Georgiana Street, London NW1 0QS

Bangor Wharf

Report to accompany planning application:

FRA & Sustainable Drainage Strategy
Conisbee

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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 Georgiana Street, Camden in London.

This Flood Risk Assessment has been be undertaken in accordance with the best practice guidance stated in National Planning Policy Framework (NPPF), PPS25 – Development and Flood Risk pursuant to Local Authority approval and to informing the design. It is also mandatory Camden Council's requirement to undertake the BREEAM New Construction non-residential assessment for all mixed use developments. The proposed mixed use development has been set a minimum BREEAM target of excellent rating. This Flood Risk Assessment demonstrates how the Credits for Pol 3 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) and Planning Policy Statement 25 (PPS25) Development and Flood Risk (TSO, March 2010)

The National Planning Policy Framework and the PPS 25 set 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 The London Borough of Camden Strategic Flood Risk Assessment (URS, 2014)

This Level 1 SFRA was prepared on behalf of the London Borough of Camden. It defines the flood risks within the area and advises on flood risk management in accordance with the requirements of PPS 25.

2.1.4 The London Borough of Camden flood risk management strategy (Camden, 2013)

The London Borough of Camden has undertaken a Lead Local Flood Authority Role for the borough and prepared a flood risk management strategy in 2013 in order to alleviate the flooding by assesing the level of risk, providing an action plan and sustainable and holistic approach to flood management.

2.1.5 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.

2.1.6 BREEAM New Construction (SD5073-2.0: 2011)

This is an environmental assessment method for rating and certifying the design and construction of new commercial development with a view of encouraging continuous improvement in sustainable urban development, construction and use. It includes objectives for the management of surface water and flood risk.

2.2 Site Specific Documents

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

- *Appendix A – Topographical Survey*
- *Appendix B – Thames Water Survey Plan*
- *Appendix C – Thames Water Asset Location Plan*
- *Appendix D – Envirocheck Maps*
- *Appendix E – Flood Maps extracted from North London SFRA*
- *Appendix F – Preliminary Drainage Layout*
- *Appendix G – The SUDS Management Train*

3.0 EXISTING SITE

3.1 Location

The site is located at NGR 529331,183999 in London Borough of Camden in London. The site forms an irregular shape and is bound on its sides by the following:

- To the north-west the site is immediately bound by industrial building at 146 Royal College Street and its adjacent hard standing surfacing.
- To the north-east the site is immediately bound by the Regent's Canal.
- To the south-east the site is bound by Georgiana Street.
- To the south-west the site is bound by terraced residential properties.

Refer to figure 1 for site location plan.

Figure 1: Site Location Plan

3.2 Existing Site Description and Topography

The existing site consists of warehouse, offices and associated car park. The access to the site is from Georgiana Street. The site area measures approximately 1,852 m².

In terms of topography the site has a retaining wall running along its western boundary with the Regent's canal; the level at site level is approximately 23.80 m AOD, whilst immediately behind the wall the canal's water level is approximately 23.13 m AOD. The canal is approximately 1.36 m deep.

Internally the site's topography falls from level of 25.86 m AOD at its entrance to an elevation of 24.14 m AOD. The continuous fall of the site is 1 in 25. The existing topographical site survey is contained in Appendix A.

3.3 Ground Conditions

British Geological Survey Maps indicate that the site is underlain by alluvium superficial geology (clay, silt and sand), which is underlain by London Clay bedrock geology consisting of sand, silt and clay. Intrusive geological survey is to be undertaken in next design stage.

3.3.1 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.

Figure 2: Superficial Aquifer Designation Map (Source: EA maps, 2015)

Figure 3: Bedrock Aquifer Designation Map (Source: EA maps, 2015)

3.3.2 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.

Figure 4: Source Protection Zone Map (Source: EA maps, 2015)

3.4 Existing Site Drainage

The existing site consists of warehouse and offices buildings with associated car parking. Two L shaped buildings are located on the north and eastern site boundaries while two smaller single storey buildings are adjacent to the Regent's Canal. The Regent's Canal is located immediately to the east of the site.

It is assumed that the site is served by separate foul and surface water systems connecting to public sewer. It might be possible that some of the surface water runoff is discharging into the Regent's Canal. Several manholes and a gully have been identified on the topographical survey (Appendix A). Further investigation is required on site to ascertain the positions and locations of the existing drainage outfalls.

The Thames Water asset search identified a trunk combined water sewer crossing the eastern corner of the site. A 1550mm diameter combined ''fleet'' trunk sewer is approximately 7 m deep. A detailed section showing the new piled foundation arrangement in relation to the existing sewer has been submitted to Thames Water for their approval. A 3 m easement zone is to be provided in order to protect the Thames Water sewer. The location of the sewer is illustrated on extract from the Thames Water sewer records (figure 5). Further details can be found on topographical survey contained in Appendix B and complete Thames Water sewer records in Appendix C. The exact location of the trunk sewer has been confirmed by an intrusive CCTV and GRP survey carried out by Thames Water approved contractor. Refer to drawing 03089-XX-00501 in APPENDIX A.

The Thames Water asset search also identifies 1200 mm diameter surface water located in Georgiana Street. The surface water sewer is approximately 6.8 m deep.

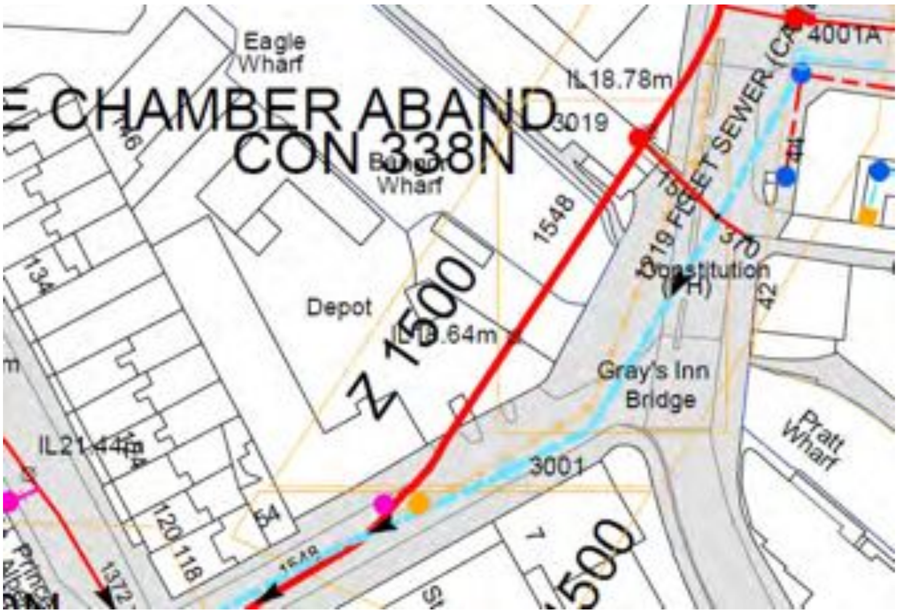


Figure 5: The Thames Water sewer records (Source: Thames Water)

3.5 Existing Site Characteristics

The existing hydrological characteristics for the site are as follows:

- Area of Development Site = 1,852 m^2
- Total Existing Impermeable Area assessed to be 97 % = 1,852 m^2
- Existing run off rate Q_{WR}= 25.7 l/s
- Infiltration rate = Unknown/ to be confirmed

4.0 PROPOSED DEVELOPMENT

4.1 Description

The existing buildings will be demolished to accommodate the construction of a new 6 storey building. The development will include commercial units at ground floor and residential units at the uppers levels consisting of private and affordable housing. A total of 46 units will be provided along with approximately 686 square meters of commercial space. The development will not include basement or parking on site.

4.2 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 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**.

4.3 Sequential Test

The Environment Agency Flood Plain map indicates that this site is located in Flood Zone 1 as illustrated on figure 6. 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' offices building site which is being redeveloped. This site is within an area identified as being appropriate for a mixed-use development incorporating residential and commercial use.

Figure 6: Flood Map (Source: EA maps, 2015)

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. The London Borough of Camden SFRA prepared specifically for the Camden Borough has been also reviewed.

5.1.1 Fluvial Flooding

The North London SFRA states that Camden has no fluvial watercourses within its borough boundaries. 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.

The London Borough of Camden confirm the same findings. Therefore, the fluvial flooding does not pose any risk to the development site.

The surface water sewer located in Georgiana Street called Fleet sewer is forming a part of the sewer network accommodating the subterranean River Fleet.

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 located between Camden Road train station and St Pancras hospital with the topography falling gently towards Camden Road station.

The North London and London Borough of Camden Strategic Flood Risk Assessments do 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. The London Borough of Camden SFRA's map 4e show no groundwater flooding incidents. 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. The development site lies on a silty clay, sand layer on top of the impermeable London Clay geology. 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 3.2 km 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 the Camden Borough. 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 North London SFRA's Map 22 in Appendix E show the roads affected by the 2002 flooding event. The map 22 indicates Kentish Town road which is in close proximity of the development site has been flooded in 1975. Other than that there are no further records of flooded roads.

The North London SFRA's Map 13 in Appendix E provides the Thames Water sewer flood data during the 10 year period from August 1997 to August 2007. The map 13 indicates that up to 3 flooding events occurred in the vicinity of the site. In Camden most of the flooding incidents have historically occurred in the West Hampstead, Cricklewood, South Hampstead and Church End and area located northeast of the site.

The London Borough of Camden SFRA provides similar results. Refer to Flood Map 5a in Appendix E. The development site is not susceptible to sewer flooding.

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 are mandated by regulation to identify and resolve any recurrent flooding issues on their network. Therefore reducing the level of flood risk from sewers.

Surface Water Flooding

The London Borough of Camden SFRA identified a number of critical drainage areas within the borough which are defined as *''a discreet geographic area where multiple and interlinked sources of flood risk (surface water, ground water, sewer, main river and/or tidal) which cause flooding in once or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure''.* Which means that the critical drainage area (CDA) might contribute to a flooding hot spot. All CDA have been identified on the flood map 6 (Appendix E). The development site is located in CDA Group 3 and in a close proximity to the Local Kings Cross Flood Risk Zone as illustrated on the figure 7.

Also, Map 3ii in Appendix E and figure 8 illustrates that a small part of the site is located in a low (1 in 1000 year storm) to medium (1 in 100 year storm) surface water flooding zone.

Therefore, it is recommended to provide additional gullies along Georgina Street and Aco channels in access road.

Numerous roads and houses were flooded during sever rain storm events in 1975 and 2002. 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.

Figure 7: Extract from the SFRA flood map 6 (The London Borough of Camden SFRA, 2014)

Figure 8: Extract from the SFRA flood map 3ii (The London Borough of Camden SFRA, 2014)

The extent of the 2002 Camden floods is shown on the Map 22 (Appendix E). The cause of these floods was attributed to surcharged sewers which could not cope with the volume of run-off. The development site has not been affected by the floods illustrated on the Map 22.

Further surface water flooding data have been obtained from Environment Agency as illustrated on figure 9. The flood map indicates the depth of the surface water flooding varies from 300mm to 900mm and overspills into the development site. Therefore, it is proposed to provide additional gullies along Georgina Street and Aco channels in access road to prevent surface water flooding.

Figure 9: Surface water flooding (Environment Agency, 2015)

5.1.6 Flooding from Artificial Sources

Camden does have a number of water bodies which pose a very low risk of flooding. The Regent's Canal immediately adjacent to the development site is owned and maintained by the Canal and River Trust (CRT). Regent's Canal runs from the west to east and bisects Camden borough. The CRT actively operate a series of sluices and gates along the Canal for navigation and flood risk management purposes.

The site is adjacent to the Regent's Canal. However, the site is located at a higher elevation. The average site elevation is approximately 25 m AOD while the canal's water level is at an elevation of 23.13 m AOD. Therefore this site can be considered to be at low risk from flooding.

The CRT have been contacted regarding the water levels associated with the stretch of the canal adjacent to the development site and have confirmed that the Regent's Canal poses a very low risk of flooding. The CRT has to ensure that no flooding occurs from the canal network. The London Borough of Camden SFRA confirmed that there are no recorded incidents of overtopping or breaches of the Regent's Canal in or within 500 m of London Borough of Camden.

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.

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. The data collated by the North London SFRA contained in Appendix E confirm that the site is in a low flood risk area. 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 rainfall.

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 = 1,852 m^2
- Total proposed Impermeable Area = 1,852 m^2
- Net decrease of impermeable area after development = 0 m^2
- Existing discharge rate = 25.7 l/s
- Both the London Plan and PPS25 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 PPS25, 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 25.7 l/s. The surface water runoff rate is to be restricted to 12.85 l/s. The attenuation is to be provided in form of rain gardens, geo-cellular tank and blue roof. The proposal is to discharge the storm water run-off to existing combined Thames Water sewer crossing the site. Refer to Appendix F for drainage proposal.

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. The courtyard is to be formed of the porous paving. All trapped gullies will also be introduced for all other proposed hard paved areas. The proposed development will be car free with vehicular traffic, deliveries and refuse collection restricted to Georgiana Street.

<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 12.85 l/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 to be 92 m^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	Mixed Use
Soil type	Made Ground underlain by London Clay Formation.
Area draining to SUDS components	1,852 m²
Minimum depth to water table	80m to 90m below ground level
Site slope	1:25
Available head	7.0 m
Available space	Limited.
Water quality treatment potential	Rain gardens, Porous Pavement, catchpits, gullies and cut-off valve to all hydrobrake chambers.
Hydraulic control	The surface water will be discharged at a restricted discharge of 12.85 l/s.
Maintenance	Desilting and emptying of catchpits and gullies every six months
Community acceptability	High
Cost	Low cost if possible
Habitat creation potential	Medium

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
	Rain garden	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

Table 6.3 - SUDS Selection Factors

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 and roofs. 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 the aggregate matrix of the permeable paving sub-base, trapped gullies and catchpits. Therefore the applicable SUDS option for this site, which have been highlighted in Table 6.3 is the following:

- Subsurface Storage – Modular Storage Units.
- Permeable Pavement.
- Blue roof.
- Rain garden

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 means:

- Underground modular storage units.

<u>Key Design Criteria</u>

- 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, but the site development is car free.

Table 6.4 below outlines the advantages and disadvantages of this technique.

Table 6.4 – Subsurface Storage Summary Sheet

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 Porous Pavements

Porous pavements provide a pavement suitable for the communal public courtyard. Porous Pavements allows rainwater to infiltrate through the surface into the underlying layers. Porous pavements with aggregate sub bases provide good water quality treatment. In this instance the permeable pavement will have a tanked sub-base, in order to attenuate the surface water runoff prior to discharge into the proposed underground modular storage units which is to be regulated through the hydro-brake. The attenuation volume provided by the porous pavements is illustrated on the drawings C100 and C101 in Appendix F.

Key Design Criteria

- Pervious surface and sub-base to be structurally designed for site purpose and design vehicular loading.
- Surface infiltration rate should normally be an order of magnitude greater than the design rainfall intensity.
- Temporary subsurface storage volume to meet requirements for infiltration and/or controlled discharge.
- Geotextile may be specified as a filtration treatment component near the top of the structure.
- Soil and other material must be prevented from contaminating the pavement surface and sub-structure.

Table 6.5 below outlines the advantages and disadvantages of this technique.

ADVANTAGES	PERFORMANCE
• Effective in removing urban runoff pollutants. • Lined systems can be used where infiltration is not desirable, or where soil integrity would be compromised. • Significant reduction in volume and rate of surface runoff • Suitable for installation in high density development. • Good retrofit capability. • No additional land take, allows dual use of space. • Low maintenance. • Removes need for gully pots and manholes. • Eliminates surface ponding and surface ice. • Good community acceptability. **DISADVANTAGES** • Cannot be used where large sediment loads may be washed/carried onto the surface. • In the UK, current practice is to use on highways with low traffic volumes, low axle loads and speeds of less than 30mph. • Risk of long-term clogging and weed growth if poorly maintained.	Peak flow reduction: Good Volume reduction: Good Water quality treatment: Good Amenity potential: Poor Ecology potential: Poor **TREATMENT TRAIN SUITABILITY** Source control: Yes Conveyance: No 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: High Capital cost: Medium (Net capital cost: Low) Maintenance cost: Medium **POLLUTANT REMOVAL** Total suspended solids: High Nutrients: High Heavy metals: High
KEY MAINTENANCE REQUIREMENTS:	
• Sweeping • Regular brushing and vacuuming.	

6.6.3 Blue Roofs

Blue 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.

The blue 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 roof system. Further storage will be provided within the geo-cellular layer installed below the blue roof's substrate.

As the rainfall events become longer or more intense, the positive effect of a blue roof remains as there is still a significant reduction in peak runoff rates. This increase in the 'time of concentration' means that the blue roof will be beneficial throughout a wide range of rainfall conditions

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

<u>Key Design Criteria</u>

- 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 6.6 below outlines the advantages and disadvantages of this technique.

Table 6.6 – Blue Roof Summary Sheet

ADVANTAGES	PERFORMANCE
• Mimics 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 • Helps 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)	

6.6.4 Rain Garden

The surface water runoff from the roof area will be collected in landform drain and directed into proposed rain gardens. The rain garden will be designed for the 1 in 100 plus 30% for the Climate Change event.

Key Design Criteria

- Designed to provide the 1 in 100 year storm event plus 30% for the Climate change.
- The sides are battered to 1 in 4 / 1 in 10 slopes and a maximum depth of 300mm in the centre, for children safety. Geotextile will be specified at the base of the attenuation pond to facilitate infiltration of surface water runoff.

Table 6.7 below outlines the advantages and disadvantages of this technique.

Table 6.7 – Rain Garden Summary Sheet

ADVANTAGES	**PERFORMANCE**
• Facilities natural attenuation of surface water runoff. • Facilitates the settling of silts prior to discharge. • Good removal of surface water runoff pollutants, when reed beds and aquatic plants are incorporated. • Facilitates surface infiltration. • Medium capital costs. • Maintenance can be incorporated into general landscape management. • High ecology and amenity potential. **DISADVANTAGES** • Cannot be used where large sediment loads may be washed/carried onto the surface. • Risk of long-term clogging and weed growth if poorly maintained. • Safety risk to children when ponds are deep.	Peak flow reduction: High Volume reduction: None Water quality treatment: High Amenity potential: High Ecology potential: High **TREATMENT TRAIN SUITABILITY** Source control: Yes Conveyance: No Site system: Yes Regional system: Yes **SITE SUITABILITY** Residential: Yes High density: No Retrofit: No Contaminated sites/sites above vulnerable groundwater (with liner) Yes **COST IMPLICATIONS** Land-take: High Capital cost: Medium Maintenance cost: Medium **POLLUTANT REMOVAL** Total suspended solids: High Nutrients: Medium Heavy metals: Medium
KEY MAINTENANCE REQUIREMENTS:	
• Regular inspection and monitoring. • Grass cutting and removal of cuttings. • Cleaning of inlets and outlets from debris and sediment. • Removal of sediment from pre-treatment. • Removal and cleaning or replacement of stone.	

6.7 Assessment of Appropriate SUDS Technique

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, blue roofs, rain gardens and porous pavements be used for rainwater attenuation.

The developed drainage strategy will enable credits to be awarded under BREEAM 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 rate less 2.3 l/s into the Thames Water public sewer network. The foul water is to drain by gravity via a new foul water outfall pipe provided within the site.

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 92 m^3 of modular storage/blue roofs and porous pavement storage. The surface water will discharge at a restricted rate of 12.85 l/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 COMMERCIAL REQUIREMENTS

It is proposed to achieve 'excellent' level of compliance for this development.

11.1 Pol 3 – Surface water runoff

11.1.1 The surface water runoff issue is split into three parts:

- Flood Risk (1 – 2 credits).
- Surface water runoff (2 credits).
- Minimising water course pollution (1 credit).

11.1.2 Flood Risk

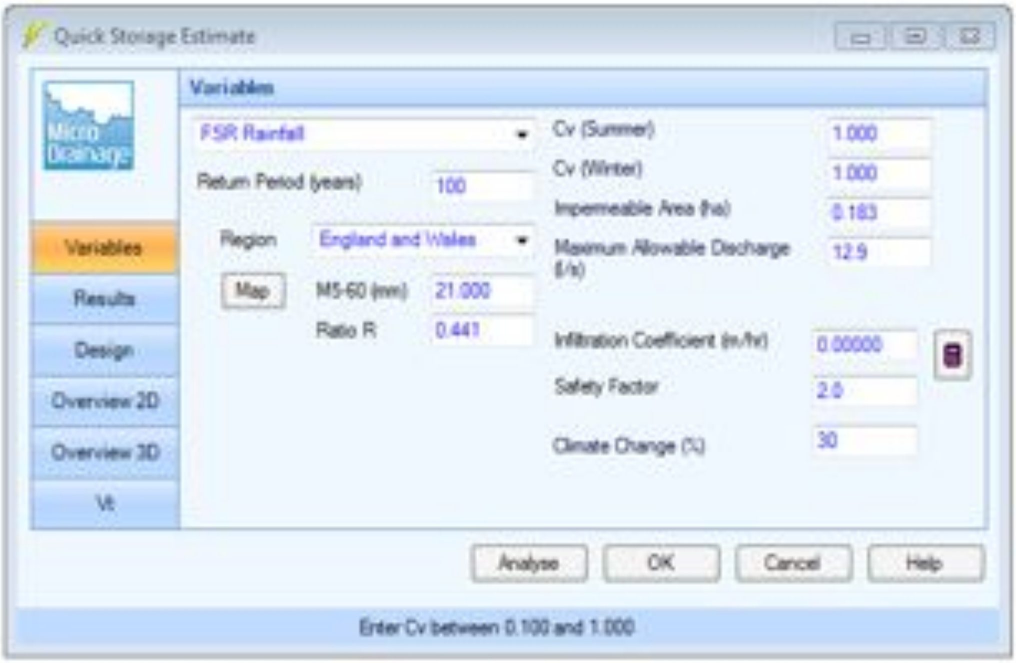
To encourage developments in areas with low risk of flooding or if developments are situated in areas with a low risk of flooding, that appropriate measures are taken to reduce the impact in an eventual case of flooding.

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. And a site specific FRA confirms that there is a low risk of flooding from all sources – achieved.

2 credits will be achieved for complying with Flood Risk policy.

11.1.3 Surface water runoff

Drainage measures are specified to ensure that the 100 year storm return period peak rate of surface water runoff from the site is no greater for the development site than it was for the pre-development site. The calculations are to include an allowance for the 30% of climate change. The quick storage calculations shown on figure 8 show the allowance for climate change and required return storm evet. One credit – achieved.



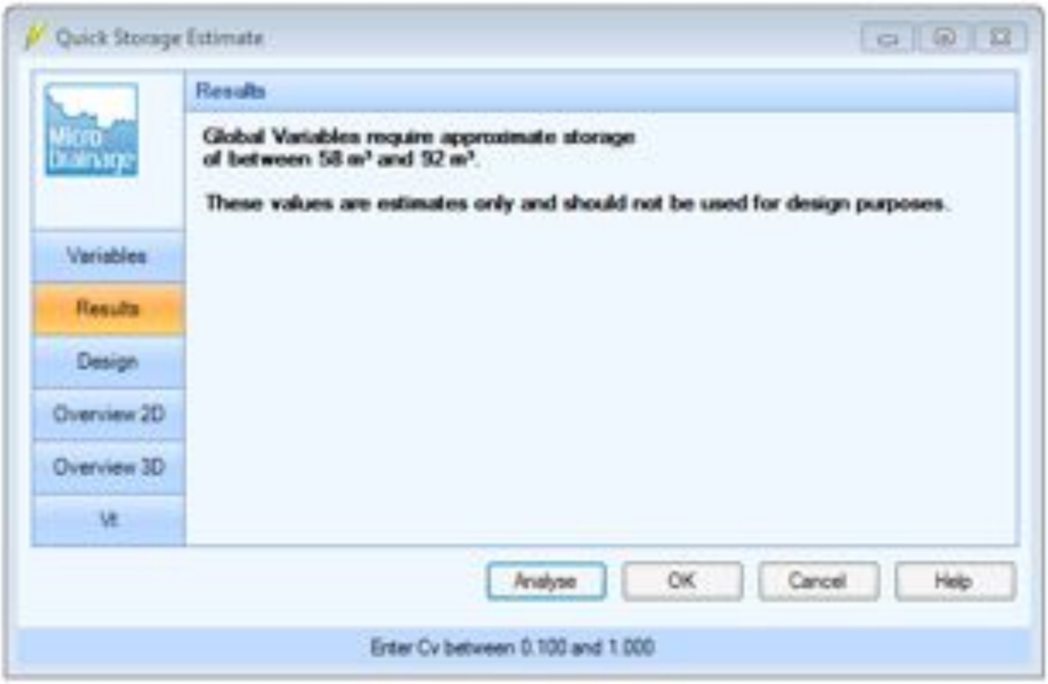


Figure 8: Quick Storage Estimate Calculations (Windes, 2015)

Second credit is available where flooding of property will not occur in the event of local drainage failure and the post-development runoff volume, is no greater than it would have been prior to the assessed site's development.

The local drainage system is maintained by Thames Water. Therefore, the site is in low risk of flooding from drainage failure. The post-development runoff is to be restricted by 50%.

2 credits will be achieved for complying with Surface water runoff part.

11.1.4 Minimising Watercourse Pollution

Porous Pavement is proposed to provide treatment, together with trapped gullies and catchpits. There will be no discharge from the development site for rainfall up to 5 mm as this will be intercepted within the porous pavement, blue roofs, rain gardens and trapped gullies. Additional Credit requirement – achieved.

11.1.5 Total Credits

Total 5 credits have been awarded for compliance with Pol 3 of the BREEAM assessment. Therefore, an 'excellent' rating will be awarded.

12.0 RECOMMENDATIONS

It is recommended that the proposed drainage network contained in Appendix F, 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 flooding. Further, both the SFRAs and the site specific flood risk assessment for this development has not identified potential flood risks for the site that cannot be managed. However, the development site is in low to medium risk of surface water flooding. Therefore, it is recommended to provide additional gullies and ACO channels in access road and along Georgina Street. Refer to drawing C100 in APPENDIX F. Also, 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.