Surface Water Drainage Statement

Former Belsize Fire Station, 36 Lancaster Grove, London NW3 4PB

February 2016

Dr Paul Garrad
Consultant Hydrologist
66 Charlock Way
Guildford
Surrey
GU1 1XZ

Surface Water Drainage Statement
Former Belsize Fire Station, 36 Lancaster Grove, London NW3 4PB

Contents

Figures

1 INTRODUCTION

1.1 Requirements for a Surface Water Drainage Assessment

As from 6 April 2015 the Lead Local Flood Authorities (LLFAs) are the statutory consultees on flood risk and require a Surface Water Drainage Statement for all "major" planning applications irrespective of size or Flood Zone. This requires the completion of a SUDS proforma with a short report of supporting calculations which details the peak flows and volumes of runoff from the site and the type, size and location of suggested SUDS measures. This should include a maintenance and operation plan for the lifetime of the development.

The basic premise, as required by NPPF paragraph 103, is that a new development should not increase flood risk elsewhere off the site using SuDS methods to control site runoff. In the London Borough of Camden the adopted SuDS methods must be also consider the London Plan and Policy 5.13 which provides a preferred hierarchy of SUDS measures and requires that the runoff volume for the 100 year 6 hour storm must be constrained as close as is reasonably practicable to the greenfield rate. Camden's Planning Guidance 3 (CPG3) also requires that a new development should achieve the greenfield runoff rate but if this is not feasible then a 50% reduction in the existing runoff is acceptable. These runoff rates are therefore based on the permeable and impermeable areas of the existing and the proposed site which are detailed below.

1.2 The Existing Site

The proposed development is located at the former Belsize Fire Station in north west London at the junction of Lancaster Grove and Eton Avenue (Figure 1.1). The L shaped building covers an area of 685m^2 with 748m^2 of impermeable ground level impermeable areas as shown on an aerial photograph (Figure 1.2) hence with a total impermeable area of 1433m^2. The permeable gardens to the front occupy 375m^2 so the total site area is 1808m^2 (Table 1.1).

Table 1.1 Land Use of Existing Site

Land Use	Impermeable Buildings (m^2)	Impermeable Ground Level (m^2)	Permeable Area (m^2)	Total Area (m^2)
North Parking		488		
East Parking		57		
Building	685			
Paths		203		
Garden			375	
Total	**685**	**748**	**375**	**1808**

The site is generally flat and between 59.04m and 59.44m OD (Figure 1.3) with a slight gradient to the north. This also shows that runoff from the existing site currently drains to the storm sewer on Lancaster Grove to the north and to Eton Avenue to the south.

1.3 The Proposed Development

The proposals are for the change of use of the existing building to provide 12 residential units, with car parking to the rear. Apart from internal refurbishment the only external change to the building will be the introduction of three small extensions (Figure 1.4) over 61m^2 and located on land currently occupied by the east parking area (18m^2) and the side path to the west (43m^2). The site will therefore have the same permeable and impermeable areas as existing (Table 1.2).

Table 1.2 Land Use of Proposed Site

Land Use	Impermeable Buildings (m^2)	Impermeable Ground Level (m^2)	Permeable Area (m^2)	Total Area (m^2)
North Parking		488		
East Parking		39		
Building	685			
Extensions	61			
Paths		160		
Garden			375	
Total	**746**	**687**	**375**	**1808**

The proposals are to use the same storm sewers as existing with on site underground storage to reduce the developed site peak flows to the existing, greenfield or other suitable rate.

1.4 Report Structure

In addition to SUDS Camden's Development Policy 23 (Water) also requires that the risk of fluvial, tidal, groundwater and other sources of flooding are considered to determine whether a development is in an area at flood risk. For this Statement these potential sources of flooding are considered in Section 2. The existing, greenfield and the developed site runoff without SUDS are considered in Section 3 and suitable Sustainable Urban Drainage Systems (SUDS) detailed in Section 4. The SUDS proforma are provided as a separate document.

2 FLOOD RISK

2.1 Fluvial Flood Risk

The Environment Agency's flood map (Figure 2.1) shows the site is located in Flood Zone 1 with an annual probability of tidal and fluvial flooding of less than 0.1% per year, above the 1000 year flood level. The site therefore has a low risk of fluvial and tidal flooding.

2.2 Other Sources of Flooding

Camden Development Policy 23 and NPPF emphasise the need to consider all sources of flooding when planning a development as there may be other sources of flooding which could affect the site and which may be important considerations for managing flood risk. For this site these other sources may include:

- Storm Water Flooding. This can occur when excess water runs off the surface of a site particularly during short but intense storms. Flooding occurs because the ground is unable to absorb the high volume of rain water or because the amount of water is greater than the capacity of the drainage system to take it away. This can particularly occur on developed impermeable sites such as concrete, tarmac or buildings. There are no records of the existing site, the local area or nearby properties having flooded. The EAs pluvial flood risk map and in the SFRA (Figure 2.2) shows the site the site is at a very low risk which is defined as less than the 200 year event. As the ground and first floor residential floor are raised above the local ground level this will prevent storm water ponding from entering the dwellings and the risk of flooding is therefore low.

- Road flooding can occur from an intense rain storm on a road surface when the amount of water arriving on the road is greater than the capacity of the local drainage network to take it away resulting in ponding. As above the EA and SFRA pluvial flood risk map show the site is at very low risk (Figure 2.2). This type of flooding is difficult to predict at any location but as the ground floor and the residential upper floors are raised above the local road level the risk of flooding from this source is considered to be low.

- Sewer flooding. This can occur when a storm sewer or combined sewer network becomes overwhelmed and its maximum capacity is exceeded. Higher flows are likely to occur during periods of prolonged rainfall, the autumn and winter months, when the capacity of the sewer systems is most likely to be reached. During summer periods sewers can become susceptible to blockage as the low flows are unable to transport solids which leads to the gradual build up of solid debris. There are no records of sewer flooding in this area in the SFRA (Figure 2.3) and whilst this is difficult to predict with any certainty the raised floor levels will provide protection and the risk of flooding from this source is considered to be low.

- Groundwater flooding is most likely in low-lying areas underlain by permeable rocks (e.g. Chalk or Sandstone) and occurs as water rises up through the underlying rocks or from water flowing from abnormal springs. This tends to occur after long periods of sustained high rainfall which can cause the water table to rise above normal levels and particularly in lower lying areas and the risk will depend on local ground conditions. The geology in this area is London Clay and raised groundwater levels are unlikely. Additionally recharge in such urban areas is usually limited due to the presence of impermeable surfaces and storm water drainage systems. There are no recorded incidents of groundwater flooding in the area (Figure 2.3) and it is likely that if groundwater levels reach the ground surface this would drain through the surface water network. With raised residential ground floor levels the risk from groundwater flooding is considered to be low.

- Flooding from Impounded Water Bodies. The potential risk associated with artificial sources of flooding has been investigated by the EA which shows there are no reservoirs and/or water storage facilities within or near the site that may potentially pose a potential risk of flooding to the site either directly or in case of failure (Figure 2.3). The risk of flooding from this source is considered to be low.

2.3 Implications for the Proposed Development

The site is in Zone 1 and at a low risk of pluvial, road, sewer, reservoir and groundwater flooding. There is therefore no requirement to consider raising the floor levels, flood storage compensation or flood resilience and resistance measures and a safe escape route from the site exists.

3 SITE RUNOFF

NPPF and the Environment Agency normally seek to achieve the most sustainable drainage system reasonably practical which should aim to ensure the developed site runoff does not exceed the existing rate so as not to increase flood risk to others. The London Plan and the SFRA requires that surface water runoff from a site to be as close to Greenfield rate as feasibly possible. The more recent London Plan "Sustainable Design and Construction Supplementary Planning Guidance" (April 2014) indicates (Section 3.4.10) that for developments on previously developed sites the runoff should not be more than three times the greenfield rate although 50% of the existing rate is also specified, as is the limiting discharge of 5 l/s. This requires a comparison of the existing, greenfield and the developed site surface water runoff rates to demonstrate that measures for reducing surface water run off based on appropriate SUDS can be included in the new development proposals.

3.1 Existing Site

The CIRIA guidance on SUDS (CIRIA C697) recommends the use of IH124 for existing and greenfield runoff for sites less than 50 ha. However this site is small (0.18ha) and far below the lower limit of the IH124 method (110ha) and as the site is urban and does not contain a watercourse IH124 is not considered to be valid. A recent EA R&D report (SC090031) recommended that IH124 should no longer be used for site runoff calculations and this is included in the latest EAs Flood Estimation Guidelines.

The Wallingford or Rational Method is therefore used to provide the peak flows and volumes for the existing site based on the impermeable site area of 1433m^2, the urban percentage runoff of 75% and rainfall data provided by the Flood Estimation Handbook (FEH)[1] at the nearest 1km grid point to the site (TQ 270 850) (Table 3.1).

Table 3.1 FEH Point Rainfall (mm)

Return Period (yrs)	Storm Duration				
	15min	30min	1 hr	3 hr	6 hr
1.1	4.1	5.2	6.6	9.7	12.4
2	8.9	10.9	13.4	18.5	22.8
10	18.7	22.2	26.3	34.4	40.7
30	27.8	32.3	37.6	47.7	55.5
50	33.2	38.3	44.1	55.3	63.8
100	42.1	48.0	54.7	67.4	76.8

The 100 year 1 hour storm on the existing site would provide a peak flow of 16.3 l/s and a volume of 59m^3 whilst the 6 hour storm a peak flow of 3.8 l/s and a volume of 83m^3 (Table 3.2).

[1] Flood Estimation Handbook, Centre for Ecology and Hydrology 1999

Table 3.2 Existing Site Peak Flows and Volumes

Return Period (years)	15 min		30 min		1 hr		3 hr		6 hr	
	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)
1.1	4.9	4.4	3.1	5.6	2.0	7.1	1.0	10.4	0.6	13.3
2	10.6	9.6	6.5	11.7	6.1	22.0	2.7	29.4	1.6	35.3
10	22.4	20.1	13.3	23.8	7.8	28.2	3.4	36.9	2.0	43.7
30	33.2	29.9	19.3	34.7	11.2	40.4	4.8	51.3	2.8	59.6
50	39.7	35.7	22.9	41.1	13.2	47.4	5.5	59.4	3.2	68.5
100	50.3	45.2	28.7	51.6	16.3	58.8	6.7	72.4	3.8	82.5

3.2 Greenfield Site

The peak flows and volumes for the Greenfield site are based on the same drainage area and FEH rainfall but with a rural percentage runoff based on the soil type from FEH (SPRHOST) which is 50.6%. The 100 year 1 hour storm would provide a peak flow of 11.0 l/s and a volume of 40m^3 and the 6 hour a flow of 2.6 l/s and a volume of 56m^3 (Table 3.3).

Table 3.3 Greenfield Site Peak Flows and Volumes

Return Period (years)	15 min		30 min		1 hr		3 hr		6 hr	
	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)
1.1	3.3	3.0	2.1	3.8	1.3	4.8	0.7	7.0	0.4	9.0
2	7.2	6.5	4.4	7.9	4.1	14.9	1.8	19.8	1.1	23.8
10	15.1	13.6	8.9	16.1	5.3	19.1	2.3	24.9	1.4	29.5
30	22.4	20.2	13.0	23.4	7.6	27.3	3.2	34.6	1.9	40.2
50	26.8	24.1	15.4	27.7	8.9	32.0	3.7	40.1	2.1	46.2
100	33.9	30.5	19.3	34.8	11.0	39.7	4.5	48.9	2.6	55.7

The greenfield peak flows and volumes are 66% of the existing rate due to the difference in the percentage runoff of 50.6% and 75% respectively.

3.3 Developed Site Without SUDS

The proposed development is based on the change of use of the existing building and although small extensions are proposed the impermeable area will remain as existing with an assumed percentage runoff of 75%. The post development runoff should also include an allowance for increased rainfall due to climate change over the lifetime of the development which for residential properties is taken as 100 years. The latest guidance suggests that peak rainfall is expected to increase by 30% up to 2110 and hence the FEH rainfall totals are increased by 30%. The 100 year 1 hour storm on the developed site would provide a peak flow of 21.3 l/s and a volume of 76m^3 and the 6 hour a flow of 5.0 l/s and a volume of 107m^3 (Table 3.4).

Table 3.4 Developed Site Peak Flows and Volumes

Return Period (years)	15 min		30 min		1 hr		3 hr		6 hr	
	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)	Q (l/s)	Vol (m^3)
1.1	4.9	4.4	4.0	7.3	2.6	9.3	1.3	13.6	0.8	17.3
2	10.6	9.6	8.5	15.3	8.0	28.6	3.5	38.2	2.1	45.9
10	22.4	20.1	17.2	31.0	10.2	36.7	4.4	48.0	2.6	56.9
30	33.2	29.9	25.1	45.2	14.6	52.5	6.2	66.7	3.6	77.5
50	39.7	35.7	29.7	53.5	17.1	61.6	7.2	77.3	4.1	89.1
100	50.3	45.2	37.3	67.0	21.3	76.4	8.7	94.1	5.0	107.3

The 30% increase in peak flows and volumes above the existing rate is due to the change in the rainfall totals from climate change as the percentage runoff and the impermeable site area will remain the same as existing. The use of Sustainable Urban Drainage Systems to reduce the developed site flows to the existing and the Greenfield rate are detailed below in Section 4.

4 SUSTAINABLE URBAN DRAINAGE MEASURES

4.1 Principles of SUDS

4.1.1 SUDS Hierarchy

To reduce storm runoff from impermeable drainage areas a range of Sustainable Urban Drainage Systems (SUDS) can be used. The London Plan (Policy 4A.14*)* requires that surface water run-off should be based on the following drainage hierarchy:

- Store rainwater for later use such as rainwater harvesting or green roofs
- Infiltration techniques, such as soakaways or permeable surfaces.
- Attenuate rainwater in ponds or open water features for gradual release to a watercourse
- Attenuate rainwater by storing in tanks or sealed water features for gradual release to a watercourse
- Discharge rainwater direct to a watercourse
- Discharge rainwater to a surface water sewer or drain
- Discharge rainwater to the combined sewer.

Before disposal of surface water to the public sewer is considered all other options set out in the drainage hierarchy should be exhausted. When no other practicable alternative exists the Water Company should confirm that there is adequate spare capacity in the existing system taking future development requirements into account.

4.1.2 SUDS Disposal Rates

The size of any SUDS feature will also depend on the allowable release rate and there are different standards:

- NPPG and NPPF require that to ensure there is no increase in flood risk to others off the site that runoff with climate change should not exceed the existing rate.
- The London Plan (Policy 5.13) requires that runoff from a developed site should not exceed the greenfield rate as far as possible.
- The London Plan Supplementary Planning Guidance (SPG 3.4.10) states that on greenfield sites a new development should maintain the greenfield runoff rate but that on previously developed sites runoff should not be more than 3 times the greenfield rate.
- SPG (Section 3.4.8) states that the minimum expectation from a development proposal is to achieve a 50% attenuation of the existing peak flow.
- SPG (Section 3.4.9) indicates that where the greenfield rate is extremely low and the outfall of a piped system would be prone to blockage then a minimum discharge of 5 l/s is acceptable.

As the existing site is developed the required standard is therefore 3 times the greenfield rate, 50% of existing rate or 5 l/s. The options to achieve these rates are considered in outline below based in the London Plan hierarchy and with any SUDS measures that are impractical discounted.

4.2 Storage of Rainwater for Later Use

4.2.1 Rainwater Harvesting

Rainwater harvesting is the collection of runoff from roofs and other surfaces that would otherwise be directed to the local drainage system. Once collected and stored it can be used to replace mains water for non-potable purposes such as toilet flushing. This can reduce storm runoff without the need for treatment or oil separators as the risk of contamination is low. The collected water is held in roof level or underground storage tanks and over the course of a year will reduce the volume of water entering the storm water system.

The BS8515:2009[2] intermediate approach is based on the average annual rainfall (SAAR) of 651mm and the useable roof area of the building taken as 600m^2 which gives a total volume of 390m^3 per year. A drainage coefficient (DC) of 0.8 is then used to account for losses such as overflowing gutters and evaporation and it is estimated that only 90% of the water flowing into the system is retained hence a filter coefficient (FC) of 0.9 is also used and the available water is therefore 281m^3/yr (Table 4.1). BS8515 suggests the installed tank size should be 5% of the annual rainwater supply which gives a required storage volume of around 14.0m^3.

Table 4.1 Rainwater Harvesting Volumes

Roof Area (m^2)	Rainfall (mm)	Total Runoff Volume (m^3)	Drainage Coefficient	Filter Coefficient	Net Runoff Volume (m^3)	Storage Volume (m^3)
600	650	390	0.8	0.9	281	14.0

As water is collected from roof gutters and down pipes an underground rather than roof level tank of this size would be the preferred option from which a pump would take water to roof level header tank where a gravity feed would distribute water to the dwellings for flushing WCs etc. This will require an overflow to discharge excess runoff to the local storm sewer.

Assuming a grey water use for toilet flushing per person of 25 litres/day the total water requirement of 33 occupants is 825 l/day and hence the suggested tank would provide a supply for around 17 days (Table 4.2). This is not considered to be an economically viable or practical option as the tanks would run dry if there was no rainfall in this period and this often arises with a small roofed area and a large number of occupants in the multi-storey building.

Table 4.2 Water Demand

Item	Number
No 1 Bed flats (2 persons)	6
No 2 Bed flats (3persons)	3
No 2 Bed flats (4persons)	3
Total Occupants	33
Total Water Demand (25 l/p/d)	825
No Days Supply	17.0

In addition RWH tanks are intended to provide a reliable water supply and hence the aim would be to keep the tanks as near as full as possible. It cannot be guaranteed that there would be any spare capacity at the start of an extreme rainfall event and hence RWH is not considered to be a suitable option for runoff control.

[2] British Standard 8515:2009 *Rainwater Harvesting Systems – Code of Practice* (BS 8515)

4.2.2 Green Roof

A green roof is a multi-layered system that covers the top of a building with vegetation and soils which can provide rain storm attenuation and a reduction in site runoff. These can either be low maintenance extensive roofs with a 25-125 mm soil layer in which a variety of hardy drought tolerant low plants are grown, or intensive roofs with trees and planters which impose a greater load on the roof structure but are more suitable in certain circumstances. Green roofs can be used to reduce the volume and rate of runoff from a site or allow other SUDS techniques to be reduced in size. However the existing building has a pitched tiled roof and it will not be possible to fit a green roof onto this existing structure and this option is discounted.

4.3 Infiltration Techniques

4.3.1 Soakaways

Source control systems can include soakaways where water is dispersed into the ground and these may be suitable if the soils and underlying strata are relatively permeable. The British Geological Survey maps show the site lies on London Clay (Figure 4.1) which are impermeable strata with no drift deposits in the area (Figure 4.2). This is reflected in the high FEH percentage runoff (SPRHOST) of 50.61% and suggests that infiltration techniques such as soakaways will not be suitable.

4.3.2 Permeable Surfaces

Permeable pavements can often be considered for ground level impermeable areas such as pavements and parking areas but these also require permeable underlying strata to dispose of water. These will not be a suitable option due to impermeable strata below the site.

4.3.3 Permeable Conveyance

There is limited space on this site for permeable conveyance systems such as open channel swales or infiltration trenches and as detailed above as the underlying soils are impermeable and these are not considered suitable.

4.4 Storage and Attenuation

As source control or conveyance systems cannot provide a suitable solution on this site then passive treatment based on storage and attenuation have to be considered. For small urban sites such as this, where lakes or basins are not appropriate, the options can include an underground tank, sub-surface attenuation structures such as Storm cells or an oversized drainage network.

Preliminary routing calculations have been undertaken to assess the required size of a storage facility based on maintaining the maximum developed site runoff at the existing rate, and the greenfield rate, and assuming any excess water is taken into storage. This suggests (Table 4.3) that a storage facility of 4.7m^3 would be required for the 1 hour storm to ensure the developed site runoff does not exceed the existing rate (Figure 4.3) or 6.6 m^3 for the 6 hour storm. To achieve the greenfield rate would require a larger volume of 15.7m^3 for the 1 hour and 22.0m^3 for the 6 hour storm (Figure 4.4). At Camden's request the shorter 15min and 30min storm durations are also included but these will require smaller storm volumes.

Table 4.3 Storage to Maintain Developed Site Runoff at Existing Rate - 100 year storm

Storm	Peak Flow (l/s)			Storage Reqd (m3)	
Duration (hrs)	Existing	Greenfield	Developed	Existing	Greenfield
0.25	50.3	33.9	65.4	3.6	12.1
0.5	28.7	19.3	37.3	4.1	13.8
1	16.3	11.0	21.3	4.7	15.7
3	6.7	4.5	8.7	5.8	19.3
6	3.8	2.6	5.0	6.6	22.0

As detailed above the London Plan SPG (3.4.10) states the required standard on previously developed sites such as this is for runoff to not exceed 3 times the greenfield rate but as these flows are higher than the developed site this suggests that no SUDS measures are required. This arises as the greenfield rate is relatively high due to the high percentage runoff of the London Clay soils of 50.6%.

DEFRAs Non-statutory Technical Standards for SUDS (March 2015) indicates that for previously developed sites the peak runoff rate and volume must be as close as reasonably practicable to the greenfield rate for the same rainfall event and should not exceed the existing rate. The require standard is therefore between the existing and the greenfield rate and for the 6 hour storm a storage volume of 6.6m^3 to 22.0m^3 is required. Camden BC has advised that the greenfield rate is required.

The London Plan SPG also states (para 3.4.9) that there may be situations where it is not appropriate to discharge at the greenfield rate where the low flow rate could lead to blockage and a minimum limiting discharge of 5 l/s is considered appropriate. However the developed site runoff is always higher than 5 l/s and hence this limiting discharge is not required.

The options to achieve the required volume for the 100 year 6 hour storm and the greenfield rate would include:

- A 22m^3 underground tank is too large to be practical on this small urban site and there is no available space for a pond or basin and these options are discounted.
- Storm cell may be suitable and a typical storm-cell is 1.2m wide, 2.4m long and 0.52m deep with 95% void space and can provide 1.42m^3 of storage although various sizes are available. To maintain runoff at the existing rate would require 5 storm cells over an area of 14.5m^2 or for the greenfield rate 16 storm cells over an area of 46m^2.
- An oversized drainage network. A new 20m long 150mm diameter storm water pipe will provide a storage volume of 0.35m^3 and increasing this to 20m of 250mm diameter pipe will provide 0.98m^3 of storage which is not sufficient to provide the storage required and the available space on the site is limited.

In summary to maintain the developed sites flows and volumes at the existing or the greenfield rate will require storage and attenuation features and storm cells offer the best and most practical solution. These SUDS measures will then meet the requirements of NPPF, NPPG, the EA, the SFRA and the London Plan drainage hierarchy.

4.5 Outline Drainage Strategy

As the ground floor is raised above the local ground level then flooding of the building will not occur in the event of local drainage system failure, whether by extreme rainfall or a lack of maintenance. The flow routes in the event of a system failure or the storage facility being full, will be as existing which is down gradient towards the storm sewer on Lancaster Grove and Eton Avenue.

The proposed SUDS system will include arrangements for ongoing maintenance based on the manufacturers recommendations. This will allow access to undertake any necessary works over the life-time of the development including system monitoring, inspection, routine and remedial maintenance.

Figures

Figure 1.1 Site Location and Layout

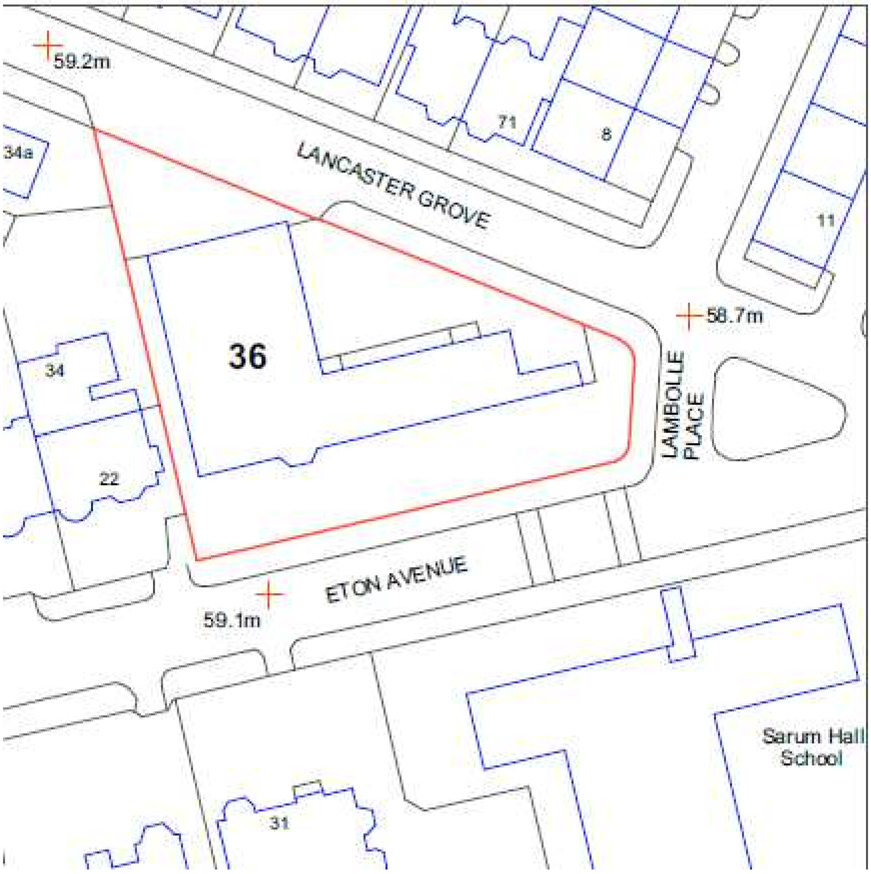


Figure 1.2 Aerial Photograph (from the south)

Figure 1.3 Topographical Survey

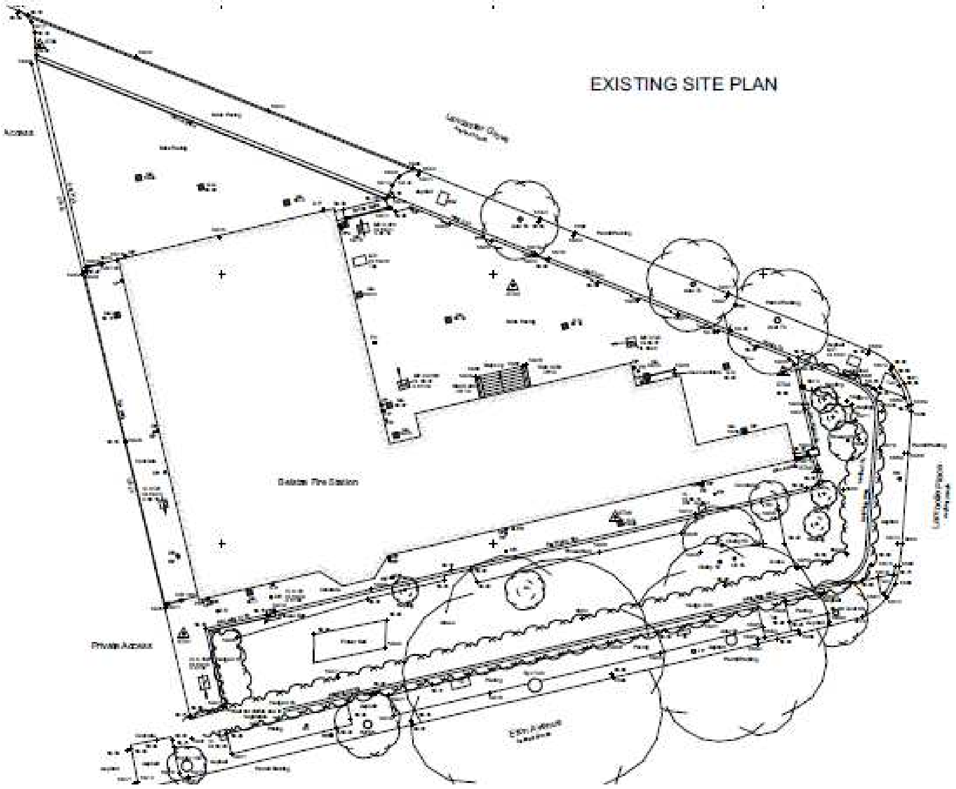


Figure 1.4 Proposed Development Plans

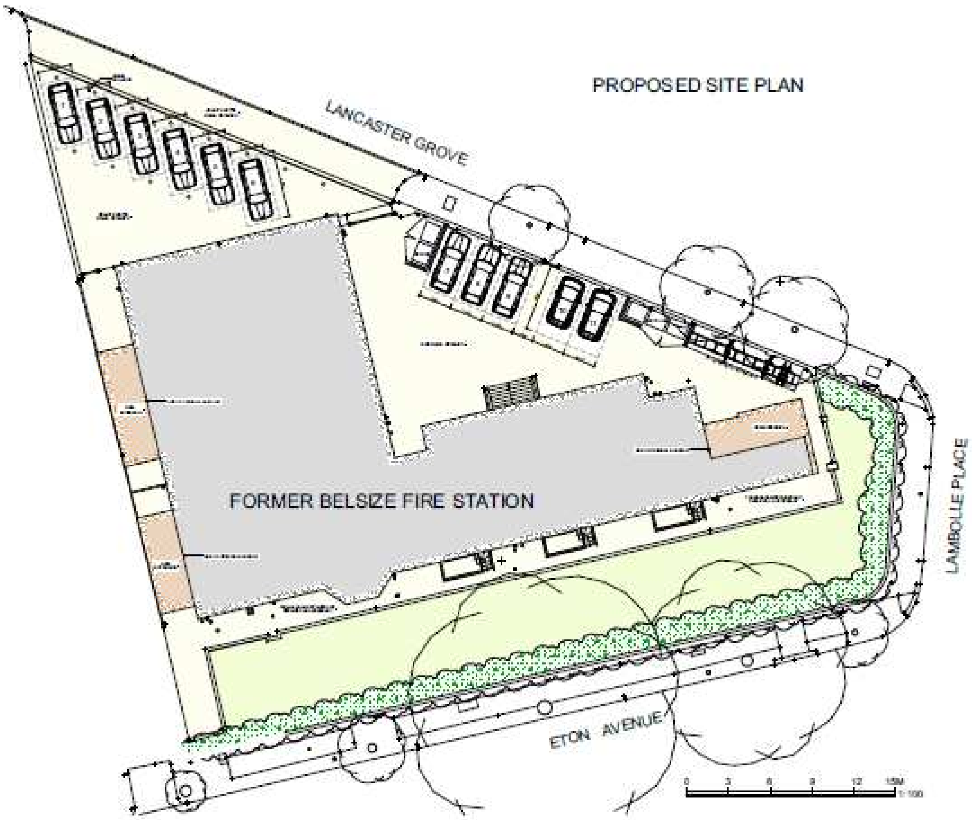


Figure 2.1 Environment Agency's Flood Map

Figure 2.2 Pluvial Flood Risk Maps

EA

SFRA

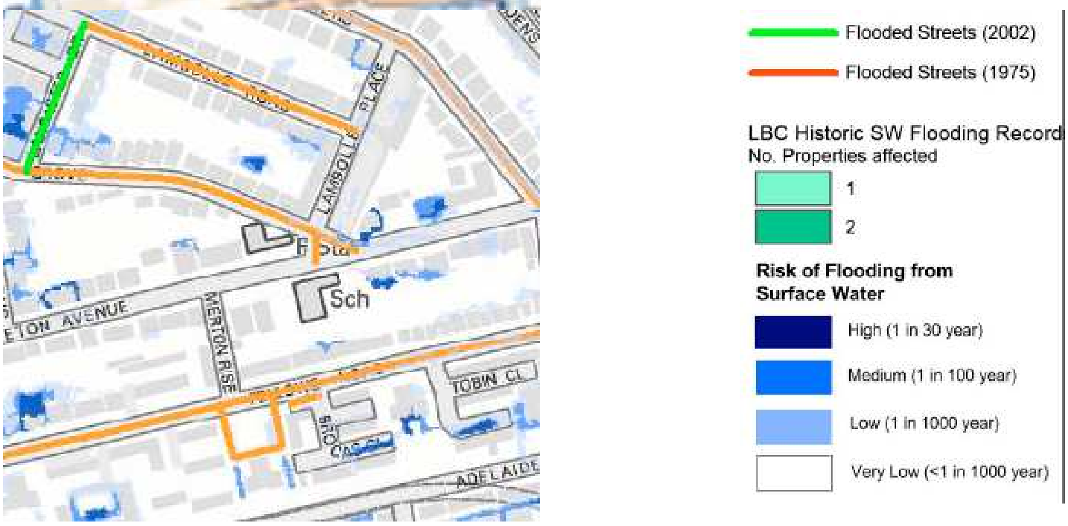
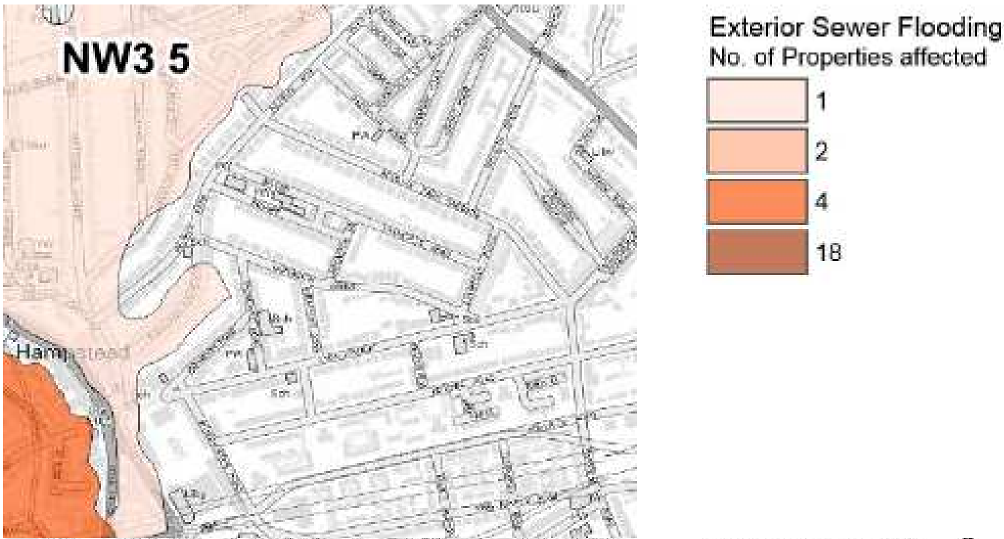
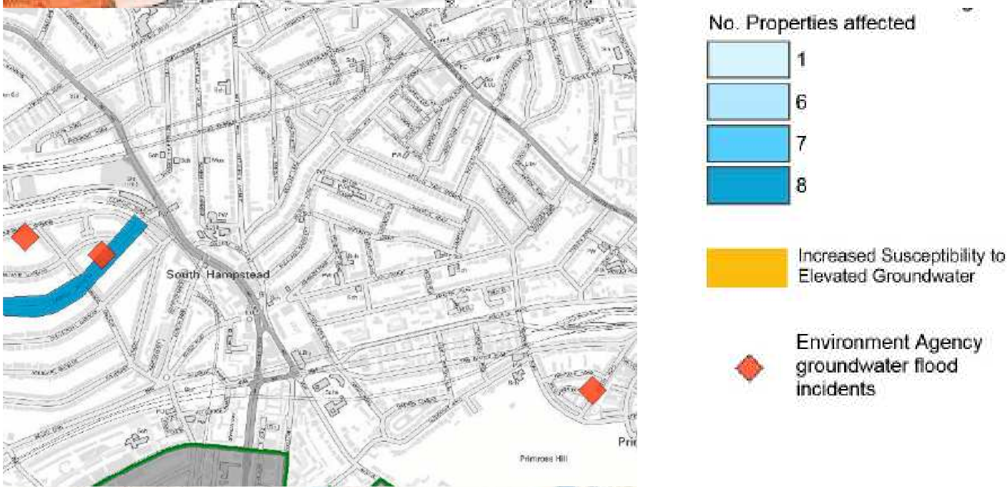


Figure 2.3 SFRA Flood Risk From Other Sources

Sewers



Ground water



Reservoir Failure

Figure 4.1 Bed Rock Geology

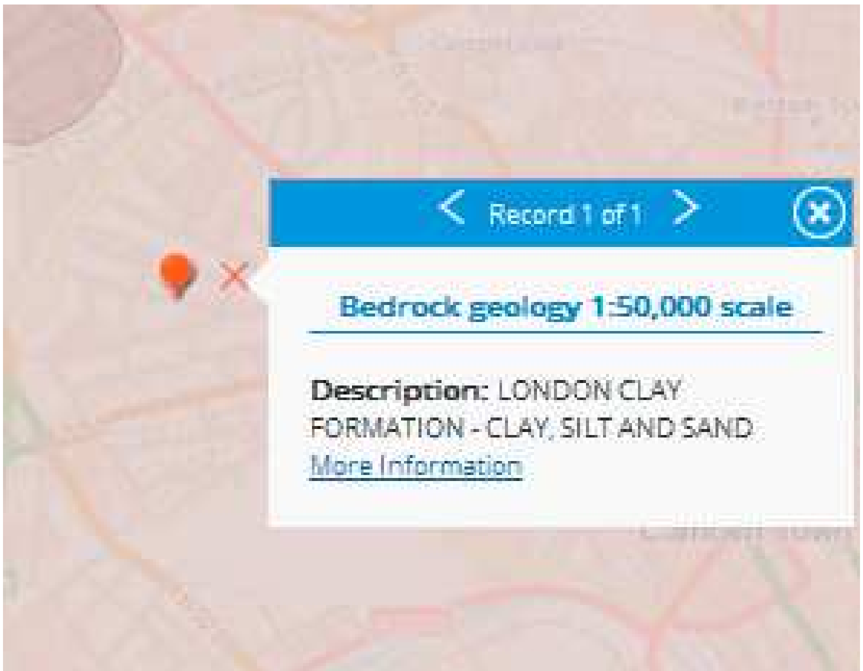


Figure 4.2 Drift Geology

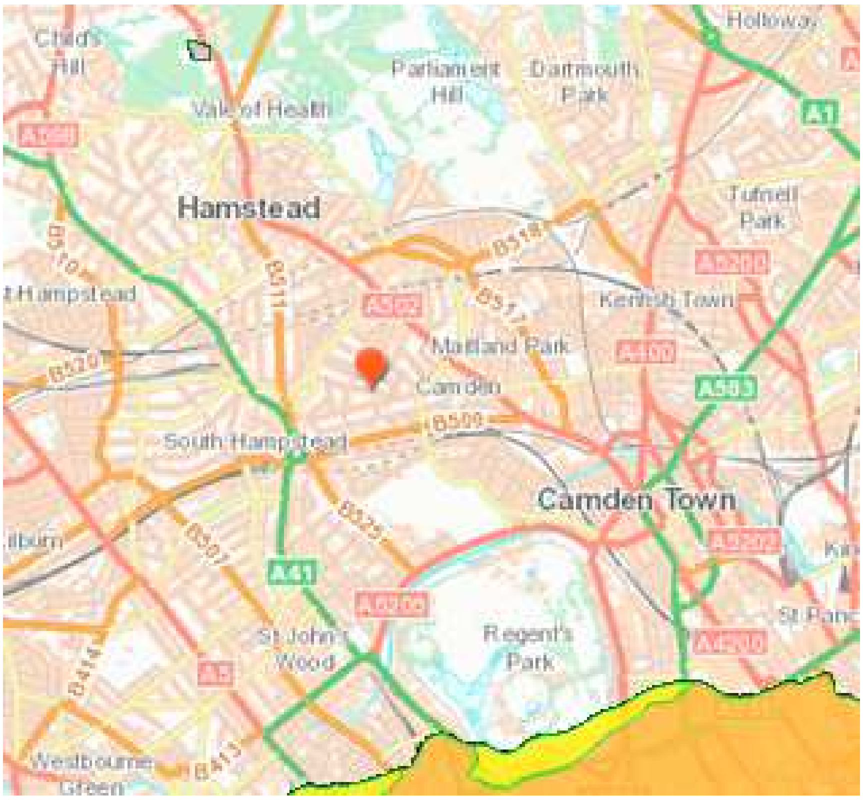


Figure 4.3 Storage to Maintain Developed Site Runoff at the Existing Rate – 1 hour storm

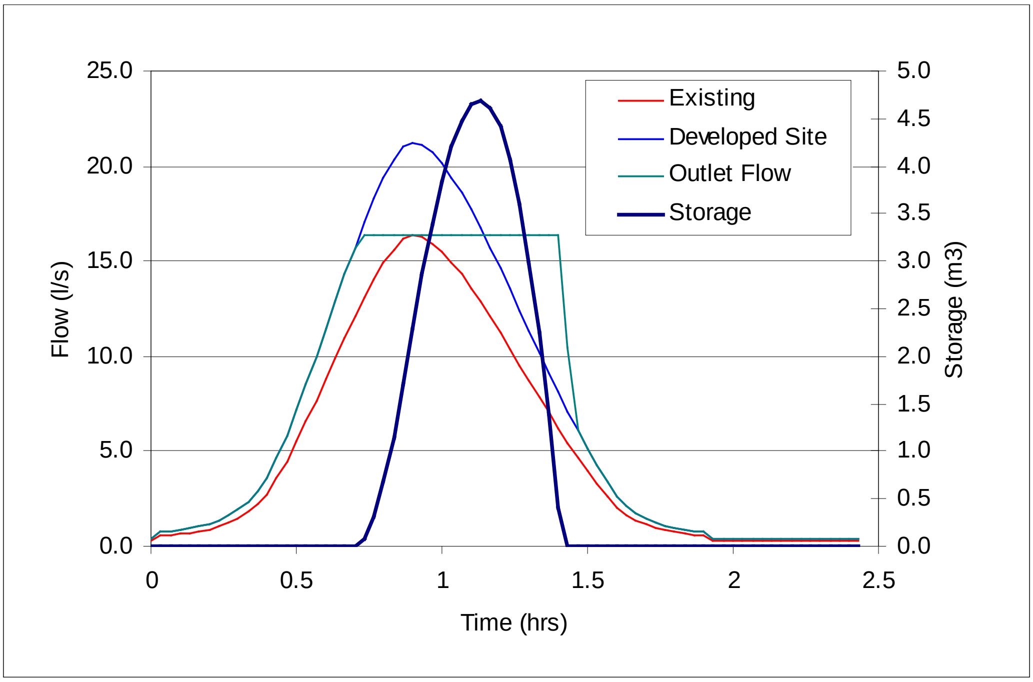


Figure 4.4 Storage to Maintain Developed Site Runoff at Greenfield Rate – 1 hour storm