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Flood Risk Assessment & Sustainable Drainage Strategy Conisbee

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1.0 INTRODUCTION

Conisbee have been appointed as Civil Engineering Consultants to undertake a Flood Risk and Sustainable Drainage Assessment for the proposed mixed use development at 5-17 Haverstock Hill, Camden in London.

This Flood Risk Assessment will be undertaken in accordance with the best practice guidance stated in National Planning Policy Framework (NPPF), pursuant to Local Authority approval and to informing the design.

This Flood Risk Assessment will also meet the requirements for BREEAM New Construction 2014 and demonstrates how the Credits for Pol 03 have been met.

2.0 BACKGROUND

This flood risk assessment refers to the following documents.

2.1 General Documentation

2.1.1 National Planning Policy Framework (NPPF) (TSO, March 2012)

The National Planning Policy Framework sets out government policy on development and flood risk. The aim is to ensure that flood risk is taken into account at all stages of the planning process and that inappropriate development is not undertaken within areas of flood risk.

2.1.2 The North London Boroughs Strategic Flood Risk Assessment (Mouchel, August 2008)

This Level 1 SFRA was prepared on behalf of the seven northern boroughs of London consisting of Barnet, Camden, Enfield, Hackney, Haringey, Islington and Waltham Forest. It defines the flood risks within the area and advises on flood risk management in accordance with the requirements of PPS25.

2.1.3 Camden Core Strategy 2010 to 2025 (Camden Council, November 2010)

The redevelopment site is located in the Chalk Farm area of the London Borough of Camden. The Core Strategy for the London Borough of Camden states that the Borough seeks to exceed its target for the construction of 596 new homes per annum during the period 2010 to year 2017. Additionally the Camden Borough of London will to maximise the supply of additional housing over the entire plan period to meet or exceed a target of 8,925 homes during the entire plan period of 2010 to 2015.

2.2 Site Specific Documents

The following documents and drawings have been consulted for the preparation of this flood risk assessment.

- *Appendix A – Site Boundary Plan & Topographical Survey*
- *Appendix B – Geological Maps & Borehole Logs*
- *Appendix C – Thames Water Asset Location Plan*
- *Appendix D – SFRA flood maps*
- *Appendix E – Preliminary Drainage Layout & Site Calculations*
- *Appendix F – The SUDS Management Train*

3.0 EXISTING SITE

3.1 Location

The site is located at NGR 528100, 184430 in Chalk Farm, London. The site is roughly triangular in shape measuring approximately 60m by 40m on the longest dimensions.

- To the north the site is immediately bound by Haverstock Hill Road, on the opposite side of the road is a modern three storey building
- To the east the site adjoins a one and a half storey building used as Chalk Farm station, and by several small shops.
- To the south the site is immediately bound by Adelaide Road, this edge of the building consists of a two storey row of small mixed shops.
- To the west the site borders Eton Place, a large detached mansion block set within landscaped grounds.

3.2 Existing Site Description and Topography

The existing site a vacant vehicle garage that was previously used by the Metropolitan Police for the storage of stolen vehicles. Where the building fronts onto Haverstock Hill and Adelaide Road the building is stepped down to two storeys high, the frontage on Adelaide road is used by several small shops including a newsagents, dry cleaner and estate agent.The Haverstock Hill ground floor is a blank frontage. The site area measures approximately 2,070m^2.

The site is generally level at about 32m AOD.

3.3 Ground Conditions

Geological Maps from Enviocheck and intrusive geotechnical investigation by Geotechnical and Environmental Consultants (GEA) shows that the site geology consists of made ground overlying London Clay bedrock geology. Investigations on the site show that the made ground varies in thickness across the site from 0.80m to 2.60m. The respective borehole logs are included in Appendix B.

Aquifer Designation

The Environment Agency has recently amended their aquifer designations so that they are consistent with the Water Framework Directive. Both the Superficial (Drift) and Bedrock geology indicate that this site is not underlain by an Aquifer.

Source Protection Zone

Groundwater provides a third of our drinking water in England and Wales, and it also maintains the flow in many of our rivers. In some areas of Southern England, groundwater supplies up to 80% of the drinking water that you get through your taps. It is crucial that we look after these sources and ensure that your water is completely safe to drink.

The site is not located within a Source Protection Zone.

3.4 Existing Site Drainage

The site consists of a large office block and a car park with an impermeable surface. Existing drainage consists of a short length of storm water sewer draining the car park at the edge of the site, this flows into the foul water sewer, which runs along the southern half of the western side of the building. The combined sewer flows into the combined Thames Water sewer in Adelaide Road with an expected invert level of 28.97m. These sewers have been identified from a CCTV survey carried out by APR services. The Thames Water records of the public sewers found in the vicinity of the site are contained in Appendix C.

3.5 Existing Site Characteristics

The existing hydrological characteristics for the site are as follows:

- Area of Development Site = 2,070m^2
- Total Existing Impermeable Area assessed to be 100% = 2,070m^2
- Existing run off rate Q_{WR}= 28.8l/s
- Infiltration rate = Unknown

4.0 PROPOSED DEVELOPMENT

4.1 Description

The scheme consists of the demolition of the existing building at 5-17 Haverstock Hill and redevelopment of the site to provide 77 residential units (8 x studios, 18 x 1 bedroom, 32 x 2 bedroom, 19x 3 bedroom) in two 7 storey blocks around a central raised courtyard. The proposals include the re-provision of 284m^2 retail floorspace at ground floor level on Adelaide Road. The proposed development will include residential (C3) and retail (A1- A5).

Vulnerability Classification

Table D.2: Flood Risk Vulnerability Classification, Annex D of PPS25 shows that the intended residential use of the proposed housing development has a Vulnerability Classification of "More Vulnerable". However the site lies in Flood Zone 1, of the EA River Flood maps.

Table D.2: Flood Risk Vulnerability Classification

Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly Vulnerable	• Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.[19] (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure'[20]).
More Vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste.[21] • Sites used for holiday or short-let caravans and camping, **subject to a specific warning and evacuation plan**.

4.2 Sequential Test

The Environment Agency Flood Plain map indicates that this site is located in Flood Zone 1. Flood Zone 1 comprises of land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%). Table D.3: Flood Risk Vulnerability and Flood Zone 'Compatibility', Annex D of PPS25, shows that the development is appropriate for this zone and therefore the Exception Test is not required.

Table D.3[23]: Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability classification (see Table D2)		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table D.1)	Zone 1	✔	✔	✔	✔	✔
	Zone 2	✔	✔	Exception Test required	✔	✔
	Zone 3a	Exception Test required	✔	✗	Exception Test required	✔
	Zone 3b 'Functional Flood plain'	Exception Test required	✔	✗	✗	✗

Key:

✔ Development is appropriate

✗ Development should not be permitted

Secondly the site is a 'brownfield' a dis-used car storage facility. The site is an area which supports residential uses.

5.0 DEFINITION OF THE FLOOD HAZARD

5.1 Sources of Flooding

The North London Strategic Flood Risk Assessment (SFRA) was prepared for the 7 North London Boroughs of Barnet, Camden, Enfield, Hackney, Haringey, Islington and Waltham Forest in order to identify the potential sources of flooding for this area, in accordance with Annex C of PPS25, which may affect the site. These sources are discussed below.

5.1.1 Fluvial Flooding

The North London SFRA states that Camden has no fluvial watercourses within its borough boundaries. The River Fleet, which is formed from two springs on Hampstead Heath is the largest of London's subterranean rivers and historically drained to the Camden area. The River Fleet historically originates from springs on Hampstead Heath and drains to the Thames approximately via Kentish Town, Camden Town and Holborn. Through Camden and the City of London the Fleet is now entirely incorporated within the sewer network, owned and maintained by Thames Water.

Regents Canal runs from the west to east and bisects Camden borough. British Waterways are charged with maintaining Regents Canal. They actively operate a series of sluices and gates along the Canal for navigation and flood risk management purposes. The site is located 600m north of the nearest reaches of Regents Canal at a higher elevation, therefore this site can be considered to be at low risk from fluvial flooding.

5.1.2 Tidal Flooding

This site is remotely located from the Thames therefore it is not at risk from Tidal Flooding.

5.1.3 Overland Flooding

Overland flooding can occur when high intensity rainfall overwhelms man made drainage systems or cannot soak into the ground. Excess water can flow across the ground following the contour gradient and cause flooding downstream. It is exacerbated by steep topography. The site is situated on a gentle slope towards the south east.

The North London Strategic Flood Risk Assessment does not state this site is in an area susceptible overland flood. Therefore the site is not at risk from overland flooding.

5.1.4 Groundwater Flooding

For bedrock geology the groundwater profile through London shows relatively little change in elevation, however, the topography of the North London sub-region shows significant variation, with a general fall in an easterly direction from the higher ground in Barnet to the Lee Valley, where much of the area is only a few metres above sea level. As expected, groundwater levels are closest to the surface around watercourses, particularly in the low lying Lee Valley. The groundwater levels in the Lee catchment are significantly closer by approximately 30m to the surface, whilst those in Camden are at depths between 80m and 90m beneath ground levels. GARDIT operate an ongoing abstraction scheme across London to maintain the level of the groundwater table in the Chalk Bedrock which is assisted by the London Clay impermeable geology. Therefore there is no risk of groundwater flooding from the underlying bedrock geology.

However the groundwater has a different characteristic for the superficial shallower geology. In places the London Clay layer is overlain by deposits of gravels and silts. This is most prominent in the Lee Valley and East of Hackney where alluvium deposits from the River Lee are in evidence. There are also notable outcrops of gravels and silts further to the west in Enfield, Stanmore gravels in Barnet and gravel outcrops on Hampstead Heath. These gravel and silt deposits are much more permeable than the underlying clay layer and flooding can occur at the edges of these deposits and outcrops when the groundwater percolating through the permeable layer meets the impermeable clay layer, causing the water to flow out at surface level, appearing as small springs. Hampstead Heath lies on a silty sand layer on top of the London clay. During rainfall events water drains through the sands before reaching the impermeable layer beneath, causing the formation of springs which feed the Highgate Ponds and form the source of the River Fleet. The nearest ponds to the site are the Hampstead Ponds located 2.50km northeast of the site.

5.1.5 Sewer and Surface Water Flooding

Sewer Flooding

Traditionally sewer networks are designed to cope with storm events up to and including the 1 in 30 year storm event. If this storm event is exceeded surface water flooding would occur following the topography of the area subjected to the flooding event.

The North London SFRA states that surface water and sewer flooding poses a moderate flood risk to the Borough. In particular reference to this site if the capacity of sewer networks was exceeded flood waters would discharge through the gullies and manholes accumulating at the low points along the road. High rainfalls levels and flood events are a recurring feature in Camden due to the nature of summer thunderstorms and the topography of Hampstead. The report suggests that the similarities between floods in 1975 and 2002 and concludes that these flood events have not been recently created by changes in the global climate.

The 2002 flood event was caused by a sudden summer storm which overwhelmed the sewer capacity and led to extensive surface water flooding in the NW2 and NW6 post code areas. The NW3 area experienced some flooding, the extent of this flooding is shown by Map 22 in Appendix D, this shows that while some of the surrounding roads were flooded in both 1976 and 2002 the site itself was not flooded. Thames Water sewer flood data shows that there have been no sewer flooding events near the site. In Camden most of the flooding incidents have historically occurred in the West Hampstead, Cricklewood, South Hampstead and Church End an area located 2.0km northwest of the site.

The North London SFRA states that following the 2002 flood event Thames Water were to make further funding cases to OFWAT to relieve more properties from flooding and they indicated that flooding issues in Camden will be picked up as part of their prioritisation programme. Thames Water is mandated by regulation to identify and resolve any recurrent flooding issues on their network, thereby reducing the level of flood risk from sewers.

Surface Water Flooding

The areas of West Hampstead, Cricklewood and South Hampstead would appear to be the areas at most risk from pluvial flooding within the North London areas. This flood risk extends to a lesser extent to Church End in the Barnet and also into the east of Camden, which experienced flooding during the 2002 Camden Floods. The extent of the 2002 Camden floods is shown on Map 22. The cause of these floods was attributed to surcharged sewers which could not cope with the volume of run-off. EA mapping shows that the site is very low risk from surface water flooding although the adjacent Haverstock Hill is a medium risk area.

5.1.6 Flooding from Artificial Sources

The two small reservoirs in Hampstead Heath are part of a series of ponds owned by the City of London Corporation. These reservoirs lie within the River Fleet catchment. The flood management plans and supporting inundation mapping to manage these reservoirs became a legal requirement from spring 2009.

It is anticipated that the Flood Management Plans and associated inundation mapping will provide a more accurate appraisal and assessment of flood risk presented by the reservoir. As it is a statutory obligation for the City of London Corporation to maintain the reservoirs this ensures that a robust flood risk management strategy is developed for the reservoirs. The Environment Agency maps of flood risk from reservoirs shows the site to be in an area outside the maximum area which can be flooded by reservoirs.

5.2 Probability of Flooding

As discussed above the probability of flooding within this site from any source is minimal as long as the onsite drainage for the site is suitably designed. As previously stated this flood risk is associated with inadequate sewer capacity which the SFRA has indicated that Thames Water applied for funding to OFWAT to address this issue.

5.3 Flood Risk due to Climate Change

The effect of climate change will be to increase the intensity and duration of rainfall events, thus increasing the likelihood of localised flooding. It is current policy therefore to add 30% to design rainfall profiles when designing surface water drainage to accommodate Climate change weather induced future increases.

In this case the drainage will be designed to retain the 100 year + 30% for climate change return period storm event within the system.

6.0 PROPOSED SURFACE WATER DRAINAGE STRATEGY

6.1 Site Characteristics

The physical design and hydrological characteristics for the site are as follows;

- Total Catchment Area = 2,070m^2
- Total proposed Impermeable Area = 2,070m^2
- Net decrease of impermeable area after development = 0m^2
- Existing discharge rate = 28.8l/s
- Both the London Plan and NPPF guidance is to discharge surface water from both Greenfield and brownfield sites at Greenfield discharge rates. The London Plan also states that the discharge rate can be reduced to 50% of the pre-existing discharge rate.

6.2 Proposed Surface Water Strategy

In accordance with best practice guidelines stipulated in NPPF, it is proposed to provide attenuation up to and including the 1 in 100 year plus 30% for the Climate Change storm event for this site. In line with the London Plan the proposed discharge rate will be 50% of the current discharge rate of 28.8l/s. The attenuation will consist of underground modular storage units together with blue/green roofs and hydro-brake flow control units restricted to 14.0/s. These will attenuate surface water runoff from the new building and access road. The proposal is to discharge storm water run-off to existing Thames Water sewer in Adelaide Road. The Proposed Drainage Layout drawing and calculations can be found in Appendix E.

In terms of pollution control all surface water manholes will be catchpits and the hydrobrake chambers will consist of cut off valves to stop flows in emergencies. Trapped gullies will also be introduced in all the other proposed hard paved areas, additional filtration will be through blue/green roofs. The proposed development will be car free with vehicular traffic, deliveries and refuse collection restricted to Adelaide Road and the proposed access road.

<u>Rate of Discharge & Proposed Outfall</u>

The Building Regulations recommend a hierarchy of methods of disposal of surface water. In order, these are disposal by infiltration, discharge to watercourses and if neither of these options are reasonably practical then discharge to a public surface water sewer. Chapter 6 of the Mayor’s Draft Water Strategy (Rainwater in London) sets out a similar hierarchy. The objective is for surface water discharged from urban developments to replicate the predevelopment response of the site as far as possible.

Therefore the applicable surface water discharge rate is 14.0/s for all storm events up to and including the 1 in 100 year plus 30% for climate change storm event. The surface attenuation required is 70m^3.

6.3 Site Design Objectives and Constraints

The requirements for a sustainable surface water drainage strategy at this site are to:

- Limit the peak rate of surface water discharge into the public sewer to the predevelopment level,
- To attenuate all storm events up to and including the 1 in 100 year storm plus climate change event.
- Prevent pollution of the groundwater

Infiltration drainage techniques have been precluded owing to site constraints and the underlying geology.

6.4 Sustainable Drainage Systems (SUDS)

SUDS is a term used to describe the various approaches that can be used to manage surface water drainage in a way that mimics the natural environment. SUDS can improve the sustainable management of water for a site by:

- reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- reducing volumes and the frequency of water flowing directly to watercourses or sewers from developed sites;
- improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- reducing potable water demand through rainwater harvesting;
- improving amenity through the provision of public open space and wildlife habitat;
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

The SUDS Manual, CIRIA C697, provides a hierarchy of techniques that will incrementally reduce pollution, flow rates and volumes and this is called The SUDS Management Train. The methods are categorised depending on whether their primary use is considered to be pre-treatment, conveyance, source, site or regional controls, and they can be ranked based on their hydraulic and water quality performance potential. Table 6.1 categorises the capability of different SUDS techniques. Table 3.3 of the SUDS manual indicates how many components are recommended to deal with the runoff from differing land uses.

Further information describing the SUDS management train is attached at Appendix F.

Table 6.1 - Summary of SUDS Techniques

Technique	Description	Management Train Suitability						Water quantity				Water quality								Environmental benefits		
		Prevention	Conveyance	Pre-treatment	Source control	Site control	Regional control	Conveyance	Detention	Infiltration	Water	Sedimentation	Filtration	Adsorption	Biodegradation	volatilisation	precipitation	Uptake by plants	Nitrification	Aesthetics	Amenity	Ecology
Water butts, site layout & management	Good housekeeping and good design practices.	○	●		○			●	●	○	●	●	●	●	●	●	●	●	●	●	●	●
Pervious pavements	Allow inflow of rainwater into underlying construction/soil.	○			○	●			○	○	●	○	○	○	○	○				●	●	●
Filter drain	Linear drains/trenches filled with a permeable material, often with a perforated pipe in the base of the trench.		○		○	●		○	○				○ ○	○	○	○						
Filter strips	Vegetated strips of gently sloping ground designed to drain water evenly from impermeable areas and filter out silt and other articulates.			○	○			●	●	●		○	○	○	○					●	●	●
Swales	Shallow vegetated channels that conduct and/or retain water (and can permit infiltration when un-lined). The vegetation filters particulates.		○		○	○		○	○	●		○	○	○	○			●		●	●	●
Ponds	Depressions used for storing and treating water. They have a permanent pool and bank side emergent and aquatic vegetation.					○	○		○	●	○	○	○	○	○	○	○	○	○	○	○	○
Wetlands	As ponds, but the runoff flows slowly but continuously through aquatic vegetation that attenuates and filters the flow. Shallower than ponds.		●			○	○	●	○	●	○	○	○	○	○	○	○	○	○	○	○	○
Detention basin	Dry depressions designed to store water fro a specified retention time.					○	○		○			○	●	●	○			●		●	●	●
Soakaways	Sub-surface structures that store and dispose of water via infiltration.				○					○			○	○	○							
Infiltration trenches	As filter drains, but allowing infiltration through trench base and sides.		●		○	○		●	○	○			○	○	○	○						
Infiltration basins	Depressions that's store and dispose of water via infiltration.					○	○		○	○			○	○	○	○				●	●	●
Green roofs	Vegetated roofs that reduce runoff volume and rate.	○		○	○				○				○	○	○	○	○	○	○	○	●	○
Bioretention areas	Vegetated areas for collecting and treating water before discharge downstream, or to the ground via infiltration.				○	○			○	○		○	○	○	○	○	○	○	○	○	○	○
Sand filters	Treatment devices using sand beds as filter media.			○		○	●		○	●			○	○	○	○	○					
Silt removal devices	Manhole and/or proprietary devices to remove silt.			○								○										
Pipes, subsurface storage	Conduits and their accessories as conveyance measures and/or storage. Water quality can be targeted using sedimentation and filter media.		○			○		○	○			●	●									

Key to symbols ● some opportunities, subject to design ○ High/primary process

6.5 SUDS Selection Criteria

The appropriate selection of a SUDS scheme for this development is dependent upon the factors listed in Table 6.2 below. These characteristics are then considered against the available techniques as illustrated in Table 6.3 so that an assessment of the suitability of each can be made.

Table 6.2 - Site Specific Characteristics

Category	**Site characteristics**
Proposed land use	Residential
Soil type	Made Ground underlain by London Clay Formation.
Area draining to SUDS components	2, 070m2
Minimum depth to water table	80m to 90m bgl with a perched water table also shown in borehole logs
Site slope	Level
Available head	2.62m
Available space	Limited.
Water quality treatment potential	Blue/Green roofs, catchpits, gullies, attenuation tank and cut-off valve to all hydrobrake chambers.
Hydraulic control	The surface water will be discharged at a restricted discharge of 14.0l/s.
Maintenance	Desilting and emptying of catchpits and gullies and inspection of blue/green roofs every six months
Community acceptability	High
Cost	Medium
Habitat creation potential	Low

Table 6.3 - SUDS Selection Factors

SUDS GROUP	TECHNIQUE	Residential	Permeable soils	0-2 ha draining to single SUDS component	Min depth to water table 0-1m	Site slope 0-5%	Available head 0-1m	Available space low	Water Quality Treatment Potential					Hydraulic Control				Maintenance	Community acceptability	Cost	Habitat creation potential
									Total suspended solids removal	Heavy metals removal	Nutrient removal	Bacteria removal	Capacity to treat fine suspended sediments and dissolved pollutants	Runoff Volume Reduction	0.5 (1/2yr)	0.1-0.3 (10/30yr)	0.01 (100yr)				
Retention	Retention Pond	Y	Y	Y	Y	Y	Y	N	H	M	M	M	H	L	H	H	H	M	H	M	H
	Subsurface Storage	Y	Y	Y	Y	Y	Y	Y	L	L	L	L	L	L	H	H	H	L	H	M	L
Wetland	Shallow Wetland	Y	Y	Y	Y	Y	Y	N	H	M	H	M	H	L	H	M	L	H	H	H	H
	Extended detention wetland	Y	Y	Y	Y	Y	Y	N	H	M	H	M	H	L	H	M	L	H	H	H	H
	Pond/wetland	Y	Y	Y	Y	Y	Y	N	H	M	H	M	H	L	H	M	L	H	H	H	H
	Submerged gravel/wetland	Y	Y	Y	Y	Y	Y	N	H	M	H	M	H	L	H	M	L	M	L	H	M
	Wetland channel	Y	Y	Y	Y	Y	Y	N	H	M	H	M	H	L	H	M	L	H	H	H	H
Filtration	Surface sand filter	Y	Y	Y	Y	Y	N	N	H	H	H	M	H	L	H	M	L	M	L	H	M
	Sub-surface sand filter	Y	Y	Y	Y	Y	N	Y	H	H	H	M	H	L	H	M	L	M	L	H	L
	Perimeter sand filter	N	Y	Y	Y	Y	Y	Y	H	H	H	M	H	L	H	M	L	M	L	H	L
	Bioretention/ filter strip	Y	Y	Y	Y	Y	Y	N	H	H	H	M	H	L	H	M	L	H	H	M	H
	Filter trench	Y	Y	Y	Y	Y	Y	Y	H	H	H	M	H	L	H	M	L	M	M	M	L
Detentio	Detention basin	Y	Y	Y	Y	Y	N	N	M	M	L	L	L	L	H	H	H	L	H	L	M
Open channels	Conveyance swale	Y	Y	Y	Y	Y	Y	N	H	M	M	M	H	M	H	H	H	L	M	L	M
	Enhanced dry swale	Y	Y	Y	Y	Y	Y	N	H	H	H	M	H	M	H	H	H	L	M	M	M
	Enhanced wet swale	Y	Y	Y	Y	Y	Y	N	H	H	M	H	H	L	H	H	H	M	M	M	H
Source	Green roof	Y	Y	Y	Y	Y	Y	Y	NA	NA	NA	NA	H	H	H	H	L	H	H	H	H
	Porous pavements	Y	Y	Y	Y	Y	Y	Y	H	H	H	H	H	H	H	H	L	M	M	M	L

6.6 Suitable SUDS Options

The SUDS system chosen for this site will primarily be required to dispose of surface water runoff from hard surfaced areas; roofs, the garden roof, landscaped garden and footpaths. Therefore as the site is car free and will not require pre-treatment before surface water runoff is discharged, therefore any of the techniques considered suitable for source control will be acceptable. However following good practice surface water runoff will be treated by passing through, trapped gullies, catchpits and the blue/green roof matrix. Therefore the applicable SUDS option for this site, which have been highlighted in Table 6.3 is the following:

- Subsurface Storage – Modular Storage Units
- Blue and Green Roof

This SUDS option has been assessed below in order to qualify its suitability for the proposed site.

6.6.1 Subsurface Storage

The subsurface storage will be provided by the following by underground modular storage units, the discharge from these units will be regulated by a Hydrobrake.

Key Design Criteria

- Design to meet site drainage standards – generally 1 in 100 year plus 30% increase in rainfall for the climate change design event
- Appropriate pre-treatment is required.

Table 6.4 below outlines the advantages and disadvantages of this technique. The proposed underground modular storage units will provide 47m^3 of rainwater attenuation volume.

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ADVANTAGES	PERFORMANCE
• Significant reduction in volume and rate of surface runoff • Suitable for installation in high density development. • No additional land take, allows dual use of space. • Low maintenance. • Good community acceptability. • Can also be incorporated into a rainwater harvesting system. **DISADVANTAGES** • No water quality treatment • No reduction in runoff volume	Peak flow reduction: Good Volume reduction: Poor Water quality treatment: Poor Amenity potential: Poor Ecology potential: Poor **TREATMENT TRAIN SUITABILITY** Source control: No Conveyance: Yes Site system: Yes Regional system: No **SITE SUITABILITY** Residential: Yes Commercial/industrial: Yes High density: Yes Retrofit: Yes Contaminated sites/sites above vulnerable groundwater (with liner) Yes **COST IMPLICATIONS** Land-take: Low Capital cost: Medium Maintenance cost: Medium **POLLUTANT REMOVAL** Total suspended solids: Low Nutrients: Low Heavy metals: Low
KEY MAINTENANCE REQUIREMENTS:	
• Occasional jetting and de-silting.	

6.6.2 Blue/Green Roofs

Green roofs can help to reduce both the pollution and surface runoff entering the drainage system. In this way, they are often, in dense urban areas, the only applicable source control mechanism in the Sustainable Drainage Systems (SUDS) management train.

A green replicates what the landscape provides in terms of allowing infiltration into the vegetation, substrates and engineered drainage layers.

A green roof will typically intercept the first 5mm and more of rainfall providing interception storage, the amount of which will be dependent on the depth and type of substrate in the green roof system.

This type of roof also provides attenuation with a void ‘crate’ system installed below the growing medium.

In the summer a green roof can typically retain between 70% - 80% of the runoff

As the rainfall events become longer or more intense, the positive effect of a green roof remains as there is still a significant reduction in peak runoff rates.

This increase in the 'time of concentration' means that a green roof will be beneficial throughout a wide range of rainfall conditions.

The above benefits collectively mean that by incorporating a green roof into new development, there will be a reduction in the amount and cost of the overall drainage infrastructure required to serve that development.

Key Design Criteria

- Design for interception storage
- Minimum roof pitch of 1 in 80, maximum 1 in 3 (unless specific design features are included)
- Structural roof strength must provide for the full additional load of saturated green roof elements
- Hydraulic design should follow guidance in BS EN 12056-3 (BSI,2000)
- Multiple outlets to reduce risks from blockage
- Lightweight soil medium and appropriate vegetation

Table 6.5 below outlines the advantages and disadvantages of this technique. The proposed blue/green roof will provide 23m^3 of rainwater attenuation volume.

ADVANTAGES	PERFORMANCE
• Mimic predevelopment state of building footprint. • Good removal of atmospherically deposited urban pollutants • Can be applied in high density developments • Can sometimes be retrofitted • Ecological, aesthetic and amenity benefits • No additional land take • Improve air quality • Help retain higher humidity levels in city areas • Insulates buildings against temperature extremes • Reduces the expansion and contraction of roof membranes • Sound absorption **DISADVANTAGES** • Cost (compared to conventional runoff). • Not appropriate for steep roofs • Opportunities for retrofitting may be limited • Maintenance of roof vegetation • Any damage to waterproof membrane likely to be more critical since water is encouraged to remain on the roof	Peak flow reduction: Medium Volume reduction: Medium Water quality treatment: Good Amenity potential: Good Ecology potential: Good **TREATMENT TRAIN SUITABILITY** Source control: Yes Conveyance: No Site system: No Regional system: No **SITE SUITABILITY** Residential: Yes Commercial/industrial: Yes High density: Yes Retrofit: Yes Contaminated sites/sites above vulnerable groundwater (with liner) Yes **COST IMPLICATIONS** Land-take: None Capital cost: Low-High (depending on roof type and capacity) Maintenance cost: Medium **POLLUTANT REMOVAL** Total suspended solids: High Nutrients: Low Heavy metals: Medium
KEY MAINTENANCE REQUIREMENTS: • Irrigation during establishment of vegetation • Inspection for bare patches and replacement of plants • Litter removal (depending on setting and use) • Inspection of restrictor units and down pipes	

6.7 Assessment of Appropriate SUDS Technique

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There is only one viable option available for the disposal of surface water from the site; discharging into the existing sewer. It is recommended that the tanked underground modular storage units and blue/green roofs are used for rainwater attenuation.

The developed drainage strategy will enable credits to be awarded under BREEAM New Construction 2014 environmental assessment criteria.

The proposals for this site would preclude the use any infiltration drainage techniques owing to the prevailing site geology and physical site constraints.

7.0 FOUL WATER DRAINAGE

In terms of the foul drainage strategy, it is proposed to discharge at 9.5l/s into the Combined Thames Water public sewer network, located in Adelaide Road.

8.0 FLOOD RISK MANAGEMENT MEASURES

The proposed drainage system will be designed to ensure that the surface water generated by a 1 in 100 year plus 30% for climate change storm event will be attenuated by providing $47m^3$ of modular storage tanks and $23m^3$ of blue/green roof storage. The surface water will discharge at a restricted rate of 14.0l/s.

Therefore there is no offsite surface water overflow for all storm events until this threshold is exceeded, thus providing a robust flood management regime.

9.0 OFFSITE IMPACTS

It is considered that the proposed drainage designs mean that the surface water and foul flows generated by the proposed development will not have any adverse effect off site.

10.0 RESIDUAL FLOOD RISKS

The only remaining risk following the construction of the proposed systems relates to exceedance of the design criteria. Design flows generated from excess rainfall events will be directed away from buildings. There is perceived to be a very low risk from the development.

11.0 COMPLIANCE WITH BREEAM NEW CONSTRUCTION 2014 REQUIREMENTS

11.1 Pol 03 – Flood Risk

The site is located in Flood Zone 1, both this Flood Risk Assessment and the SFRA have also been found this site to be a low risk from flood from all other sources. Therefore this requirement has been met. Two credits achieved.

11.2 Pol 03 – Surface Water Run off

The peak rate of runoff from the site to the sewer is no greater for the developed site than it was for the pre-development site. This complies at the 1-year return period events.

Flooding of property will not occur in the event of local drainage system failure.

The volumetric runoff generated by the proposed development will be equal to that from the predevelopment. There is no change of impermeable areas for the site pre and post development. Two credits achieved.

11.3 Pol 03 – Minimising Watercourse Pollution

11.3.1 The site is car-free, therefore with a low risk of watercourse pollution and an appropriate level of pollution prevention treatment is provided. Blue/Green roofs provide treatment for the water by filtration for all the rainfall on the roofs of the building, other treatment is provided by trapped gullies and catchpits.

11.3.2 Although measures will be implemented to minimise watercourse pollution, this credit is not expected to be achieved due to the requirement for no discharge from the development site for rainfall up to 5mm, which is considered challenging in London.

12.0 RECOMMENDATIONS

It is recommended that the proposed drainage network contained in Appendix E, be implemented for this site in order to ensure that a robust drainage solution is achieved for this site.

13.0 CONCLUSION

The site is located in Flood Zone 1 and is at minimal risk of fluvial flooding. Further, both the SFRA and the site specific flood risk assessment for this development has not identified potential flood risks for the site that cannot be managed. The following flood management measures are recommended: It is proposed that the proposed surface water drainage scheme be implemented in order to provide a robust and sustainable drainage regime to the proposed residential development.

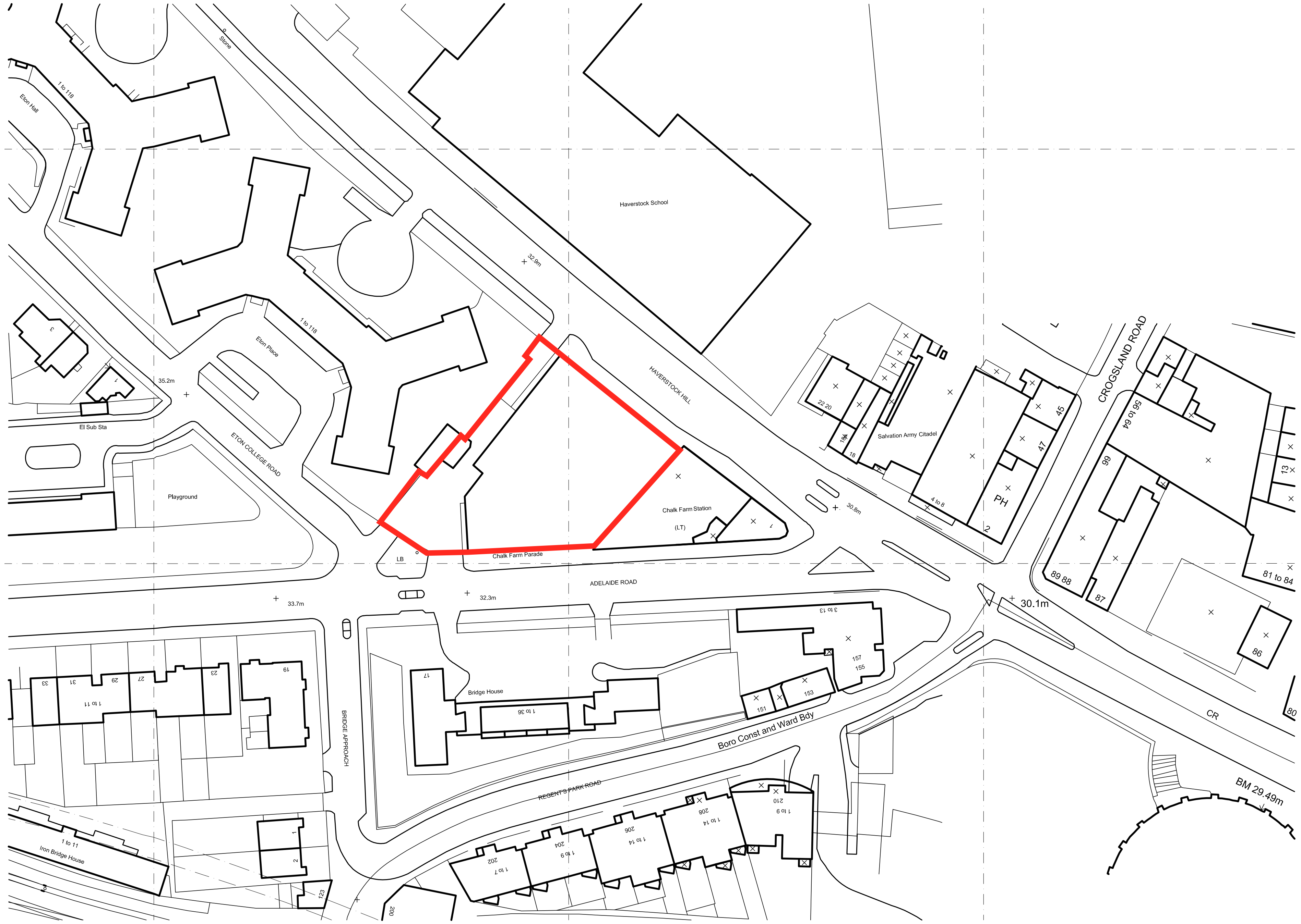
It is considered that the development of this site will not increase flood risk elsewhere.

APPENDIX A

Survey Plan & Site Boundary Plan

NOTES

[Ordnance Survey mapping does not negate the requirement for a measured topographical survey]



Location Plan

Scale 1:1250

dexter
moren
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architecture urban design
interior design creative media
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57d
jamestown road
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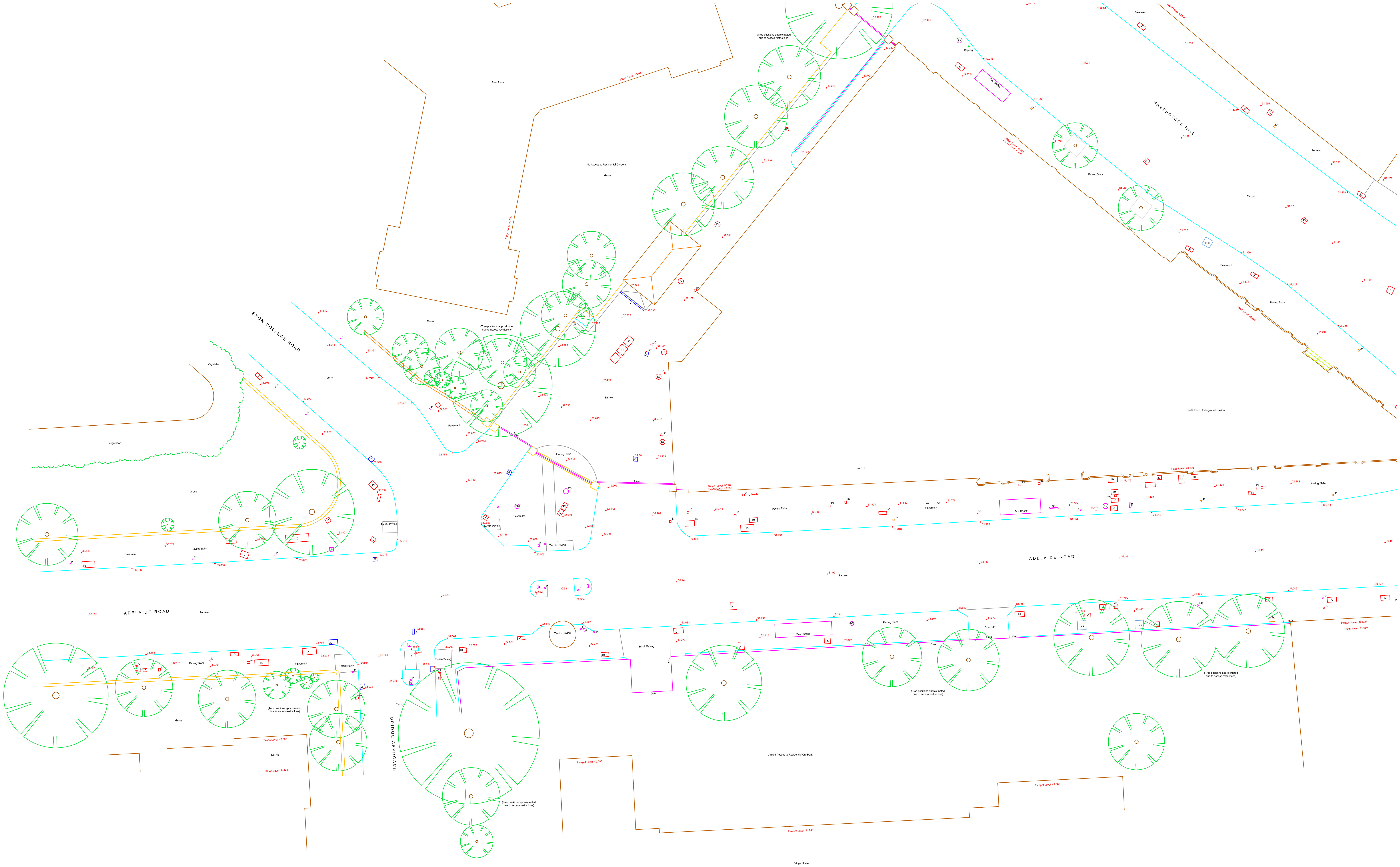
project	drawing title	scale	date	drawn by	checked by
5-17 Haverstock Hill	Location Plan	1:1250 @ A3 NTS @ A4	13.05.13	NM	-
client	**drawing status**	**job no.**	**drawing no.**		**revision**
Cambridge Gate Properties	FOR INFORMATION	1075	A-000-001		P0

rev	amendments	date	by
T0	ISSUED FOR INFORMATION		



Eton Place
No Access to Residential Gardens
Grass
(Tree positions approximated due to access restrictions)
ETON COLLEGE ROAD
HAVERSTOCK HILL
Vegetation
Tarmac
Pavement
Paving Slabs
Tactile Paving
Bus Shelter
No. 1-5
Chalk Farm Underground Station
ADELAIDE ROAD
BRIDGE APPROACH
Block Paving
Gate
Concrete
No. 10
Limited Access to Residential Car Park
Bridge House

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APPENDIX B

Geotechnical Maps

Geology 1:50,000 Maps Legends

Artificial Ground and Landslip

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	WGR	Worked Ground (Undivided)	Void	Holocene - Holocene
	MGR	Made Ground (Undivided)	Artificial Deposit	Holocene - Holocene

Superficial Geology

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	LASI	Langley Silt Member	Clay and Silt	Devensian - Devensian
	LHGR	Lynch Hill Gravel Member	Sand and Gravel	Wolstonian - Wolstonian

Bedrock and Faults

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	LC	London Clay Formation	Clay, Silt and Sand	Eocene - Eocene
	CLGB	Claygate Member	Clay, Silt and Sand	Eocene - Eocene
	BGS	Bagshot Formation	Sand	Eocene - Eocene

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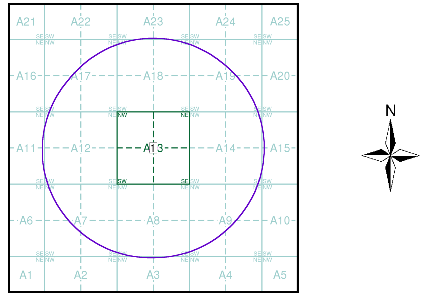
Geology 1:50,000 Maps

This report contains geological map extracts taken from the BGS Digital Geological map of Great Britain at 1:50,000 scale and is designed for users carrying out preliminary site assessments who require geological maps for the area around the site. This mapping may be more up to date than previously published paper maps.
The various geological layers - artificial and landslip deposits, superficial geology and solid (bedrock) geology are displayed in separate maps, but superimposed on the final 'Combined Surface Geology' map. All map legends feature on this page. Not all layers have complete nationwide coverage, so availability of data for relevant map sheets is indicated below.

Geology 1:50,000 Maps Coverage

Map ID:	1
Map Sheet No:	256
Map Name:	North London
Map Date:	2006
Bedrock Geology:	Available
Superficial Geology:	Available
Artificial Geology:	Available
Faults:	Not Supplied
Landslip:	Available
Rock Segments:	Not Supplied

Geology 1:50,000 Maps - Slice A



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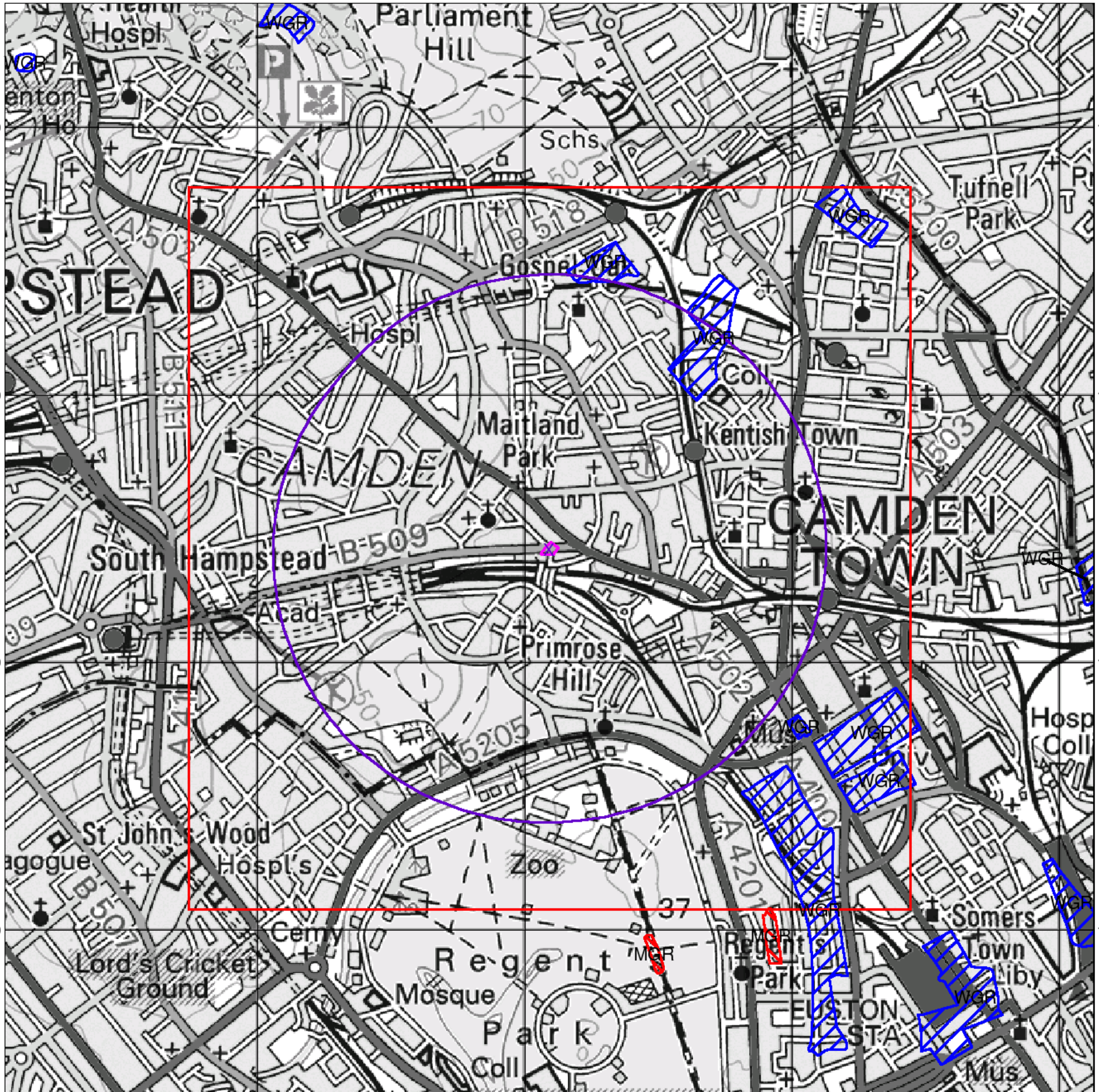
National Grid Reference:	528090, 184420
Slice:	A
Site Area (Ha):	0.19
Search Buffer (m):	1000

Site Details:

5-17 Haverstock Hill, LONDON, NW3 2BL



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Artificial Ground and Landslip

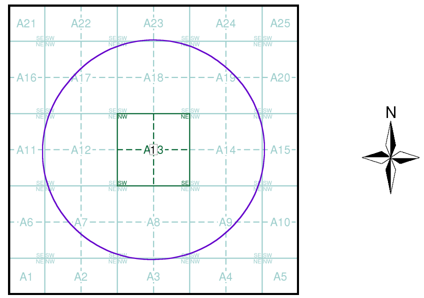
Artificial ground is a term used by BGS for those areas where the ground surface has been significantly modified by human activity. Information about previously developed ground is especially important, as it is often associated with potentially contaminated material, unpredictable engineering conditions and unstable ground.

Artificial ground includes:

- Made ground - man-made deposits such as embankments and spoil heaps on the natural ground surface.
- Worked ground - areas where the ground has been cut away such as quarries and road cuttings.
- Infilled ground - areas where the ground has been cut away then wholly or partially backfilled.
- Landscaped ground - areas where the surface has been reshaped.
- Disturbed ground - areas of ill-defined shallow or near surface mineral workings where it is impracticable to map made and worked ground separately.

Mass movement (landslip) deposits on BGS geological maps are primarily superficial deposits that have moved down slope under gravity to form landslips. These affect bedrock, other superficial deposits and artificial ground. The dataset also includes foundered strata, where the ground has collapsed due to subsidence.

Artificial Ground and Landslip Map - Slice A



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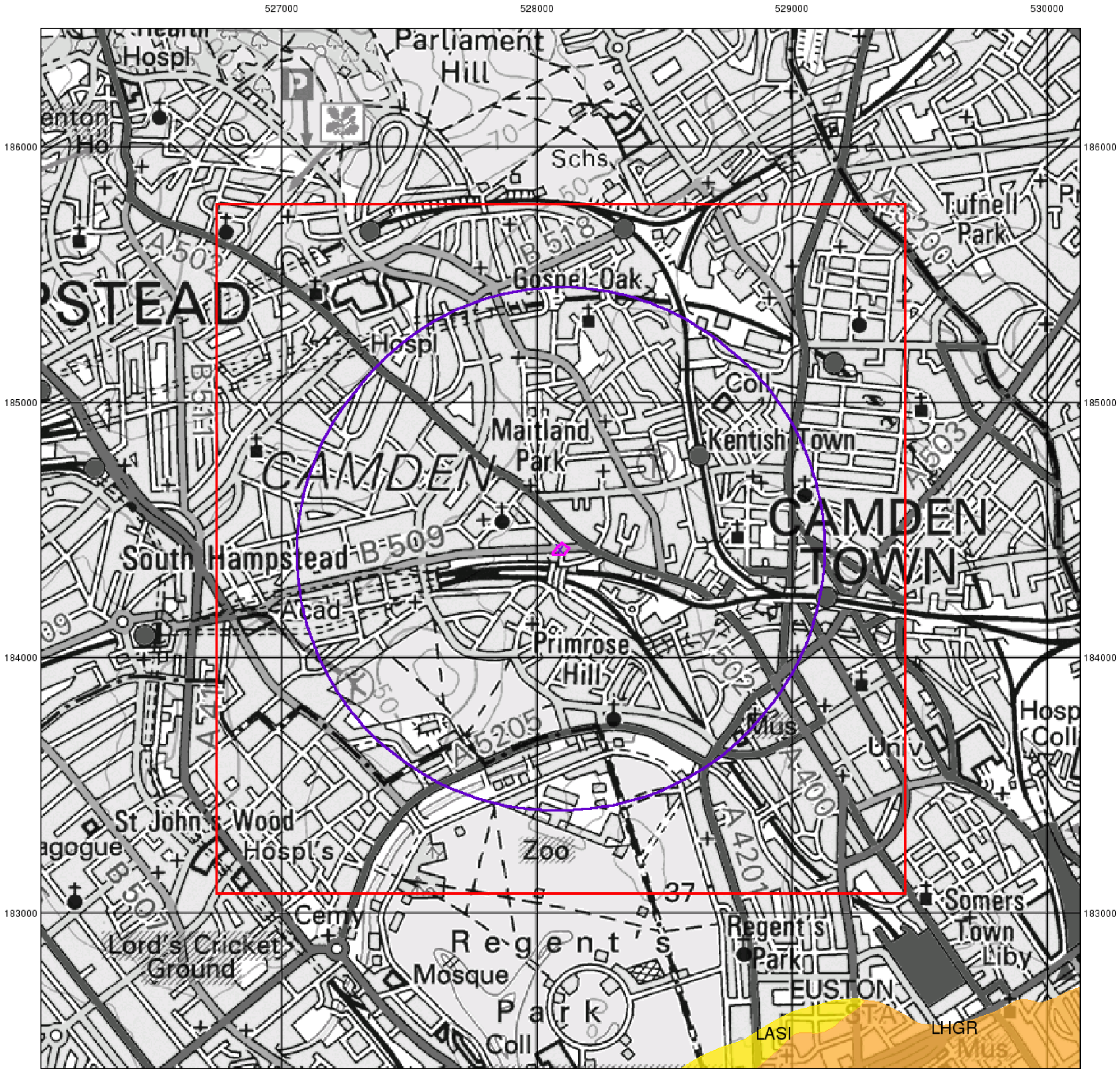

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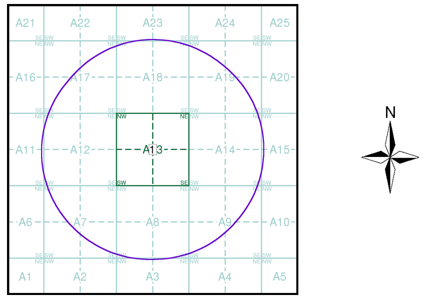
Superficial Geology

Superficial Deposits are the youngest geological deposits formed during the most recent period of geological time, the Quaternary, which extends back about 1.8 million years from the present.

They rest on older deposits or rocks referred to as Bedrock. This dataset contains Superficial deposits that are of natural origin and 'in place'. Other superficial strata may be held in the Mass Movement dataset where they have been moved, or in the Artificial Ground dataset where they are of man-made origin.

Most of these Superficial deposits are unconsolidated sediments such as gravel, sand, silt and clay, and onshore they form relatively thin, often discontinuous patches or larger spreads.

Superficial Geology Map - Slice A



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Site Area (Ha):	0.19
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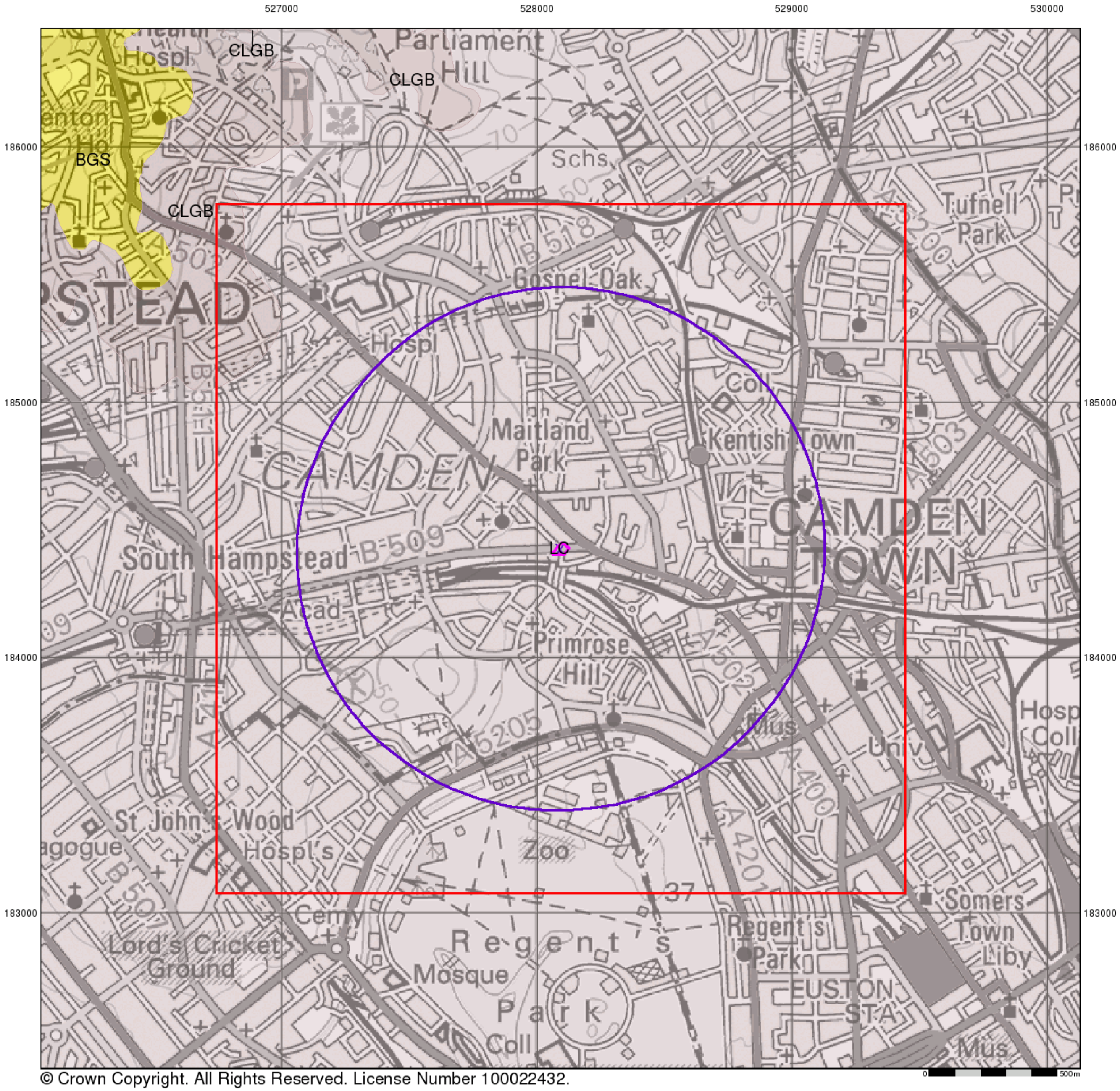
Site Details:

5-17 Haverstock Hill, LONDON, NW3 2BL



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Bedrock and Faults

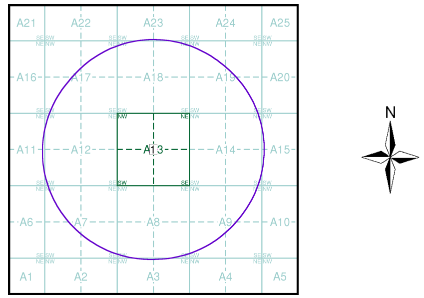
Bedrock geology is a term used for the main mass of rocks forming the Earth and are present everywhere, whether exposed at the surface in outcrops or concealed beneath superficial deposits or water.

The bedrock has formed over vast lengths of geological time ranging from ancient and highly altered rocks of the Proterozoic, some 2500 million years ago, or older, up to the relatively young Pliocene, 1.8 million years ago.

The bedrock geology includes many lithologies, often classified into three types based on origin: igneous, metamorphic and sedimentary.

The BGS Faults and Rock Segments dataset includes geological faults (e.g. normal, thrust), and thin beds mapped as lines (e.g. coal seam, gypsum bed). Some of these are linked to other particular 1:50,000 Geology datasets, for example, coal seams are part of the bedrock sequence, most faults and mineral veins primarily affect the bedrock but cut across the strata and post date its deposition.

Bedrock and Faults Map - Slice A



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Slice:	A
Site Area (Ha):	0.19
Search Buffer (m):	1000

Site Details:

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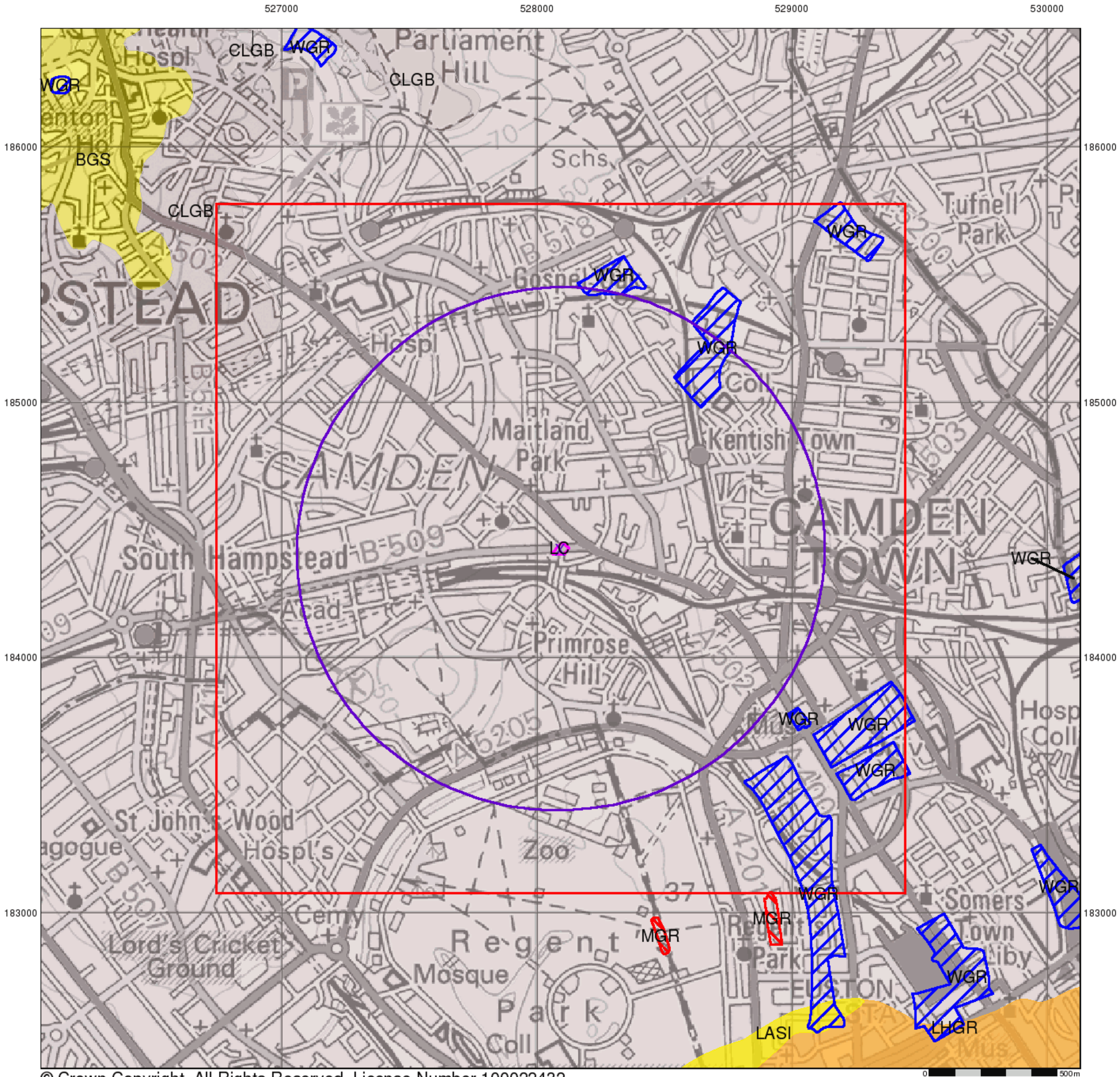
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



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Combined Surface Geology

The Combined Surface Geology map combines all the previous maps into one combined geological overview of your site.

Please consult the legends to the previous maps to interpret the Combined "Surface Geology" map.

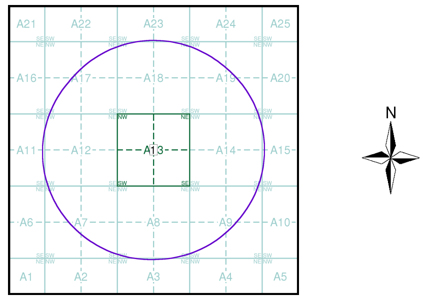
Additional Information

More information on 1:50,000 Geological mapping and explanations of rock classifications can be found on the BGS website. Using the LEX Codes in this report, further descriptions of rock types can be obtained by interrogating the 'BGS Lexicon of Named Rock Units'. This database can be accessed by following the 'Information and Data' link on the BGS website.

Contact

British Geological Survey
Kingsley Dunham Centre
Keyworth
Nottingham
NG12 5GG
Telephone: 0115 936 3143
Fax: 0115 936 3276
email: enquiries@bgs.ac.uk
website: www.bgs.ac.uk

Combined Geology Map - Slice A



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APPENDIX C

Thames Water Asset Location Plan

Asset Location Search

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1 - 5

LONDON
N1 1DH

Search address supplied	5-17 Haverstock Hill London NW3 2BL

Your reference	140870
Our reference	ALS/ALS Standard/2015_3161923
Search date	6 October 2015

You are now able to order your Asset Location Search requests online by visiting
www.thameswater-propertysearches.co.uk