screened for ACMs; and pieces of ACMs be segregated and disposed of as Hazardous waste.<br>Remedial measures, such as a clean cover system, will be required in areas of proposed soft landscaping. A Remedial Strategy will be required followed by Post Remediation Verification of the measures undertaken.<br>Should traditional shallow foundations be considered then trial excavations should be undertaken to assess trench stability and the intensity of groundwater ingress; and they should be designed and constructed in accordance with NHBC Building Standards Chapter 4.2 guidelines.<br>Should piled foundations be considered, the advice of a specialist piling contractor should be obtained to determine the most appropriate pile type, depth and its design using their particular systems. |

This executive summary should be read in conjunction with the main report.

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## CONTENTS

**APPENDICES** – ***see overleaf***

# APPENDICES

## APPENDIX A - PLANS AND PHOTOGRAPHS

- Site Location Plan
- Exploratory Hole Location Plan - Existing Site Layout
- Exploratory Hole Location Plan - Showing Development Proposals
- Site Photographs

## APPENDIX B - FIELDWORK AND TESTING

- Legends and Abbreviations Log Key
- Cable-tool Percussive Borehole Logs
- Continuous Tube Sampler Borehole Logs
- Foundation Inspection Pit Logs
- Gas and Groundwater Monitoring Results

## APPENDIX C - LABORATORY TEST REPORTS

- Geotechnical Laboratory Test Report
- Chemical Laboratory Test Report

## APPENDIX D - CONTAMINATION RISK ASSESSMENT WORKSHEETS

- Contaminated Land Risk Assessment Methodology
- CLEA 1.071 Settings
- CLEA 1.071 Results

## APPENDIX E - GEOTECHNICAL PLOTS AND TABLES

- Shear Strength v Depth Plot
- Preliminary Pile Design Data

## APPENDIX F - WASTE CLASSIFICATION

- HazWasteOnline Report
- WAC Testing Results

## APPENDIX G - DESK STUDY INFORMATION

- Groundsure Enviro and Geo Insight
- Historical Ordnance Survey and National Grid Maps

# GROUND INVESTIGATION REPORT

## INTRODUCTION

A Ground Investigation has been undertaken for a proposed new building at Yardley Primary School, Hawkwood Crescent, London, E4 7PH. A Site Location Plan is provided in Appendix A. The Ordnance Survey National Grid reference for the approximate centre of the site is 537962, 195506.

Instructions to undertake the investigation were received from the client, Evolve Norse Ltd, in their purchase order dated 11th October 2024.

This report describes the desk study and intrusive site investigation activities carried out by ListersGeo in order to provide an evaluation of the ground conditions and the extent of any soil, gas or groundwater contamination present on the site. The report presents human health and groundwater risk assessments based on the findings of the desk study information and subsequent contamination laboratory testing. The report also discusses the geotechnical implications with regard to the proposed development.

At the time of issuing this report five of the six scheduled gas and groundwater monitoring visits have been completed. A revised copy of this report will be issued on completion of the monitoring.

To our knowledge, the site has not been subject to any previous investigations.

This report has been prepared for the sole use of the client and their professional advisors. This report shall not be relied upon by third parties without the express written authority of ListersGeo. If an unauthorised third-party comes into possession of this report, they must not rely on it and the authors owe them no duty of care and skill.

### SCOPE OF THE INVESTIGATION

The scope of the investigation as requested by Perega, acting on behalf of the client, was to undertake a desk study and walkover survey, provide an assessment of the geotechnical engineering properties of the ground and the extent of any soil, gas or groundwater contamination on the site. A contaminated land risk assessment was undertaken based on the Contaminated Land Exposure Assessment (CLEA) and Environment Agency (EA) Remedial Targets Methodology (RTM) guidelines. The investigation also includes a preliminary assessment of the waste characteristics of the soils the feasibility of adopting a soakaway drainage solution at the site and parameters to aid pavement design.

### PROPOSALS

It is proposed to redevelop the site to accommodate a new two-storey education facility building with an associated access road and car parking and limited areas of soft landscaping. A proposed site layout plan is provided in Appendix A. The report is based upon the above development proposals and the existing ground levels. Should either of these alter significantly following issue of this report, then the contents will require re-evaluation.

## SITE INFORMATION AND RECONNAISSANCE

A reconnaissance of the site and its immediate surrounds was undertaken on the 22nd October 2024 in conjunction with the fieldwork. A selection of site photographs is presented in Appendix A along with a plan showing the existing site layout.

The site consists of a near trapezoid shaped parcel of land in the western grounds of Yardley Primary School. With maximum dimensions of approximately 43m east-west by 38m north-south the site extends to some 0.12ha in area.

The site comprises an asphalt surfaced car park in the west, a single storey brick masonry constructed building associated with the school in the central section of the site and pavements and soft landscaping in the east. A two-storey brick masonry constructed structure is attached to the northern wall of the main building. A few mature trees and bushes are present along the southern and eastern site boundary. Mature woodland extends on to the northern section of the site.

The general topography of the area slopes down to west towards the River Lea which is located approximately 340m east of the site. A topographical survey plan of the site was not available but to the eye the site appears to generally follows this trend, sloping down to the west. Sloping ground with retaining walls up to 1m high are present in the south-east of the site to accommodate steps and footpaths surrounding the building. Sloping ground with a retaining wall up to approximately 2.0m high defines the western and north-western site boundary.

The site is bordered by:

| Direction | Feature |
|---|---|
| North | Woodland with residential properties approximately 40m beyond |
| East | Yardley Primary School playground with main building approximately 24m beyond |
| South | Access road and car parking spaces with residential properties approximately 10m beyond |
| West | School caretakers residential property with residential properties approximately 40m beyond |

No evidence of gross contamination or significant potential sources of contamination were observed during the walkover survey. However, a thickness of Made Ground is anticipated at the site associated with the construction of the existing building and infrastructure and historical landscaping activities.

## DESK STUDY AND BACKGROUND INFORMATION

A desk study review of the site and its history has been undertaken to determine the former land use and the potential for any historically derived sources of chemical contamination, as well as provide information to aid our geotechnical assessment.

The information provided in the desk study is obtained from independent third-party sources. We have relied on this information, but no guarantee can be given for the accuracy or completeness of the third-party data used. It should be appreciated that such data is not exhaustive and is constantly being updated and reviewed in light of new information and procedures. Therefore, improved practices, technology and new information may affect our conclusions and hence this report should be referred back to us for reassessment if new data comes to light, or changes in legislation/best practise is identified prior to development. Similarly, should the development commence more than one year from publication of this report, then we recommend this report is referred back to us for reassessment. A copy of the desk study information obtained from Groundsure is presented in Appendix G and the findings summarised below:

| **Environmental Setting** | | |
|---|---|---|
| **Published Geology** | Reference to the BGS 1:50,000 scale map, Sheet 256 (North London, 2006), and other published geological information on the area indicates that the site is directly underlain by Palaeogene aged Bedrock geology of the London Clay Formation. | |
| | Artificial Ground: | No records on or within 150m of the site, but thicknesses are anticipated beneath the site associated with the construction of the existing building and infrastructure, and historical landscaping activities. |
| | Superficial Geology: | No Superficial Deposits are mapped on or within 150m of the site, however, the BGS acknowledges that Head is widely under mapped in the London region and records the site in a 'Head propensity' area. The BGS notes that such areas are *'most likely to be covered by Quaternary Head deposits as interpreted from digital slope analysis and confirmed by borehole data'*.<br><br>Head comprises a mixture of gravel, sand and clay depending on the upslope source and distance from the source, locally with lenses of silt, clay, peat or organic material. Given that the source material is likely to comprise the London Clay Formation, it is considered that any Head beneath the site will likely comprise a clay-dominated matrix. |
| | Bedrock Geology: | The London Clay Formation is generally represented by blue-grey or grey-brown slightly calcareous silty clay and clayey silt with some layers of sandy clay, with cementstone nodules and pyrite. The formation is recorded up to 50m thick in the area. |
| | Historical Boreholes: | The BGS holds records of exploratory holes historically put down during previous investigations. There are records of three historical boreholes put down approximately 25m north-west of the site in December 1934 and January 1935. The limited logs are interpreted to have found Topsoil down to 0.15m depth above Head (gravelly locally organic clay and sandy gravel) to around 4.00m to 4.60m depth above the London Clay Formation to the base of the deepest hole at 6.10m depth. No groundwater observations are recorded on the logs. |

<table>
<tr><th colspan="3">Environmental Setting</th></tr>
<tr><td>Background Soil Chemistry</td><td colspan="2">Information from the BGS does not indicate any naturally elevated background levels in the Topsoil in the area.<br><br>The London Clay Formation is known to contain pyrite, or iron sulphide, which, if allowed to oxidise, can provide an aggressive chemical environment for buried concrete.</td></tr>
<tr><td>Radon Gas</td><td colspan="2">Desk study information indicates that the site lies within an area where less than 1% of homes exceed the action level of 200Bq/m3 for radon gas. Therefore, in accordance with BR 211, ‘Radon: guidance on protective measures for new dwellings’, no radon protection measures are necessary in the construction of new dwellings or extensions without underground rooms on this site.</td></tr>
<tr><td rowspan="9">Naturally Occurring Geotechnical Hazards</td><td colspan="2">The risk of naturally occurring geotechnical hazards at the site (excluding an assessment of any Topsoil or Artificial Ground) is recorded in the Groundsure report to be as follows:</td></tr>
<tr><td>Shrinking and swelling clays</td><td>Moderate *</td></tr>
<tr><td>Collapsible deposits</td><td>Very Low</td></tr>
<tr><td>Landslides</td><td>Very Low</td></tr>
<tr><td>Running sand</td><td>Very Low</td></tr>
<tr><td>Compressible deposits</td><td>Negligible</td></tr>
<tr><td>Ground dissolution of soluble rocks</td><td>Negligible</td></tr>
<tr><td colspan="2">*As a typically clay-dominated soil, the London Clay Formation is likely to be prone to seasonal, water-content related, shrinking and swelling movements, which will be exaggerated by nearby vegetation.</td></tr>
<tr><td colspan="2">Stantec UK Ltd hold no records of natural cavities within 500m of the site.</td></tr>
<tr><td>Hydrogeology</td><td colspan="2">The EA records the London Clay Formation as an Unproductive Bedrock Aquifer.<br><br>There is one active groundwater abstraction record within 500m of the site, which is located approximately 432m north-west of the site. The abstraction is a potable water supply held by Thames Groundwater. According to information provided by the EA the site is within a Zone 2 Source Protection Zones (SPZ), associated with the potable groundwater abstraction.</td></tr>
<tr><td>Hydrology</td><td colspan="2">The general topography of the area slopes down to west towards the River Lea which is located approximately 340m east of the site. An unnamed tributary stream, which feed the River Lea, is located approximately 16m north of the site.<br><br>There are no active surface water abstraction licenses recorded within 500m of the site.</td></tr>
<tr><td>Potentially Sensitive Land Uses</td><td colspan="2">Epping Forest, a Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC) is located approximately 139m north-east of the site.</td></tr>
</table>

| History of the Site | |
|---|---|
| **Historical Site Use** | Research indicates that the site comprised and agricultural field with woodland to north from as early as 1863, until circa 1959 when the existing building is mapped, with sloping ground to the north. By 1999 the existing retaining walls and adjacent caretaker property are recorded.<br>The adjacent main school building was constructed circa 1936 in addition to the surrounding residential properties. |
| **Unexploded Ordnance (UXO)** | The Zetica bomb risk map shows that the site is located in an area where there is a low risk of encountering unexploded ordnance (UXO) beneath the site. Works can normally proceed without any special precautions. |

| Industrial & Potentially Contaminative Land Uses | |
|---|---|
| **Environmental Permits, Incidents and Registers** | There are no current licensed discharge consents, licenced industrial activities, licenced pollutant releases, historical substantiated pollution incidents or contaminated land recorded within 250m of the site. |
| **Industrial Land Uses** | Beyond a pest and vermin control business (100m west of the site) and a distribution substation (135m north-east of the site), no further historical or recent industrial land uses are recorded within 150m of the site. |
| **Landfill and Waste Treatment Sites** | Reference to records indicates that there are no historical or active landfill disposal sites within 500m of the site; and no waste transfer, waste treatment or waste management facilities within 250m of the site. |
| **Mineral Extraction** | Stantec UK Ltd hold no records of mining cavities within 500m of the site; and the desk study information does not provide any evidence to indicate that the immediate site area has been subject to historical surface (quarries) or underground (mining) mineral extraction activities. |

## INITIAL CONTAMINATION CONCEPTUAL SITE MODEL

A qualitative Preliminary Risk Assessment (PRA) has been undertaken in line with the EA's online guidance, Land Contamination: Risk Management (LCRM).

It is understood that the development proposals are for a new two-storey education facility building with associated access road, car parking and limited areas of soft landscaping.

Potential sources of contamination and potential receptors have been assessed using the source-pathway-receptor principle to create a Conceptual Site Model (CSM). This takes into account the fact that a complete pathway must exist between a potential source of contamination and a potential receptor for there to be considered a risk.

### POTENTIAL CONTAMINATION SOURCES

*Potential Solid-, Liquid- and Vapour-phase Contamination Sources*

The results of the desk study and walkover indicate that the following potential sources of soil or groundwater contamination are present at, or in close proximity to, the site:

- Made Ground is likely to be present at the site associated with the construction of the existing building and infrastructure and historical landscaping activities.
- The London Clay Formation is known to contain pyrite, or iron sulphide, which, if allowed to oxidise, can provide an aggressive chemical environment for buried concrete.

*Potential Ground Gas Contamination Sources*

Two main groups of gaseous-phase contamination have been considered: the gases (including methane and carbon-dioxide) that result from organic decomposition of constituents in the ground; and Radon gas that results from the radioactive decay of thorium and uranium (found, in varying quantities, in most soils and rocks).

The site is located in an area where the risks from ground gases are considered to be low. We have therefore provisionally assessed the risk of ground gas impacting the site, by reference to the CL:AIRE research bulletin RB17, "A pragmatic approach to ground gas risk assessment" 2012.

The following potential sources have been assessed:

- The site has not been a registered landfill.
- No credible sources or pathways for landfill gas migration from an off-site landfill have been identified.
- Any Made Ground present is not expected to be 5m deep or an average of 3m in thickness.
- The site is not mapped to be underlain by naturally organic soil, such as Alluvium or Peat.
- Radon protection measures are not required for this development (without underground rooms).

Therefore no significant potential sources of ground gases have been identified for the site.

**RECEPTORS**

The following most sensitive receptors have been identified at the site:

*Human Health – Long Term Exposure*

- End users of the site - the future staff and pupils

*Human Health – Short Term Exposure*

- Construction workers (during redevelopment)
- Adjacent school users and general public (during redevelopment)
- Maintenance Workers

*Controlled Waters and Environment*

- The unnamed tributary stream approximately 16m north of the site
- The potable groundwater abstraction approximately 432m north-west of the site and associated Zone 2 Source Protection Zone that extends on to the site
- Epping Forest (SSSI and SAC) approximately 139 north-east of the site

*Infrastructure*

- Substructures
- Water supply pipes

**PATHWAYS**

It is considered that a number of potential pathways exist between these potential sources and the above identified receptors. The viability of these pathways is discussed in the preliminary risk assessment.

*Human Health*

- Direct soil ingestion in areas of exposed soil
- Inhalation of indoor and outdoor vapours and dust
- Dermal contact with contaminated soil
- Inhalation of vapours migrating through permeable strata into the building

*Controlled Waters and Environment*

- Migration/leaching of contaminants through the unsaturated zone
- Migration of contaminants through the groundwater
- Movement of contaminants through drains or services runs

*Infrastructure*

- Leachable or corrosive contaminants within the soil
- Corrosive contaminants within the groundwater

## PRELIMINARY RISK ASSESSMENT

Based on the desk study research, the following potentially-complete pollutant linkages have been assessed and in accordance with CIRIA C552, a consequence and probability rating has been applied to each potential contamination source to create an overall risk rating. The definitions and methodology are presented in Appendix D and the results are presented in the following table:

<table>
<tr><th colspan="3">Potential</th><th rowspan="2">Probability</th><th rowspan="2">Consequence</th><th rowspan="2">Risk Classification</th></tr>
<tr><th>Source</th><th>Pathway/s</th><th>Receptor</th></tr>
<tr><td rowspan="11">Made Ground associated with historical construction and landscaping activities</td><td rowspan="3">Ingestion<br>Dermal Contact<br>Inhalation</td><td>End Users: Staff & Pupils</td><td rowspan="2">Low</td><td rowspan="3">Medium</td><td rowspan="2">Moderate/Low</td></tr>
<tr><td>Construction Workers</td></tr>
<tr><td>Maintenance workers</td><td>Unlikely</td><td>Low</td></tr>
<tr><td colspan="5">Explanation: The majority of the site is proposed to be covered by hardstanding which will significantly limit the exposure routes; it is in the soft landscaped areas of the site where it is considered complete pollutant linkages may occur.<br>Whilst a moderate/low risk classification has been established for construction workers, exposure to this receptor can be mitigated by use of appropriate PPE, work practices and maintaining good hygiene levels.</td></tr>
<tr><td rowspan="4">Migration through unsaturated zone, groundwater, drains and/or service runs</td><td>Unnamed Tributary Stream located approximately 16m north of the site</td><td rowspan="2">Low</td><td rowspan="4">Medium</td><td rowspan="2">Moderate/Low</td></tr>
<tr><td>Zone 2 SPZ</td></tr>
<tr><td>Potable groundwater abstraction approximately 432m to the north-west</td><td rowspan="2">Unlikely</td><td rowspan="2">Low</td></tr>
<tr><td>Epping Forest (SSSI & SAC) approximately 139m to the north-east</td></tr>
<tr><td colspan="5">Explanation: Widespread gross levels of contamination (that pose a risk to controlled waters) are not anticipated (low-likelihood).</td></tr>
<tr><td>Direct contact</td><td>Water supply pipes</td><td>Low</td><td>Medium</td><td>Moderate/Low</td></tr>
<tr><td colspan="5">Explanation: Organic contaminants, such as polycyclic aromatic hydrocarbons, may attack plastic pipes. Utility companies often have their own local guidelines and standards that should be referenced prior to installation.</td></tr>
<tr><td rowspan="2">Pyrite and Selenite in the London Clay Formation</td><td>Direct contact</td><td>Substructures</td><td>High</td><td>Mild</td><td>Moderate*</td></tr>
<tr><td colspan="5">Explanation: The London Clay Formation is known to potentially contain sulphates at concentrations that may accelerate the degradation of buried concrete. However, the method of foundation installation can reduce the risk and appropriate testing of the formation can be undertaken to assist in the concrete mix design to mitigate this effect.<br>*Risk classification based on no mitigating design measures being implemented; potentially, in turn, resulting in the building being rendered unsafe to occupy.</td></tr>
</table>

The geoenvironmental investigation and risk assessment detailed in the remainder of this report have been conducted to validate this CSM.

## INITIAL GEOTECHNICAL GROUND MODEL

The site is mapped to be directly underlain by bedrock geology of the London Clay Formation with a propensity for an overlying thickness of Head. A thickness of Made Ground is anticipated at the site associated with construction and historical landscaping activities.

Should Made Ground and/or Head be present at the site they are unlikely to be suitable founding strata due to their typical variable and low-strength composition and potential for unacceptable settlement movements.

The London Clay Formation is typically a competent founding strata for lightly loaded traditional strip and pad foundations. However, as a typically clay-dominated soil, the formation is likely to be susceptible to water related seasonal movements that will be exaggerated due to the influence of vegetation, or potential rehydration and swelling as a result of vegetation removal. Therefore, where new foundations are to be constructed in proximity of existing and proposed vegetation, they will require deepening below any currently and potentially future desiccated soils. The London Clay Formation is also unlikely to offer favourable infiltration characteristics.

The intrusive investigation has been implemented to address these main issues and establish any potential problems for foundations and the general development of the site.

## EXPLORATION AND TESTING

As part of the Phase 2 intrusive investigation, a total of ten exploratory holes were formed at the site. The works comprised:

- Two cable-tool percussive borehole (BH01 and BH01a)
- Three continuous tube sampler boreholes (CT01 to CT03)
- Five hand-excavated foundation inspection pits (FIP01 to FIP05)
- In-situ testing (including Standard Penetration Tests and Soil Infiltration tests)
- Three gas and groundwater monitoring well installations
- Six gas and groundwater monitoring visits (of which five of the six scheduled visits have currently been completed)
- Geotechnical laboratory testing
- Chemical laboratory testing

The exploratory holes were formed on the 22nd and 23rd October 2024. The monitoring visits have currently been conducted between the 31st October 2024 and the 13th January 2025.

The positions of all exploratory holes can be seen on the Exploratory Hole Location Plan in Appendix A, the logs, and field test and monitoring results are provided in Appendix B and the results of the laboratory testing are provided in Appendix C.

Conclusions given in this report are based on data obtained from these sources, but it should be noted that variations, which affect these conclusions, may inevitably occur between and beyond the test locations. Also, water levels may vary seasonally and with other factors.

### SAMPLING STRATEGY

The investigation was undertaken in accordance with the scope of works agreed with Perega, acting on behalf of the client. The positions of the exploratory holes were initially selected by Perega, prior to the fieldwork. A few locations were adjusted on-site by ListersGeo with consideration to access limitations, suspected buried services and the presence of concrete and brick cobbles.

### METHODOLOGY

To minimise the dangers from and to buried services the proposed locations were scanned using a Cable Avoidance Tool. At positions located in the existing car park the surfacing was broken-out using a hand held electric breaker.

At the borehole locations a service avoidance pit was dug, using insulated hand tools, to around 1.00m depth. CT03 was put down through the base of FIP04. No buried services were encountered in the exploratory holes, however, at the proposed location of BH01 brick and concrete cobbles were encountered in the hand excavated service avoidance pit (down to 0.80m depth), which could not be bypassed with hand tools. The borehole location was subsequently re-positioned approximately 5m to the south-west (BH01a).

BH01a was drilled utilising a standard cable percussion rig, at a diameter of 150mm, down to its target depth of 20.00m below ground level. Metal casing was extended to 2.70m depth to support the upper part of the bore. Disturbed samples were collected at regular intervals throughout the borehole for future laboratory inspection and testing. Standard Penetration Tests (SPTs) and undisturbed tube samples (U100s) were taken at 1.00m intervals down to 10.00m depth and at 1.50m intervals thereafter. The energy ratio for the hammer used for these SPT tests was 79%. On completion both BH01 and BH01a were backfilled with arisings, ensuring that excavated material was replaced in the same order as it had been removed.

The continuous tube sample boreholes were put down using an Archway Competitor Dart rig to their target depths of 3.00m (CT03) and 6.00m (CT01 and CT02). The boreholes were advanced using a plastic lined steel tube sampling system, driven into the ground by a top drive percussive hammer. A near continuous 85mm to 45mm diameter core sample was recovered for subsequent examination, sub-sampling and laboratory testing. Measurements of unconfined compressive strength were made in the tube samples in the field using a pocket penetrometer. Standard Penetration Tests (SPTs) were taken at 1.00m intervals and the energy ratio for the hammer used for these SPT tests was 75%. On completion continuous tube sample boreholes were utilised for the installation of a 50mm diameter slotted uPVC standpipe from 3.00m depth up to within 1.00m below existing ground level. From 1.00m depth up to ground level a plain pipe was added. The slotted section of the standpipe was surrounded with pea gravel, while expansive bentonite clay was added around the plain pipe. The standpipe was finished with a rubber bung and gas tap and protected with a stopcock cover, which was then concreted flush with ground level.

Correction to the field ‘N’ values (to ‘$N_{60}$’ values) for the effects of energy delivery have been applied to the SPT (Standard Penetration Test) results from this investigation, in line with the recommendations given in BS EN ISO 22476-3, 2005, National Annex A.

The foundation inspection pits were excavated using insulated hand tools and a Dutch portable hand auger to depths of between 1.00m and 2.10m below ground level. Details and photographs of the exposed foundations were recorded and disturbed samples were taken at selected depths for subsequent laboratory testing and inspection. On completion, all trial pits were carefully backfilled with arisings, ensuring that excavated material was replaced in the same order as it had been removed.

The ground gas monitoring was carried out in the monitoring wells using a calibrated Geotech GA 5000 gas analyser; and the groundwater levels were monitored using a standard Geotech dip meter. During the first monitoring visit infiltration testing was undertaken in the standpipe for CT03 following the general principles of BRE Digest 365 ‘Soakaway Design’.

## GROUND CONDITIONS

The intrusive investigation revealed that the general succession of strata was as follows: a surface covering of Topsoil or Fill (although locally absent) above variable thicknesses of Made Ground overlying the London Clay Formation to the full depth of the investigation at 20.00m. Further details of the relative disposition of each are provided below:

### TOPSOIL

Topsoil was encountered at three locations (CT01, CT02 and FIP05) from ground level down to depths of between 0.15m and 0.40m, with an average thickness of 0.28m.

The Topsoil comprised, in general, friable dark brown slightly gravelly organic silty clay with roots. The gravel fraction included fine to medium sub-rounded to angular flint, red brick and concrete,

(It should be noted that use of the term, Topsoil, is in accordance with BS 5930 alone and does not imply compliance of these horizons with any other standard).

### FILL

Fill was encountered at the five locations put down in the existing car park (BH01, BH01a, CT03, FIP03 and FIP04) from ground level down to depths of between 0.15m and 0.20m, with an average thickness of 0.18m.

The Fill generally comprised asphalt (between 50mm to 100mm thick) over concrete (100mm thick). At the location of CT03 and FIP04, the Fill comprised 200mm concrete.

(It should be noted that use of the term, Fill, is in accordance with BS 5930 alone and does not imply compliance any particular performance standard).

### MADE GROUND

Made Ground was encountered at each location from between ground level and 0.40m depth, with the full thickness proven to depths of between 0.80m and 1.70m. Made Ground was also encountered to the base of BH01, FIP01, FIP03 and FIP04 at depths between 0.80m and 1.00m.

The Made Ground beneath the existing car park generally comprised a variable mixture of brown sand and fine to coarse sub-angular to sub-rounded concrete, brick and flint gravel with low to medium brick and concrete cobble content; and locally slightly sandy brick and concrete cobbles. It is considered that these soils represent imported 'demolition rubble' to build up site levels against the naturally sloping topography of the area.

Elsewhere on the site the Made Ground generally comprised a variable mix of soft, firm and locally stiff light brown through to dark brown and less commonly light grey, slightly sandy through to sandy, slightly gravelly through to gravelly clay with roots. The gravel fraction included fine to coarse sub-angular to sub-rounded flint, quartzite, brick and concrete. At the location of FIP05 the Made Ground soils included broken fragments of corrugated concrete sheets which were suspected to contain asbestos. It is considered that these Made

Ground soils represent disturbed London Clay Formation soils which have been impacted with construction materials.

**LONDON CLAY FORMATION**

The London Clay Formation was encountered at six locations (BH01a, CT01, CT02, CT03, FIP02 and FIP05) from between 0.80m and 1.70m depth, down to the base of the trial pits and boreholes at a maximum depth of 20.00m.

The formation comprised, in general, initially firm, becoming stiff, very stiff and fissured with depth, initially light brown becoming grey and dark grey with depth, clay with extremely thinly bedded silt lenses and localised fine selenite.

The SPT results undertaken in the boreholes are summarised below:

| Depth (m) | SPT '$N_{60}$' Value | Approximate Undrained Shear Strength (kPa) | Indicative Soil Strength (BS 5930-2015, Table 9) |
|---|---|---|---|
| 1.00 to 3.00 | 11 to 19 | 47 to 84 | Medium and High |
| 4.00 to 9.00 | 21 to 29 | 118 to 129 | Very High |
| 11.00 to 15.00 | 45 and 57 | 200 to 250 | Very High |
| 17.00 to 20.00 | *71 and *96 | 300 to 400 | Very High (possible Extremely Weak rock) |

Approximate undrained shear-strength calculated using Stroud, $f_1$, conversion factor of 4.5.
* indicates extrapolated results.

Laboratory testing revealed the following:

| Parameter | Range | Comments |
|---|---|---|
| Water Content (%) | 21 to 34 | Values generally decrease with depth |
| The following results correspond to twenty tests undertaken on the formation | | |
| Liquid Limit (%) | 43 to 76 | CLAY of Intermediate, High and Very-High Plasticity (BS5930 Casagrande) |
| Plastic Limit (%) | 20 to 30 | |
| Plasticity Index (%) | 18 to 48 | |
| Modified Plasticity Index (%) | 17 to 48 | Shrinkable soil of Medium and High Volume-Change Potential (NHBC Standards) |
| Retained on 425µm sieve (%) | 0 to 11 | BS1377 'coarse soil' fraction |
| Passing 63µm sieve (%) | 66 to 99 | Fines (silt/clay) fraction |
| The following results correspond to tests undertaken on the U100 samples recovered from BH01a | | |
| Undrained Shear Strength (kPa) from 'Quick' Undrained Compression tests (triaxial). | 66 to 237 | Medium strength soils (4.00m), becoming High (7.90m) and Very High strength (13.10m and 16.00m) with depth (BS 5930-2015, Table 9) |
| Undrained Shear Strength (kPa) from Hand Shear Vane tests | 70 to >150 | Medium strength soils (2.00m), becoming High (4.00m to 7.90m) and Very High strength (13.10m to 18.50m) with depth (BS 5930-2015, Table 9) |

| Parameter | Range | Comments |
|---|---|---|
| The following results correspond to testing undertaken on the continuous tube sampler borehole cores | | |
| Undrained Shear Strength (kPa) Converted from Pocket Penetrometer (using conversion factor of 30) | 38 to 153 | Typically Medium and High strength soils through 1.00m to 6.00m test range (BS 5930-2015, Table 9) |

The SPT, triaxial, hand vane and pocket penetrometer test results are summarised on our Undrained Shear Strength against depth plot presented in Appendix E.

**GROUNDWATER**

Groundwater was locally encountered during the fieldwork as summarised below:

| Location | Groundwater Strike Depth (m) | Comment |
|---|---|---|
| BH01 | - | Not encountered to 0.80m depth |
| BH01a | 8.90 and 13.70 | Slight seepages |
| CT01 | - | Not encountered to 6.00m depth |
| CT02 | - | Not encountered to 6.00m depth |
| CT03 | - | Not encountered to 3.00m depth |
| FIP01 | - | Not encountered to 1.00m depth |
| FIP02 | 1.30 | Struck and standing at 1.30m depth |
| FIP03 | - | Not encountered to 1.00m depth |
| FIP04 | - | Not encountered to 1.00m depth |
| FIP05 | 1.25 | Struck and standing at 1.25m depth |

The following table summarises the current groundwater monitoring results:

| Date | Standing Groundwater Level (m) | | |
|---|---|---|---|
| | CT01 | CT02 | CT03 |
| 31/10/2024 | 1.95 | 1.52 | Dry at 2.95m depth |
| 12/11/2024 | 1.90 | 1.35 | Dry at 2.93m depth |
| 25/11/2024 | 1.73 | 1.14 | 1.51 |
| 09/12/2024 | 1.03 | 1.06 | 1.52 |
| 13/01/2025 | 1.35 | 1.17 | 1.58 |

The levels recorded during the monitoring visits may represent perched groundwater in the Made Ground pooling in the standpipes, which are embedded in the relatively impermeable London Clay Formation.

## OBSERVED SOIL CONTAMINATION

The Made Ground soils at the site included a range of anthropogenic materials, such as brick, concrete and, at the location of FIP05, broken fragments of corrugated cement sheets which were suspected to contain asbestos.

## EXISTING FOUNDATIONS

The foundation inspection pit findings are summarised below and further illustrated by the profiles on the logs in Appendix B:

| **Location** | **Foundation** | | | |
|---|---|---|---|---|
| | **Depth (m)** | **Projection (m)** | **Details** | **Stratum** |
| FIP01 | 0.80 | 0.20 | Masonry Brick Work | London Clay Formation |
| FIP02 | 1.60 | 0.20 | Masonry Brick Work | London Clay Formation |
| FIP03 | >1.00 | none | Masonry Brick Work | undetermined |
| FIP04 | 0.70 | none | Masonry Brick Work | Made Ground |
| FIP05 | Undetermined with certainty, possibly >2.00m | 0.10 | Masonry Brickwork | London Clay Formation |

## INFILTRATION TESTING

Infiltration testing was undertaken in the standpipe installation installed in CT03, following the principles of BRE Digest 365 'Soakaway Design'. Water was added to 1.74m depth (close to the Made Ground and London Clay interface) which recorded no drop over the 60-minute testing period, indicating that the London Clay Formation is a very poor infiltration media (in accordance with CIRIA C753).

## GROUND GAS MONITORING

The results of the current ground gas monitoring are provided in Appendix B and summarised below:

| **Parameter** | **Results** | | |
|---|---|---|---|
| | **CT01** | **CT02** | **CT03** |
| Oxygen (%v/v) | 17.3 to 20.6 | 19.1 to 20.8 | 20.8 to 21.4 |
| Carbon Dioxide (%v/v) | 0.2 to 3.2 | 0.1 to 1.2 | 0.1 |
| Methane (%v/v) | <0.1 | <0.1 | <0.1 |
| Flow rate (l/h) | 0.8 to 1.2 | 0.9 to 1.2 | 0.8 to 1.2 |

**CONCRETE AGGRESSION TEST RESULTS**

The results of laboratory concrete aggression tests on selected samples of soil are summarised below:

| Stratum | Water-soluble Sulphate $SO_4$ (mg/l) | pH (pH units) | Total Sulphate (% $SO_4$) | Total Sulphur (% S) | Number tested |
|---|---|---|---|---|---|
| Made Ground | 48.1 to 1360 | 6.9 to 8.7 | - | - | 6 |
| London Clay Formation | 150 to 4060 | 6.3 to 8.3 | - | - | 9 |
| | - | - | 0.121 to 2.62 | 0.011 to 0.915 | 6 |

## GROUND CONTAMINATION ASSESSMENT

The contamination risk assessment has been undertaken in line with the EA's online guidance Land Contamination: Risk Management (LCRM) in order to validate the Preliminary Risk Assessment (PRA) using Generic Quantitative Risk Assessment (GQRA), followed by Detailed Quantitative Risk Assessment (DQRA) if required.

### SOIL TESTING

Two samples of the Topsoil and four samples of the Made Ground collected on site during this investigation were tested for a range of constituents of potential concern (CoPC). The samples were selected to target the near surface soils at the site, including a sample of Made Ground from FIP05 where corrugated concrete sheeting was observed, to determine if it contains asbestos.

The suite of testing carried out on the samples was decided upon based on the CSM and following consultation of R&D CLR Publications, published as part of the Contaminated Land Exposure Assessment (CLEA), a joint venture between the Department for Environment, Food and Rural Affairs (DEFRA) and the EA. The test suite included:

| Group | Details |
|---|---|
| Asbestos | Screening for ACMs and fibres with the naked eye and microscopy |
| Inorganic substances | Arsenic, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium, zinc<br>Sulphates |
| Organic substances | 16 (EPA) speciated polycyclic aromatic hydrocarbons (PAH)<br>Total petroleum hydrocarbons (TPH) with four-band split |
| Other | pH |

Unless explicitly stated on the laboratory report, the soil samples were tested to obtain 'Total' values within the soil. The results of the chemical tests from this investigation are included in Appendix C.

In addition, a combined sample of the clay-dominated Made Ground (sample reference WAC01) was screened in line with the Waste Acceptance Criteria (WAC). The total soil results from this testing, which include PAHs, petroleum hydrocarbons, BTEX and polychlorinated biphenyls (PCBs), have also been considered in the ground contamination assessment. The results of the WAC testing are included in Appendix F.

**RISK ASSESSMENT GUIDELINES – HUMAN HEALTH**

The human health risk assessment has been undertaken using the guidance provided in the EA's LCRM guidance and the CLEA guidelines.

This assesses risks associated with the ingestion, dermal contact, and vapour inhalation pathways related to contaminated soils and groundwater. Risks associated with the inhalation of Ground Gas, for example that resulting from landfill, is not addressed by LCRM. The assessment for ground gases has been undertaken separately in the Ground Gas Risk Assessment section of this report.

Human health assessment criteria used are based upon the proposed final land use of the site. As the site is to be redeveloped to accommodate a new educational facility with limited areas of soft landscaping the Generic Assessment Criteria (GACs) for a standard 'Residential without homegrown produce' setting have initially been used as a conservative screening tool. Where exceedances were recorded above the GACs, site specific assessment criteria (SAC) for a Primary School setting were modelled using the CLEA software (discussed further below).

If the proposed site use should alter from the above, then the human health risk assessment will require re-evaluation for the new end use scenario.

The results of the soil samples tested have been compared to the following published assessment criteria:

*Category 4 Screening Levels (C4SLs)*

Published in March 2014 by DEFRA, a limited number of generic Category 4 Screening Levels (C4SLs) were produced to support the revised Statutory Guidance to support Part 2A of the Environmental Protection Act 1990, which was published in April 2012. This Guidance introduced a new four-category system for classifying land under Part 2A for cases of a Significant Possibility of Significant Harm to human health, where Category 1 includes land where the level of risk is clearly unacceptable and Category 4 includes land where the level of risk posed is acceptably low.

Further C4SLs have been and are being produced by CL:AIRE, with support from SoBRA and SAGTA, for a limited number of volatile organic compounds, as time allows.

*Suitable 4 Use Levels (S4ULs)*

To supplement the small number of C4SL, a set of Suitable for Use Levels (S4UL) were produced, in 2015, by Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH), using the EA's Contaminated Land Exposure Assessment (CLEA) software, version 1.06 (2009), and the revised assumptions used in deriving the C4SL. The S4UL are more conservative than the C4SL and are derived to represent the minimal levels of risk to human health as described in the EA's SR2 guidance, with the intention of being 'suitable for use' under planning.

*Detailed Quantitative Risk Assessment (DQRA)*

Should any results exceed the C4SLs or S4ULs used in the GQRA, or if a more site-specific model is required, then a Detailed Quantitative Risk Assessment (DQRA) is undertaken to establish site specific assessment criteria. This final stage uses specific information regarding the contamination and its potential receptors and pathways. The CLEA software was updated to version 1.071 in November 2015 to enable both site specific C4SLs and S4ULs to be determined by contaminated land practitioners, which produces less conservative, more accurate, site specific soil assessment criteria (SACs).

The model is based on the most sensitive receptor being female and aged between 4 to 10 years old. The occupancy period has been modelled as 8 hours per day inside, 2 hours per day outside, 195 days per year. A pre-1970s building has been used to model the existing school building and a sandy clay loam of 3% soil organic matter (SOM) to model the soils at the site. The worksheets for the CLEA model settings are provided in Appendix D.

**RISK ASSESSMENT GUIDELINES – CONTROLLED WATERS**

The procedures set out in EA's RTM *Hydrogeological risk assessment for contaminated land* (2006), have been followed.

**RESULTS OF ASBESTOS SCREENING**

Of the five samples screened, two recorded the presence of asbestos.

Loose chrysotile (white asbestos) fibres were identified in a shallow sample of the coarse-grained Made Ground from FIP04, which was put down through the existing car park in the north-west of the site. Gravimetric analysis revealed a concentration of 0.003%w/w in the sample as a whole.

Additionally, cement bound amosite (brown asbestos) and chrysotile (white asbestos) was identified a shallow sample of clay-dominated Made Ground tested from FIP05, which was put down adjacent to the existing building in the north-east of the site. Testing revealed a 5.6% concentration of cement bound asbestos in the sample as a whole.

**RESULTS OF TOTAL SOIL TESTS**

Results of the total soil testing have been compared to relevant published GAC as discussed above. For S4ULs, a range of values have been published for the organic contaminants based on the soil's organic matter content. Where the S4ULs have been adopted analytical results have been compared to the most conservative value, which is that for soils of 1% soil organic matter (SOM) as a preliminary screening tool.

*Inorganic Substances*

Of all of the inorganic substances tested no significantly elevated concentrations were recorded in comparison to typically naturally occurring or urban background levels; and no values were recorded in excess of the conservatively adopted residential GACs.

*Petroleum Hydrocarbons*

Three of the five samples tested recorded a total TPH concentration above the limit of detection of 10mg/kg.

This was in a sample of Topsoil from CT02 and Made Ground from CT03 and FIP04. However, the values was relatively minor (12mg/kg to 380mg/kg) and the individual bands were significantly below the conservatively adopted residential GACs.

The combined sample of Made Ground tested for WAC purposes (WAC01), recorded a relatively minor mineral oil (banded C10 to C40) concentration of 14mg/kg.

*Polycyclic Aromatic Hydrocarbons (PAH)*

Three of the six samples screened for PAHs recorded concentrations above the conservatively adopted residential GACs; and two samples recorded concentrations above the calculated SAC for a primary school setting. This was in samples of clay-dominated Made Ground tested from CT02 (south-west of the site) and coarse-grained Made Ground from CT03 (north-west of the site) as summarised below:

| PAH | GAC (mg/kg) | SAC (mg/kg) | Concentration (mg/kg) | | |
|---|---|---|---|---|---|
| | | | CT02 | CT03 | FIP01 |
| Benzo(a)anthracene | 11 | 34 | 6.7 | 17 | 1.9 |
| Benzo(b)fluoranthene | 3.9 | 8.5 | **<u>9.6</u>** | **<u>17</u>** | 3.0 |
| Benzo(a)pyrene | 5.3 | 10 | 8.5 | **<u>16</u>** | 3.0 |
| Dibenz(a,h)anthracene | 0.31 | 0.68 | **<u>0.88</u>** | **<u>1.7</u>** | 0.39 |

Note: values above the SAC emboldened and underlined

*Volatile Organic Compounds (VOCs)*

The combined sample of Made Ground tested for WAC purposes (WAC01) screened for VOCs recorded no concentrations above the limit of detection (<5.0µg/kg).

*Polychlorinated Biphenyls (PCBs)*

The combined sample of Made Ground tested for WAC purposes (WAC01) screened for PCB recorded no concentrations above the limit of detection (<0.001mg/kg).

## HUMAN HEALTH RISK ASSESSMENT

The following quantitative risk assessment has been carried out using the source-pathway-receptor principle. Potential sources of contamination identified in the Conceptual Site Model (CSM) have been assessed using the CLEA Guidelines. This takes into account the fact that a complete pathway must exist between a potential source of contamination and a potential receptor for there to be considered a risk.

The potential human receptors evaluated for their individual risk are:

*Long-Term Exposure*

- End users of the site – the future staff and pupils.

*Short-Term Exposure*

- Construction workers and adjacent school users (during redevelopment).
- Maintenance workers

If the proposed site use or layout should alter significantly, then the human health risk assessment will require re-evaluation.

### SOIL CONTAMINATION RISK

The preliminary risk assessment (PRA) identified Made Ground associated with the construction of the existing building and historical landscaping activities as potential sources of contamination at the site.

The intrusive investigation has revealed that the site is generally underlain by a surface covering of Fill (asphalt-concrete) or Topsoil, although locally absent, over Made Ground (down to between 0.80m and 1.70m depth), which in turn is underlain by naturally deposited bedrock of the London Clay Formation.

The Made Ground soils generally comprised coarse-grained soils beneath the existing car park and clay-dominated soils elsewhere. Both types of Made Ground were observed to include a range of anthropogenic materials, such as brick, concrete and broken fragments of corrugated concrete sheets, which were suspected to contain asbestos. Subsequent laboratory testing confirmed the presence of cement bound asbestos (amosite and chrysotile) in the clay-dominated Made Ground; in addition to the presence of loose asbestos (chrysotile) fibres in the coarse-grained Made Ground. Additionally, a few PAHs were locally recorded above the derived SAC for a primary school setting.

### SHOR-TERM EXPOSURE RISK

For construction workers and maintenance workers that are exposed to the ground, there is a short-term exposure risk (at each site they attend, which contributes to an overall lifetime exposure risk).

Given the presence of asbestos fibres, asbestos containing materials (ACMs) and elevated PAHs in the near surface soils at the site, there is considered to be significant short-term exposure risk if suitable controls are not implemented.  The exposure route of primary is direct soil ingestion and inhalation of asbestos fibres.

The presence of asbestos fibres and ACMs in the ground means that groundworks will need to be suitably controlled. The ground will need to remain damp to prevent any fibres becoming airborne and being inhaled and/or migrating off site. A watching brief should be employed during any excavation works and any suspected asbestos containing material double bagged and removed from site by suitably trained groundworkers.

Groundworkers should be made aware of potential risks of asbestos during the groundworks. The advice of a specialist contractor should be sought, to determine whether the proposed works will require licencing and if any further mitigating measures would be required. Any developers undertaking construction works on the site where the ground will be disturbed will have a duty of care to its employees to ensure that the Control of Asbestos Regulation 2012 are adhered to.

To reduce the ‘direct soil ingestion’ risk to as low as reasonably practicable, it is recommended that appropriate health and safety measures be implemented along with the use of Personal Protective Equipment (PPE). All personnel coming into contact with the soil, groundworkers in particular, should be instructed to use gloves when on site to avoid dermal contact and restrict inadvertent hand-to-mouth ingestion. Washing facilities should be provided for the site staff to use and should be used prior to eating or smoking. Reference should be made to the HSE Document, “Protection of Workers and the General Public during Development of Contaminated Land”.

Demolition and redevelopment activities have the potential to create short-term pollutant linkages to nearby land users (adjacent school). These risks should be managed by means of the Construction Phase (Health & Safety) Plan.

*Discovery Strategy*

In addition to the above, we recommend that a Discovery Strategy method statement is prepared for any groundworks at the site to cater for any unexpected contamination uncovered during the groundworks. Should any suspicious soils be encountered that differ from our ground model, work should cease in that area and further assessment will be necessary by a suitably experienced geoenvironmental engineer. This may require further intrusive investigation or soil sampling along with supplementary contamination risk assessment and potentially remediation. Any further recommendations will require regulatory approval

**LONG-TERM EXPOSURE RISK**

The presence of asbestos fibres, ACMs and elevated PAHs recorded within the near surface soils have the potential to cause significant harm to the future staff and pupils. The exposure route of primary concern for the PAHs is the ingestion of impacted soil and dust. The exposure route of primary concern for the asbestos fibres is inhalation, specifically where the ground becomes disturbed and fibres become airborne. These pathways will be most prevalent in the soft landscaped areas of the development.

It is therefore considered necessary to undertake remedial work in proposed areas of soft landscaping to protect the future staff and pupils. The areas of the site proposed to be covered by hardstanding (floor slabs, pavements, access roads, car parking) will prove a permanent barrier between the impacted soils and future staff/pupils, significantly reducing the potential source-pathway-receptor linkage. It is therefore considered, at this stage, that no remediation is required in these areas.

*Potential Remedial Measures*

Given the identified contaminants, and thickness of Made Ground beneath the site, a 600mm thick 'clean' Cover System is likely to be the most appropriate remedial solution for the site (in the limited areas of proposed soft landscaping). The cover system will likely be required to comprise at least 420mm of clean subsoil and at least 180mm clean Topsoil. Given the presence of asbestos fibres, a permeable geo-textile membrane or layer of hardcore should be placed at the base of the cover system, to act as a capillary break layer and a deterrent to dig.

**CONCLUSIONS**

The intrusive investigation has revealed that the near surface soils have been impacted by asbestos fibres, ACMs and PAHs. Control measures will therefore be required to protect groundworks and surrounding land users during the development; and remedial measures are necessary to reduce the long-term exposure risk to the future staff and pupils to an acceptable level.

A standalone Remediation Strategy should be prepared so that all parties involved in the development are clear about the chosen methods, implementation programmes and verification testing regimes that are required. Any remedial measures undertaken at the site will require independent verification once completed to ensure the pollutant linkage to the end users of the site has been removed. This is undertaken to satisfy the relevant regulatory authorities and other interested parties.

**REGULATORY APPROVAL**

We recommend that the conclusions of this report are agreed with the relevant Local Authority at the earliest stage, to reduce potential delays to the development.

## GROUND GAS RISK ASSESSMENT

The preliminary ground gas risk assessment did not identify any significant on- or off-site potential sources of ground gases; and no significant potential sources of ground gases were observed during the fieldwork.

Whilst the ground gas risk was considered to be low, the wells installed in CT01, CT02 and CT03 were monitored for ground gases during the groundwater monitoring visits. As previously noted, five of the six scheduled monitoring visits have currently been completed; and a revised copy of this report will be issued on completion of the monitoring.

The current data set has recorded relatively low levels of carbon dioxide gas, up to 3.2%v/v are being produced in the ground. Methane gas was recorded below the detection limit of 0.1%. Analysis of the results using a ternary plot (Using ternary plots for interpretation of ground gas monitoring results, Ambisense Limited and EPG Limited, 2018) indicates that the concentrations recorded are associated with microbial respiration of organic material in the soil, rather that landfill gas migration.

Marginal flow rates between 0.8l/hr and 1.2/hr were recorded. The low flow rates show that no significant volumes of gas are migrating to the site or being produced in the ground, verifying the CSM.

### PRELIMINARY GROUND GAS SCREENING VALUES

The current results have been evaluated with reference to Code of practice for the characterization and remediation from ground gas in affected developments, BS8485.

Using the current maximum carbon dioxide reading of 3.2% with the highest recorded absolute flow rate of 1.2l/hr, the maximum gas screening value is 0.038l/hr. As there were no carbon dioxide levels above 5% and no methane levels above 1%, this would classify the site as Characteristic Situation CS1 with an associated very low hazard potential rating.

### GROUND GAS PROTECTION MEASURES

*Carbon Dioxide and Methane Gas*

With consideration to the CSM and ground gas monitoring results, for this development it is considered that no special gas protection measures are necessary with regard to methane or carbon dioxide gas. However, this assessment will be updated on completion of the final ground gas monitoring visit.

*Radon Gas*

The BGS advises that no radon gas protection measures are necessary for buildings without underground rooms at this site.

### DECOMMISSIONING OF MONITORING WELLS

Once the gas monitoring boreholes are no longer required, any standpipes that are located beneath proposed building should be decommissioned using low permeability cement grout, or similar.

**REGULATORY APPROVAL**

The above conclusions regarding ground gases should be agreed with the relevant local Regulatory Authority as soon as possible prior to development.

## CONTROLLED WATERS RISK ASSESSMENT

The following Controlled Waters risk assessment has been carried out in accordance with the procedures set out in the EA's RTM *Hydrogeological risk assessment for contaminated land* (2006). Using the source-pathway-receptor principle, this takes into account the fact that a complete pathway must exist between a potential source of contamination and a potential receptor for there to be considered a risk.

The potential Controlled Waters receptors considered during this risk assessment were:

- The unnamed tributary stream approximately 16m north of the site
- The potable groundwater abstraction approximately 432m north-west of the site and associated Zone 2 Source Protection Zone that extends on to the site
- Epping Forest (SSSI and SAC) approximately 139 north-east of the site

### DISCUSSION

The intrusive investigation has revealed that the site is generally underlain by a surface covering of Fill (asphalt-concrete) or Topsoil, although locally absent, over Made Ground (down to between 0.80m and 1.70m depth), which in turn is underlain by naturally deposited bedrock of the London Clay Formation to the full depth of the investigation at 20.00m.

Beyond anthropogenic materials in the Made Ground (such as brick and concrete) no evidence of gross contamination was observed during the fieldwork (with regards to the Controlled Waters). Subsequent laboratory testing did not record any significantly elevated inorganic substances above typically occurring background levels. However, TPH and PAH concentrations were locally recorded in the near surface soils.

Analysis of the PAH results indicates that they are associated with coal derived products. As such substances are not readily mobile in the environment; it is considered that the PAHs present in the near surface soils at this site do not pose a significant risk to the identified receptors.

Whilst TPH concentrations were locally recorded in the near surface soils at the site, the relatively minor values (12mg/kg to 380mg/kg) are not considered to be at a level to have the potential to significantly impact the identified receptors.

Additionally, the underlying London Clay Formation is of low permeability which will significantly reduce any pathway potential to the identified receptors.

It is therefore considered that the site does not pose a significant risk to Controlled Waters. As previously noted, we recommend that a Discovery Strategy be prepared, and this initial assessment be updated accordingly should any unexpected contamination be encountered during the development.

### REGULATORY APPROVAL

We recommend that the conclusions of this report are agreed with the relevant Local Authority at the earliest stage, to reduce potential delays to the development.

## INFRASTRUCTURE RISK ASSESSMENT

### SUBSURFACE CONCRETE

Using the results of the concrete aggression tests, the concrete design mix recommendations for subsurface concrete have been assessed in terms of BRE Special Digest 1. The classification is as follows:

| Type of Site | Groundwater | Characteristic Sulphate | | | Characteristic | |
|---|---|---|---|---|---|---|
| | | Soil Soluble (mg/l) | Ground-water (mg/l) | Total Potential (%) | Design Sulphate Class | pH (pH units) |
| Brownfield | Mobile | 3,300 | n/a | n/a* | DS-4# | 6.8 |

*all six samples tested recorded oxidisable sulphide values <0.3%. # all six samples recorded magnesium values <1,200mg/l

The above assessment provides an Aggressive Chemical Environment for Concrete (ACEC) class of AC-4.

Care should be taken where sulphate or pyrite bearing soils, such as the London Clay Formation, are disturbed and used as fill materials, as the oxidation can produce sulphate minerals which attack concrete and cause the ground to heave. Care should also be taken where water levels are reduced or drainage runs introduced, exposing soils to the air.

### UNDERGROUND SERVICES

Organic contaminants, such as petroleum or polycyclic aromatic hydrocarbons, may attack plastic pipes and remedial measures may be required. The pathway with the contaminated soils could be removed by sleeving the pipe with another material or by removing the contamination source itself.

It should be noted that the utility companies often have their own local guidelines and standards on levels of shallow soil contamination in the ground that may or may not be acceptable for the installation of below ground services. These standards may be different to those specified for assessing risks to human health and groundwater. The local requirements should be obtained from the particular service supply company and approval should be sought for the type of pipes proposed before they are installed.

Guidance can be sought from the UK Water Industry Research (UKWIR), 'Guidance for the selection of water supply pipes to be used in brownfield sites', reference 10/WM/03/21, 2010. This document proposes that the assessment of the hazard to potable water supply pipes should be based on the following pathways: contact with migrating groundwater, permeation of vapour, and direct contact with soil.

Consideration should be given to the effects of trees and shrubs on service runs that cross the site. Soil movements brought on by the influence of vegetation can severely disrupt the drain runs and mains services, and measures should be incorporated into the excavations to allow for future ground movements.

## GEOTECHNICAL ENGINEERING CONCLUSIONS

We understand at it is proposed to redevelop the site to accommodate a new two-storey education facility building with an associated access road and car parking and limited areas of soft landscaping. A proposed site layout plan is provided in Appendix A. The anticipated foundation loads were not available at the time of issuing this report.

If site conditions should be altered significantly, such as changes to existing levels, then this report may require re-evaluation.

### REVISED GROUND MODEL

The intrusive investigation has revealed that the site is generally underlain by a surface covering of Fill (asphalt-concrete) or Topsoil, although locally absent, over Made Ground (down to between 0.80m and 1.70m depth), which in turn is underlain by naturally deposited bedrock of the London Clay Formation to the full depth of the investigation at 20.00m.

The Made Ground soils were generally coarse-grained (brick and concrete gravel and cobbles) beneath the existing car park and clay-dominated (disturbed London Clay Formation soils) elsewhere. Consideration should be given to inevitable ground disturbances associated with the demolition of the existing building and removal of existing foundations, which may result in greater thicknesses of Made Ground to that encountered during this investigation. Records of ground disturbances should be maintained during demolition works and passed on to the structural engineer to assist with foundation design.

The London Clay Formation was present, in general, as initially medium-strength light brown becoming high- and very high-strength, fissured and grey with depth, shrinkable clay with extremely thinly bedded silt lenses and locally fine selenite. The laboratory testing shows the formation to have up to high volume change potential as defined by NHBC Building Standards, Chapter 4.2.

During the fieldwork groundwater was locally struck at depths between 1.25m and 1.30m; and slight seepages were recorded in the deeper cable percussive borehole at depths of 8.90m and 13.70m depth. Monitoring recorded standing groundwater between some 1.00m and 2.00m depth, which may represent perched groundwater in the Made Ground pooling in the standpipes which are embedded in the relatively impermeable London Clay Formation.

### SITE EXCAVATION

Conventional hydraulic plant should be satisfactory for excavating foundation and service trenches within the soils at the site. Specialist breaking plant will be required to assist in the removal of the existing foundations and floor slabs.

In line with HSE guidelines, all excavations requiring personnel access should be adequately supported to avoid the risk of collapse. Consideration should also be given to the stability of open trenches where personnel are working in close proximity. Excavations at the site should be designed so as not to undermine existing structures or affect adjacent buildings.

No machine excavated trial pits were undertaken as part of this investigation, therefore, direct observations of excavation stability could not be made. However, it is considered likely that some instability will occur over in excavations put down through the Made Ground, particularly the coarse-grained soils beneath the existing car park, over typical construction timescales and some form of sidewall support maybe be required.

Localised groundwater entries should be anticipated from depths as shallow as 1.00m. At this stage it appears that the shallow groundwater entries encountered during the investigation relate to localised perched groundwater within the Made Ground. Therefore, where groundwater entries are encountered, conventional pumping from sumps should be satisfactory in order to maintain a dry excavation.

Nevertheless, it would be useful to undertake trial excavations before any final decisions are made to assess trench stability and the intensity of groundwater ingress.

**FOUNDATION SOLUTIONS**

The Topsoil, Fill, Made Ground and any disturbed soils associated with the removal of the existing foundations are considered unsuitable as a bearing stratum due to their variability, and potential for unacceptable total and differential settlement under applied foundation loadings. Foundations should therefore be taken through into the underlying naturally deposited London Clay Formation to reduce the risk of intolerable structural movements.

*Shallow Foundations*

Traditional shallow foundations may be suitable for the proposed development depending on the anticipated loads, construction limitations and their proximity to vegetation.

A minimum foundation depth of 1.00m below existing ground level is recommended, or 0.20m into the top of the London Clay Formation, whichever is the deeper.

Given the variable thickness of Made Ground beneath the site, up to 1.70m depth, and the potential for deeper areas of disturbed ground following the removal of the existing foundations, it should be appreciated that foundation excavations may locally be required in excess of 2.00m. In such areas due consideration will need to be given to maintaining dry stable excavations.

Additionally, where foundations are to be constructed within the vicinity of the trees on and bordering the site, then they should be deepened in accordance with guidelines given in NHBC Building Standards Chapter 4.2 and taken below any active roots and rootlets encountered in foundation excavations. For trees that are not to be removed, mature tree heights should be assumed when determining the foundation depths. We recommend that an Arboriculturist is appointed to determine tree species at the site. Care should be taken to ensure that any new planting in the development will not affect the new foundations. The London Clay Formation should be considered as being of high volume change potential. Where this requires that foundations be constructed deeper than 2.50m, further ground investigation may be required in order to establish the full depth of any localised soil desiccation beneath the footprint of the proposed structure.

The NHBC guidelines should also be referenced for the specific requirements for compressible layers, such as Claymaster or Clayshield, to be placed along the sides of foundation excavations or beneath ground beams, in order to accommodate heave forces in the ground where any trees and shrubs are removed in the vicinity of the proposed foundations or if the existing vegetation should die.

Given the plastic nature of the London Clay Formation it will be prone to rapid softening when wetted up. In the event that any delays occur between excavating for the foundations, and pouring of the concrete, a blinding layer of concrete should be placed in the base of the open excavations to prevent the occurrence of localised softening. Similarly, in dry conditions, if the soils at the base of the excavation become excessively dried out then the trenches will require re-bottoming prior to concreting.

The allowable bearing pressures recommended below is made on the assumption of an acceptable total settlement for the proposed structures of 25mm. Should the building design require a significantly different serviceability limit state (tolerance to settlement) then it is recommended that these recommendations be revised accordingly.

At the minimum founding depth provided above, an allowable bearing pressure (or net loading intensity increase) of 100kPa may be adopted for isolated, uniformly loaded, conventional strip footings between 0.60m and 1.00m wide; and an allowable bearing pressure (or net loading intensity increase) of 120kPa may be adopted for isolated, uniformly loaded, conventional pad foundations between 1.00m and 2.00m wide.

This allows for a suitable factor of safety against shear failure and should result in acceptable levels of differential and total vertical settlement generally that are likely to take place over a number of years.

*Pile Foundations*

Should the above quoted allowable bearing pressure prove insufficient or the depth of conventional foundations prove to be uneconomical (on account of deep Made Ground and/or trees and shrinkable soils), the structural loads could be supported on piled foundations embedded at depth in the London Clay Formation.

A preliminary pile design data sheet of ultimate values is included in Appendix E. The ultimate shaft friction and the end bearing has been calculated using the result of the laboratory and field strength testing which has been used to derive our shear strength against level plot also presented in Appendix E.

We recommend that any support from the Made Ground is ignored. Additionally, as previously noted, due consideration should be given to the inevitable ground disturbances associated with the demolition of the existing building and removal of existing foundations. Records of ground disturbances should be maintained during demolition works and passed on to the structural engineer/ piling contractor to assist with their design.

Where piles are located within influence of trees they should be sleeved within any existing and potentially future zones of desiccation to reduce the effects of any localised heave recovery should the trees be removed or die. This sleeving will also act to minimise the effects of seasonal uplift forces within the root zone. Void formers should be used along the sides of all subsurface concrete within the zone of existing and potentially future desiccation. The NHBC Standards Chapter 4.2 provides useful guidance for determining the theoretical influence of trees on clay soils based on the volume change potential, the tree heights (including mature heights), tree species and distances from the building. We recommend an Arboriculturist is appointed to determine tree species to assist in this regard.

For the ground conditions encountered we consider that CFA piles may present the optimum type, but the advice of a specialist piling contractor should be obtained to determine the most appropriate pile type, depth and its design using their particular systems in these ground conditions.

Based on the findings from this investigation the following factors will also require consideration in design:

- Potential sidewall instability through the Fill, Topsoil and Made Ground.
- Penetrating potential obstructions in the Made Ground (brick and concrete cobbles) and potential siltstone and mudstone nodules/beds in the London Clay Formation.
- Perched groundwater in the Made Ground and deeper groundwater seepages in the London Clay Formation.
- Volume change potential of London Clay Formation (high) and proximity to existing and proposed vegetation – as noted above sleeving piles to an appropriate depth may assist in this regard.
- Final site levels, pile commencement level and effective working pile depth range.
- The Design Sulphate (DS-4) and Aggressive Chemical Environment for Concrete (AC-4) classifications.

**GROUND FLOOR SLABS**

Given the variable thickness of Made Ground (up to 1.70m depth) and presence of shrinkable soils beneath the site suspended ground floor slabs in conjunction with the main foundations are recommended to reduce the risk of intolerable movements. A void should be left below the floor slab and ground beam to accommodate future moisture content-related soil movements. This may be achieved by use of a proprietary compressible material such as Clayboard or Cellcore.

**ACCESS ROADS AND PARKING**

The structural design of a road or hard standing is based on the strength of the subgrade, which is assessed on the California Bearing Ratio (CBR) scale.

Deep Made Ground was encountered over the whole of the site (0.80m to 1.70m depth). Pavement construction may be considered on this existing Made Ground by employing appropriate mitigation measures. It is recommended that geogrids or similar soil reinforcement techniques be employed to provide a subgrade with a known CBR value. Reinforcement measures will also mitigate lateral and vertical displacement from traffic loadings and differential settlement over variable ground. Discussions should be held with a soil reinforcement company (such as Tensar) who would design a subgrade to a specified CBR value. The following should also be taken into consideration:

- Inspection of the formation and removal of any surface areas of soft, organic or other unsuitable materials.

- ‘Heavy’ proof rolling of the resultant formation, to compact loose coarse materials and locate any soft spots at shallow depth beneath the formation for subsequent removal.
- Removal of intact or loose obstructions where noted at surface, or known based on the investigation, to a depth of at least 600mm beneath the formation to prevent the creation of hard spots or voiding.
- Backfilling of any excavation with well-compacted inert coarse material.
- Adopt a pavement design based upon an equilibrium CBR of less than 2%.

As the Made Ground is likely to be frost susceptible the pavement thickness will need to accommodate this effect.

Site conditions should be reassessed at the time of construction and the CBR/pavement design updated accordingly if considered necessary. If pavement construction is undertaken during wetter parts of the year, then a greater pavement thickness or geogrid reinforcement may be required.

The presence of trees will mean that there is potential for soil desiccation issues, which may affect the pavement surfacing within influencing distance. Thus, safeguarding against desiccation in this regard could be considered, such as lime/cement stabilisation to appropriate depth, which can limit shrinkage/swelling desiccation effects by altering the properties of the clay. Alternatively, it could be accepted that some movements may occur, which could be accommodated through flexible surface finishes.

**INFILTRATION MEASURES**

Appropriately designed sustainable drainage systems (SuDS) are more sustainable than using piped drainage to local sewer systems. However, infiltration measures close to buildings may result in undermining of foundations and softening of soils leading to instability and should be located at suitable distances from foundations and infrastructure. Consideration must also be given to the effects on slopes, flooding and mobilisation of contaminants and the potential for future rises in groundwater levels.

The preliminary ground model identified that, given the anticipated clay-dominated matrix of the London Clay Formation, the soils are anticipated to have Very Poor infiltration potential (in accordance with CIRIA C753 – The SuDS Manual). This was verified during the infiltration testing (targeted the London Clay Formation), which recorded no fall in water over the 60-minute testing period. It is therefore considered unlikely that on-site drainage measures will prove suitable, and alternative drainage measures will need to be considered.

## DISPOSAL OF ARISINGS

Site excavations, such as for foundations and services trenches are likely to produce arisings, some of which may be able to be re-used on-site and some of which will be surplus to requirements. The options for disposal of these arisings are discussed below:

### RE-USE OF MATERIAL ON SITE

Currently, if surplus arisings are 'fit for re-use' on the site and have not been treated, their re-use is allowed within the planning law. If the arisings need treating prior to re-use, exemptions can be sought from the EA to allow this activity.

A recent voluntary code of practice published by CL:AIRE, in conjunction with the EA, (the Definition of Waste: Development Industry Code of Practice, Version 2) endorses the re-use of arisings on and off the site of origin without the need for exemptions from the EA, dependent on whether it is "fit for purpose". It also supports the use of "Hub and Cluster" sites (to enable surplus soil to be used on agreed sites in the local vicinity, dependent on the soil being 'fit for purpose').

The use of a Materials Management Plan (MMP) during the earthworks phase will help to avoid paying tax on soil movements that might otherwise attract tax, if they are construed by the HMRC as being waste without the relevant documentation to prove otherwise.

Based upon the human health risk assessment the Topsoil, Fill and Made Ground soils at the site are not suitable to be re-used for landscaping purposes, but may be used at depth beneath areas of buildings and permanent hardstanding. The London Clay Formation is however considered suitable to be re-used on site for landscaping purposes. This should be agreed with the Local Authority.

*Recycled Concrete Aggregate (RCA)*

The demolition of existing structures on the site will produce large quantities of demolition rubble, and consideration should be given to the re-use of this material as recycled concrete aggregate (RCA) for the proposed development, beneath roads and pavements or, potentially, as engineered fill where ground improvement is required to fill voids, or replace areas of deep Made Ground; or as aggregate for vibro-stone columns. Recycled aggregate is also a permitted constituent for pipe bedding, haunching and surround material in the current version of the Specification for Highway Works.

Consideration will need to be given to both static and dynamic loadings on replaced materials and the sensitivity of the subgrade. It is recommended that any materials to be recycled be classified for re-use using Volume 1, Specification for Highways Works, Series 600 for Earthworks.

Recycled aggregate is a permitted constituent for Type 1 sub-base. Should this option be explored, then it is recommended that trials be conducted to confirm the suitability / class of the material. The aggregate should be well-graded and classification will take into account particle size, fines content and, where high loadings are required, hardness. The material should not include compressible or readily crushable items.

The level of control on the placement of the aggregate will have a direct effect on the performance of the platform and it is recommended that compaction be undertaken in line with the Department of Transport (DoT) specifications.

**WASTE CLASSIFICATION**

Under current waste management legislation, arisings that are surplus to requirements will be classified as waste and need disposing off-site. Records must be kept of where the waste is taken upon leaving site and its final destination.

The classification is a twofold process using the soil chemical testing results and the European Waste Catalogue for off-site disposal, followed by testing under the Waste Acceptance Criteria (WAC) of the Landfill Directive specifically for landfill disposal.

**EUROPEAN WASTE CATALOGUE DETERMINATION**

Any soil classified as waste requires classification of the chemical constituents prior to leaving site in accordance with the European Waste Catalogue (EWC). Soils containing asbestos fragments or fibres will be classified as a mixed waste unless the asbestos can be separated.

*Soils*

The 'Total' soil contamination test results from this investigation, excluding asbestos, have been used in conjunction with the HazWasteOnline spreadsheets and the Technical Guidance WM3 published by the EA.

The assessment report, which does not does not take into account the presence of asbestos, is provided in Appendix F and summarised below:

| Location | Depth (m) | Waste Stream/ Strata | EWC Classification |
|---|---|---|---|
| CT01 | 0.40 to 0.90 | Made Ground | Non-Hazardous |
| CT02 | 0.10 to 0.30 | Topsoil | Non-Hazardous |
| CT03 | 0.90 to 1.50 | Made Ground | Non-Hazardous |
| FIP01 | 0.40 | Topsoil | Non-Hazardous |
| FIP04 | 0.35 | Made Ground | Non-Hazardous |
| FIP05 | 0.30 | Made Ground | Non-Hazardous |
| WAC01 | - | Made Ground | Non-Hazardous |

*Asbestos*

Technical Guidance WM3 states that 'if the waste contains fibres that are free and dispersed, then the waste will be hazardous if the waste as a whole contains 0.1%w/w or more asbestos'. Asbestos screening recorded loose chrysotile (white asbestos) fibres in a shallow sample of the coarse-grained Made Ground from FIP04, which was put down through the existing car park in the north-west of the site. Gravimetric analysis revealed a concentration of 0.003%w/w in the sample as a whole, which therefore does not classify the soil as hazardous waste.

Technical guidance WM3 also states that 'where the waste contains identifiable pieces of asbestos (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then the waste is hazardous if the concentration of asbestos in the pieces alone is 0.1% or more'. During the fieldwork broken fragments of corrugated cement sheets, suspect to contain asbestos, were visually identified FIP05, which was put down adjacent to the existing building in the north-east of the site. Laboratory testing confirmed the fragments contained amosite (brown asbestos) and chrysotile (white asbestos). Cement bound asbestos sheeting typically contains 10% to 15% asbestos, which is above the hazardous waste limit of 0.1%. Therefore, during construction, where asbestos pieces visible by the naked eye are encountered in the ground, this soil is considered as mixed waste and must be separated whenever possible and each separate waste stream classified accordingly. Any works involving or potentially involving asbestos must be undertaken by suitably trained groundworkers.

### WASTE ACCEPTANCE CRITERIA (WAC) TESTING RESULTS

If it is decided that the surplus arisings will be disposed of at a landfill facility, the implementation of the Landfill Directive means that the waste soil requires testing under the Waste Acceptance Criteria (WAC) to determine whether it should be destined for an Inert, Non-hazardous, Stable non-reactive hazardous, or Hazardous landfill, or whether an alternative disposal method must be sought.

WAC testing has been carried out on a representative composite samples of the clay-dominated Made Ground (sample reference WAC01), the results of which are presented in Appendix F. The clay-dominated Made Ground soils were initially classified as non-hazardous waste (providing the soils are screened and any ACMs are removed); and the WAC testing indicates that the soil passes the Inert criteria.

### OVERALL WASTE CLASSIFICATION

From the above, currently, the waste soils on this site are classified as follows:

| Waste Stream | EWC Classification | WAC for Landfill Disposal | Comment |
|---|---|---|---|
| Topsoil | Non-hazardous | Not assessed | Likely remain classified as **non-hazardous** due to organic content |
| Made Ground: brick and concrete gravel and cobbles | Non-hazardous | Not assessed | May classify as **Inert** under 17 01 07 providing ACMs are removed |
| Made Ground: disturbed London Clay | Non-hazardous | **Inert** | ACM must be removed |
| London Clay Formation | Non-hazardous | Not assessed | **Inert** under 17 05 04, if clearly separated and uncontaminated |

Pieces of ACM should be segregated and disposed of as Hazardous waste.

Asphaltic surfacing (such as the existing car park) may contain coal tar. Coal tar was in production and used as a binder, and more latterly for top dressing, prior to the 1980s, when the transition was made to bitumen. Where areas of hardstanding were constructed before, or improved/repaired (using older road planings) after, the 1980s, further assessment for waste classification purposes will be necessary to determine whether or not the hardstanding contains coal tar.

Different categories of waste soils must not be mixed. The action of mixing hazardous waste with non-hazardous waste to dilute hazardous concentrations or to dispose of one waste type as/with another is illegal.

Analytical results relevant to the materials being disposed of should be provided to the waste management contractors and landfill operators to confirm whether it meets their license agreements and to confirm tipping costs.

*Waste Treatment*

The Landfill Regulations dictate that all non-Inert waste must be treated before going to landfill. This treatment should include the following criteria, where they are likely to be effective:

- Physical, thermal, chemical or biological process including sorting.
- Change the characteristics of the waste.
- Reduce the volume, reduce the hazardous nature, facilitate its handling or enhance its recovery.

The most basic method of pre-treatment is sorting of the waste and re-cycling of any possible component materials and many waste disposals companies will have on-site recycling facilities.

The Environment Agency expect all landfill operators to obtain written evidence that the waste they accept has been pre-treated. We recommend that a signed certificate describing the treatment should be obtained to give to the receiving landfill. Further testing may be required after the treatment and before the soil is accepted by the relevant landfill.

## LIMITATIONS AND RECOMMENDATIONS FOR FURTHER WORK

The ground is seldom homogeneous and variations, which affect our conclusions, may inevitably occur between and beyond the test locations. Should ground conditions vary noticeably from our Ground Model, then we recommend further assessment by a suitably qualified person.

*Environmental & Waste Soils*

Given the presence of asbestos fibres and ACMs in the ground the advice of a specialist should be sought to determine whether the proposed works will require licencing and if any further mitigating measures will be required. Any developers undertaking construction works on the site where the ground will be disturbed will have a duty of care to its employees to ensure that the Control of Asbestos Regulation 2012 are adhered to.

A Discovery Strategy should be implemented during demolition and groundworks, and should suspicious soils be encountered, work should cease immediately, and the soils be assessed by a suitably qualified engineer.

Based upon the findings of the human health risk assessment remedial measures, such as a clean cover system, will be required in areas of proposed soft landscaping. A Remedial Strategy will be required followed by Post Remediation Verification of the measures undertaken.

Waste Made Ground soils should be screened for ACMs; and pieces of ACMs be segregated and disposed of as Hazardous waste.

*Geotechnical*

Due consideration should be given to the inevitable ground disturbances associated with the demolition of the existing building and removal of existing foundations. Records of ground disturbances should be maintained during demolition works and passed on to the structural engineer/ piling contractor to assist with foundation design.

Should traditional shallow foundations be considered then we recommend that trial excavations be undertaken to assess trench stability and the intensity of groundwater ingress. Foundations should be designed and constructed in accordance with NHBC Building Standards Chapter 4.2 guidelines. Given the thickness of Made Ground encountered during the investigation (up to 1.70m depth) in addition to the high volume change potential of the London Clay Formation and the proximity to mature trees, it should be appreciated that locally foundation excavations may be required to extend to depth in excess of 2.50m.

Should piled foundations be considered, the advice of a specialist piling contractor should be obtained to determine the most appropriate pile type, depth and its design using their particular systems.

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BRE=Building Research Establishment. BSI=British Standards Institution. CIRIA=Construction Industry Research and Information Association. AGS=Association of Geotechnical and Geoenvironmental Specialists. EA=Environment Agency. HSE=Health and Safety Executive. NHBC=National House Building Council. DEFRA=Department for Environment, Food and Rural Affairs. ASP=Amherst Scientific Publishers. CL:AIRE=Contaminated Land: Applications in Real Environments. LQM=Land Quality Management. BGS=British Geological Survey. WHO=World Health Organisation. SoBRA=Society of Brownfield Risk Assessment. TRRL=Transport and Road Research Laboratory. UKWIR=UK Water Industry Research

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