Consulting Engineers

Project_

Tavistock Works
West Drayton
London, UB7 7QX

Title_

Flood Risk Assessment
Surface Water Management Report

Project No_

495

Date_

June 2024

Revision_

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Previous Report and Application Note

The current / applicable flood risk assessment and previous surface water management report were approved by London Borough of Hillingdon at an appeal (reference: APP/R5510/W/21/3288333).

The flood risk assessment in this report has NOT changed from the previous approved report. Changes made to the surface water management calculations / areas to suit the new Architectural plans only.

1. Introduction

Flo Consult UK Ltd have been appointed to undertake a flood risk assessment and surface water management report for a new development at Tavistock Works, West Drayton, London, UB7 7QX.

The report provides evidence of the assessment of current flood risks to the Site, and describes how the surface water run-off rate and volume from the Site is proposed to be managed. National and local planning policy, regulations and relevant design guidance include:

- National Planning Policy Framework (NPPF), December 2023, Paragraphs 153-158 and 159-169;
- National Planning Practice Guidance (NPPG) ('Flood Risk and Coastal Change' section), released in March 2014 and updated in August 2022;
- National Standards for Sustainable Drainage Systems (SuDS) set out by the Department for Environment, Food & Rural Affairs (DEFRA) (2011);
- CIRIA (2010) Planning for SuDS – Making it Happen C687;
- CIRIA SuDS Manual C753 (2015);
- Non-Statutory Technical Standards for Sustainable Drainage Systems (DEFRA) (March 2015).
- The London Plan (2021) Policy SI 12 (Flood Risk Management) and SI 13 (Sustainable Drainage) (see summary of policies in Section 2.0 of this report);
- West London Strategic Flood Risk Assessment (online);
- London Borough of Hillingdon – Local Plan: Part 1 Strategic Policies (Adopted November 2012);
- London Borough of Hillingdon – Local Plan: Part 2 Development Management Policies (2020);
- London Borough of Hillingdon – Local Flood Risk Management Strategy (2016);
- London Borough of Hillingdon – Preliminary Flood Risk Assessment (July 2011, addendum December 2017).
- London Borough of Hillingdon – Surface Water Management Plan – Options and Actions
- London Borough of Hillingdon – Surface Water Management Plan – Evidence Based

London Borough of Hillingdon Council (LBHC) and Thames Water (TW) need to be satisfied that the design and drainage principles of the proposed development will address the risk of flooding to the development site, and that the proposals will not in turn increase the risk of flooding to neighbouring land and property.

This flood risk assessment and surface water management report has therefore been prepared to identify and evaluate the various possible sources of flood risk to which the proposed site might be subjected to; to identify any mitigation, protection or compensation measures deemed necessary or feasible; ad to manage the surface water so it sustainable, and does not increase the probability of flooding within, or near the site.

2. National / Local Policies and Water Management Guidance

2.1. National Planning Policy Framework (NPPF) and National Planning Practice Guidance (NPPG)

NPPF (December 2023) sets out the Government's national policy on development and flood risk, and seeks to provide clarity on what is required at regional and local levels, to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk.

NPPF Paragraphs 153 to 158 provide guidance for developments to take a proactive approach to mitigating and adapting to climate change, taking into account the long-term implications for flood risk.

NPPF Paragraphs 159 to 169 provide guidance for planning and flood risk, where are plans should apply a sequential, risk-based approach to the location of development taking into account current and future impacts of climate change; to ensure that flood risk is not increased elsewhere due to the development; and to incorporate sustainable drainage systems.

NPPG, Paragraph 055 (Reference ID:7-055-20220825) states that sustainable drainage systems (SuDS) are designed to control surface water run off close to where it falls and mimic natural drainage as closely as possible, where they provide opportunities to reduce the causes and impacts of flooding; remove pollutants from urban run-off at source; and to combine water management with green space with benefits for amenity, recreation, and wildlife.

Further to this NPPG, Paragraph 056 (Reference ID:7-056-20220825) states that the aim should be to discharge surface run off as high up the following hierarchy of drainage options as reasonably practicable which (in order) are into the ground (infiltration); to a surface water body; to a surface water sewer, highway drain, or another drainage system; to a combined sewer.

2.2. Flood and Water Management Act

The Flood and Water Management Act takes forward some of the proposals from three previous strategy documents published by the UK Government - Future Water (2008), Making Space for Water (2008) and the UK Government's response to the Sir Michael Pitt's Review of the summer 2007 floods. In doing so it gives the EA a strategic overview role for flood risk, and gives local authorities responsibility for preparing and putting in place strategies for managing flood risk from groundwater, surface water and ordinary watercourses in their areas.

2.3. West London Strategic Flood Risk Assessment

The executive summary of the west London strategic flood risk assessment states:

'The West London Boroughs of Barnet, Brent, Ealing, Harrow, Hillingdon and Hounslow (hereinafter 'the Boroughs') have commissioned the production of a joint Level 1 Strategic Flood Risk Assessment (SFRA). The combined area features several cross-boundary Environment Agency-designated Main Rivers, including the Dollis Brook, Duke of Northumberland's River, River Brent, River Crane, River Colne, River Lee, River Pinn, River Thames and Yeading Brook. These rivers cross boroughs that make up six of the seven local authorities that form the West London Alliance (WLA). Due to these established associations, groupings, and shared borough boundaries, a joint SFRA is beneficial for all Boroughs.

This document and mapping provides consistency and clarity, and sign-posting to common policies and requirements. A joint SFRA also enables the identification of potential improvements which the Boroughs are recommended to adopt and enforce through their future Local Plans to improve local flood risk whilst promoting sustainable development. The Boroughs have delivered the SFRA in an innovative format as a website (for the text content) and a web map (for the supporting flood risk information). This format allows for efficient update of content in the future and ensures that the best available information is presented in a dynamic format.

The overarching aim of this SFRA is to provide the evidence base for ensuring development is steered away from areas identified most at risk from all sources of flood risk, reducing the risk of flooding to residents and buildings. This is required to provide an update to existing borough specific SFRAs, which were predominantly completed in 2008.

2.4. London Plan (March 2021) - Policy SI 12 (Flood Risk Management) states:

A. *'Current and expected flood risk from all sources (as defined in paragraph 9.2.12) across London should be managed in a sustainable and cost-effective way in collaboration with the Environment Agency, the Lead Local Flood Authorities, developers and infrastructure providers.*

B. *Development Plans should use the Mayor's Regional Flood Risk Appraisal and their Strategic Flood Risk Assessment as well as Local Flood Risk Management Strategies, where necessary, to identify areas where particular and cumulative flood risk issues exist and develop actions and policy approaches aimed at reducing these risks. Boroughs should cooperate and jointly address cross-boundary flood risk issues including with authorities outside London.*

C. *Development proposals should ensure that flood risk is minimised and mitigated, and that residual risk is addressed. This should include, where possible, making space for water and aiming for development to be set back from the banks of watercourses.*

D. *Developments Plans and development proposals should contribute to the delivery of the measures set out in Thames Estuary 2100 Plan. The Mayor will work with the Environment Agency and relevant local planning authorities, including authorities outside London, to safeguard an appropriate location for a new Thames Barrier.*

E. *Development proposals for utility services should be designed to remain operational under flood conditions and buildings should be designed for quick recovery following a flood.*

F. *Development proposals adjacent to flood defences will be required to protect the integrity of flood defences and allow access for future maintenance and upgrading. Unless exceptional circumstances are demonstrated for not doing so, development proposals should be set back from flood defences to allow for any foreseeable future maintenance and upgrades in a sustainable and cost-effective way.*

G. *Natural flood management methods should be employed in development proposals due to their multiple benefits including increasing flood storage and creating recreational areas and habitat'.*

2.5. London Plan (March 2021) - Policy SI 13 (Sustainable Drainage) states:

A. *'Lead Local Flood Authorities should identify – through their Local Flood Risk Management Strategies and Surface Water Management Plans – areas where there are particular surface water management issues and aim to reduce these risks. Increases in surface water run-off outside these areas also need to be identified and addressed.*

B. *Development proposals should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible. There should also be a preference for green over grey features, in line with the following drainage hierarchy:*

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

C. *Development proposals for impermeable surfacing should normally be resisted unless they can be shown to be unavoidable, including on small surfaces such as front gardens and driveways.*

D. *Drainage should be designed and implemented in ways that promote multiple benefits including increased water use efficiency, improved water quality, and enhanced biodiversity, urban greening, amenity and recreation'.*

2.6. LBHC – Planning Notice

LBHC issued a planning notice letter on the 8th April 2019, which (in reference to the flood risk assessment and surface water management) states:

The proposal is required to submit a Flood Risk Assessment will be required as part of any future planning application.

All new development should incorporate sustainable drainage systems. The proposals need to include a clear drainage strategy that is reflected within the designs of the development. Policy 5.13 of the London Plan sets out a hierarchy to work towards, it also requires a greenfield run-off rate to be met. This means that simply suggesting that the run-off rate will not be increased is not sufficient.

You will need to demonstrate a greenfield run-off rate in a 1:100-year (+ climate change) storm event. This needs to set out quantities of run-off and pre and post development and include the methods of attenuation to reduce it down to a greenfield rate. If infiltration methods of SUDS are proposed, you will need to demonstrate the receiving subsoils will be adequate. You will also need to set out adoption and maintenance regimes which may require consideration within a subsequent Section 106 legal agreement'.

This advice was reiterated in the LHBC letter of 22nd November 2019.

3. Site Setting and Description

3.1. Site Location

The development site is in the London Borough of Hillingdon, and is approximately 15km west of the centre of London, and 100m west of West Drayton train station.

The site is bound between a new development / building to the north and west; Tavistock Road to the south; and an existing commercial building directly to the east.

The full address of the development site is Tavistock Works, West Drayton, London, with the nearest postcode being: UB7 7QX, and the co-ordinates of the centre of the site being: Easting: 505885, Northing: 180165.

3.2. Existing Site

The existing site consists of an existing commercial building to the east, that occupies half the development area, with the remaining areas to the west being hard-standing yard areas.

The site is currently being used as a construction yard for the neighbouring Comag and Padcroft schemes under construction.

3.3. Proposed Development

The proposed site plan is shown in Appendix A, with a full description of the development site being stated by the Architect. In brief, and in relation to this flood risk assessment and surface water management report, the proposed development is:

"Pursuant to development approved under planning application ref. 35810/APP/2021/1234 (appeal ref. APP/R5510/W/21/3288333) it is proposed to remove 8no car parking spaces and provision of 1no blue badge space; provision of second stair case, replacement of winter gardens with balconies, increase in massing and height by up to 2 storeys and provision of an additional 5no units totaling 38 units."

3.4. Topography

A topographical survey was completed at the existing site in November 2018. As detailed in Appendix B, the development site has a general fall from east to west, with the floor level of the existing commercial building being 27.22m AOD, and the levels dropping to a level of 26.78m AOD within the external yard area.

3.5. Ground Conditions

A site investigation report is also submitted with the planning application and contains more detail of the site's conditions. The ground conditions can also be sourced from the British Geological Survey (BGS) website, which shows the superficial deposits and bedrock strata for the site.

The BGS Data identifies the ground at the site to have superficial deposit of Langley Silt Member (clay and silt), which is over a bedrock layer of London Clay (clay and silt).

Borehole logs found on the BGS website (see Appendix B), which are taken within 200m to the east, south, and west of the development site, show the ground to predominantly consist of made ground over clay.

3.6. Waterbody / Rivers / Canals / Reservoirs

There are no known waterbodies, rivers, canals, or reservoirs directly adjacent to the development site, with the nearest main waterbody being the Fray's River approximately 25m to the east, and the near canal being the Grand Union Canal approximately 50m to the east of the site.

3.7. On-Site Drainage / Public Sewers

Thames Water asset plans in Appendix C show that there is a 225mm diameter surface water and a 225mm diameter foul water sewer within Tavistock Road (south of site), that flow in an east to west direction.

The depth of the surface water sewer is approximately 1.09m at the development location, and the depth of the foul water sewer is approximately 3.69m at the development location.

No drainage survey has taken place at the development; however, due to the nature of the existing site (commercial building and hard-standing yard), it is anticipated that the pre-development surface water run-off discharged to the surface water seer within Tavistock Road.

3.8. Development Areas

The overall site boundary area is approximately 680m² / 0.068 ha.

The pre-development site is completely impermeable, with the surface water run-off from the area assumed to discharge off site to the surface water sewer in Tavistock Road. Therefore, for the pre-development run-off calculation, the area is to be **0.068ha**.

The proposed building and external paved areas cover the whole development area, and therefore the post development site is also completely impermeable (including permeable paving system), and therefore will also have a total surface water catchment area of **0.068 ha**.

However, there will be above ground blu-roof systems on the first, sixth, and seventh floor, as well as the roof level which will equate to **0.036 ha**. The remaining roof area and ground floor paved area will therefore equate to **0.032 ha**, of which **0.008 ha** will be formed of permeable paving.

A summary, the pre and post-development areas are as follows:

Pre-Development SW Catchment Area	-	0.068 ha
First Floor Green / Blu-Roof Area	-	0.008 ha
Sixth Floor Green / Blu-Roof Area	-	0.002 ha
Roof Level Green / Blu-Roof Area	-	0.020 ha
Ground Floor Permeable Paving	-	0.008 ha
Remaining Normal Roof and Ground Flood External Areas	-	0.030 ha
Total Surface Water Management Area	-	**0.068 ha**

Note that the surface water management will be for all areas of the site within the red line boundary as shown on drawing in Appendix H.

4. Sources of Flooding

In accordance with the NPPF, flood risk must be assessed for all sources of flooding and development of the site should be carried out in such a way as to mitigate any potential flood risk to both the site and third parties and their property. This section identifies all possible sources of flooding.

4.1. Fluvial Flooding

Fluvial flooding results from watercourses / rivers surcharging and flooding the surrounding areas.

4.2. Coastal Flooding

Coastal flooding results from high tides from the sea.

4.3. Pluvial Flooding

'Pluvial' flooding is that which results from rainfall generated overland flow before the run-off enters any watercourse, drain or sewer. It is more often linked to high intensity rainfall events (typically in excess of 30mm per hour). However, it can also result from lower intensity rainfall or melting snow where the ground is saturated, frozen, developed or has low permeability. This results in overland flow and ponding in depressions in the topography. In urban areas 'pluvial' flows are likely to follow the routes of highways and other surface connectivity to low spots where flooding can occur. In some cases, it can deviate from this route into adjacent developments via dropped kerbs (either for access to driveways or disability access).

4.4. Groundwater Flooding

Groundwater flooding is caused by the emergence of water from sub-surface permeable strata. Fluctuations in the groundwater table can cause flooding should the table rise above the existing ground level. Groundwater flooding events tend to have long durations, lasting days, or weeks.

4.5. Flooding from Drains and Sewers

Flooding from drains and sewers is caused when the capacity of the drains and sewers is exceeded, and will result in flooding from the manholes.

4.6. Canals, Reservoirs and Other Artificial Sources

Flooding from canals, reservoirs and artificial sources is caused when the capacity of the sources are exceeded, or if there is an infrastructure failure.

5. Sourced Flood Data

Data from the Environment Agency; local strategic flood risk assessments; and information from other parties are to be studied to establish which sources of flooding are at the site.

5.1. Environment Agency Flood Maps for Planning

The Environment Agency (EA) fluvial flood map shown in Figure 1, indicates that the site is in Flood Zone 1 (low probability - land having a less than 1 in 1,000 annual probability of river or sea flooding).

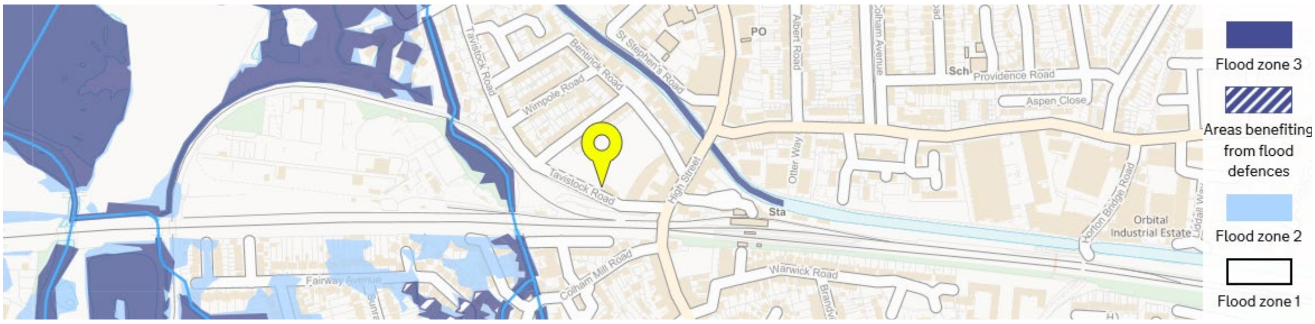


Figure 1 – EA Flood Zone Map

The EA fluvial flood map shown in Figure 2, identifies that all the site has no (less than very low) probability of fluvial flooding.

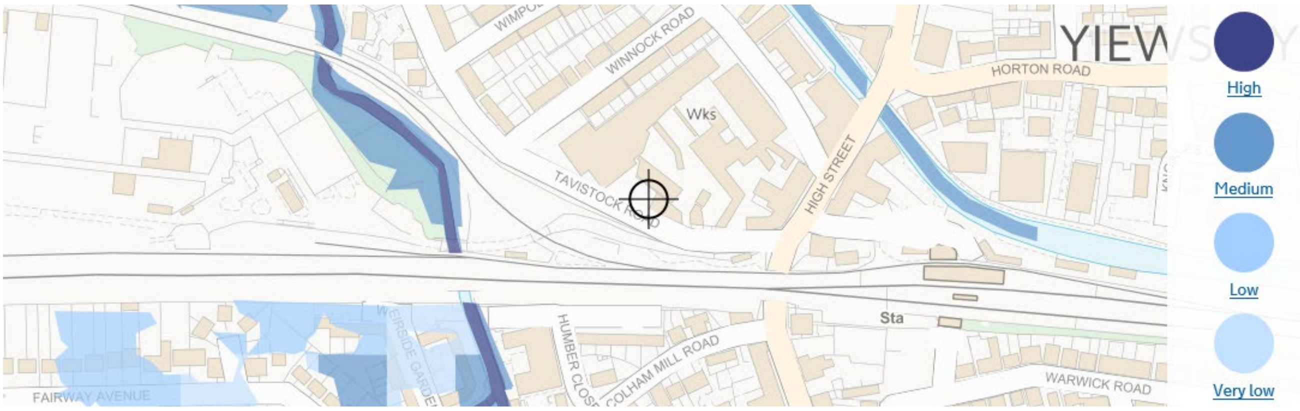


Figure 2 – EA Fluvial Flood Map

The EA pluvial flood map shown in Figure 3, identifies that the existing commercial building has a very low probability of pluvial flooding, and the existing yard area having a low probability of pluvial flooding.

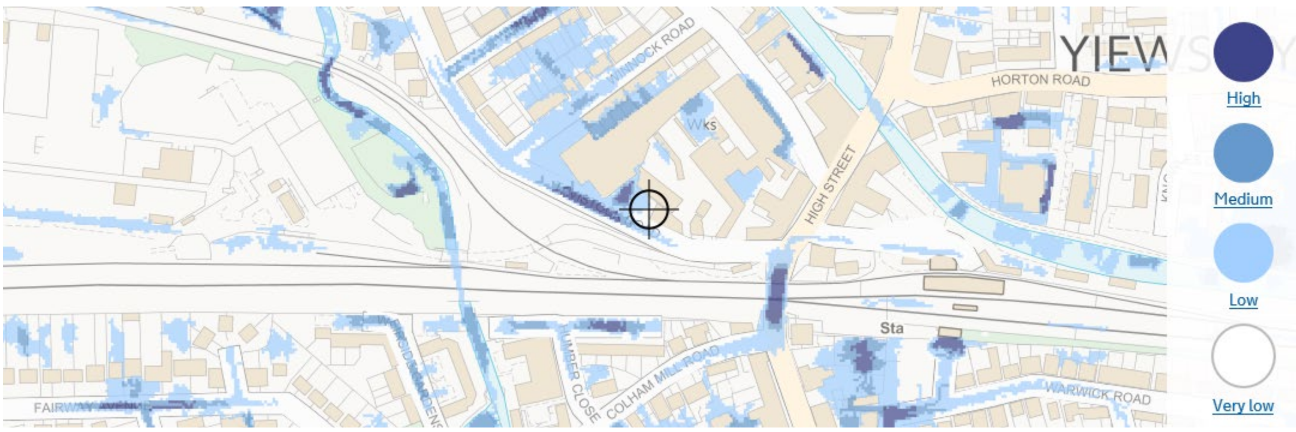


Figure 3 – EA Pluvial Flood Map

5.2. Landmark Envirocheck Data Maps

Refer to Appendix E for Landmark Envirocheck flood map data. The data shown on the maps have been sourced from studies by BGS, GeoSmart, JBA and the Environment Agency (EA). The summary of each of the maps are as follows:

5.2.1. Flood Map

The EA/NRW flood data map, also indicates that the development site is within Flood Zone 1 (low probability of flooding).

5.2.2. Surface Water Flood Depths

The Envirocheck (EA/NRW) 30-year return period flood map indicates that there is no surface water / rainfall flooding within the development site boundary.

The Envirocheck (EA/NRW) 100-year return period flood map indicates that there is no surface water / rainfall flooding within the development site boundary.

The Envirocheck (EA/NRW) 1000-year return period flood map indicates that there is no surface water / rainfall flooding at the external commercial building, with the existing yard area having a flood depth of between 0.15 – 0.30m.

5.3. Canal Failure

The Envirocheck (JBA) canal failure map indicates that the development site is in the canal coverage area, but is not in a canal failure area. The nearest canal failure area is approximately 250m north west of the development site.

5.3.1. Ground Water Flooding

The Envirocheck / BGS flood data map indicates that the development site is outside any groundwater susceptibility areas, and the ESI groundwater flood map indicates that there is negligible risk of ground water flooding for the site. However, the site investigation report does however state that the site is at risk from ground water flooding.

5.3.2. Historic Flood Map

The Envirocheck historic flood map indicates that there has been no flooding within the development site from channels, groundwater, drainage infrastructure or mechanical failure. The nearest flood event is approximately 5km north of the site in Uxbridge, where flooding occurred due to channel exceedance.

5.4. LBHC Preliminary Flood Risk Assessment Maps

The LHBC preliminary flood risk assessment also produces a series of flood probability maps for the borough. A summary of the maps (relevant to the site location) are as follows:

5.4.1. Figure A-1.2 – Summary Map of Past Floods – Surface Water Incidents

This map identifies that there has been no flooding in the past at the development location.

5.4.2. Figure A-2.2 – Summary Map of Past Floods – Main River / Fluvial / Tidal Incidents

This map also identifies that there has been no flooding in the past at the development location.

5.4.3. Figure A-3.2 – Summary Map of Past Floods – Ground Water Incidents

This map also identifies that there has been no flooding in the past at the development location.

5.4.4. Figure A-4.2 – Summary Map of Past Floods – Sewer Incidents

This map identifies that there has been between 21-50 flood incidents from sewers in the area of borough where the site is located, However, there is no evidence that the flood incidents occurred near the development site.

5.4.5. Figure A-5.2 – Summary Map of Past Floods – Elevated Ground Water Map

This map also identifies that there has been no flooding in the past at the development location.

6. Flood Risk and Vulnerability

The NPPG Paragraphs 065 to 067 sets out the flood risk for a site by assessing the flood zones, flood risk vulnerability classification, and flood risk vulnerability and flood zone 'compatibility'.

6.1. Flood Zones

NPPG Paragraph 065, Table 1 indicates that the flood zones are:

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

The EA flood map data has identified that the development site is in Flood Zone 1, which has a low probability of flooding.

6.2. Flood Risk Vulnerability Classification

NPPG Paragraph 066, Table 2 stated the flood risk vulnerability classifications as:

Table 2
Essential Infrastructure - Essential transport infrastructure (including mass evacuation routes) which should 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 and ambulance stations; fire stations and command centers; 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.
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; Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable Police, ambulance and fire stations which are not required to be operational during flooding; Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'More Vulnerable' class; and assembly and leisure; Land and buildings used for agriculture and forestry; Waste treatment (except landfill* and hazardous waste facilities); Minerals working and processing (except for sand and gravel working); Water treatment works which do not need to remain operational during times of flood.
Water-Compatible Development Flood control infrastructure; Water transmission infrastructure and pumping stations; Sewage transmission infrastructure and pumping stations; Sand and gravel working; Docks, marinas, and wharves; Navigation facilities.

This development is classed as a 'More Vulnerable' as the development is to comprise of units that are used for dwelling houses.

6.3. Flood Risk Vulnerability and Flood Zone 'Compatibility'

NPPG Paragraph 067 Table 3, gives guidance on flood risk vulnerability compared with flood zone, to determine the compatibility.

Table 3 - Flood Risk Vulnerability and Flood Zone 'Compatibility'					
Flood Zones	**Flood Risk Vulnerability Classification**				
	Essential Infrastructure	Highly Vulnerable	**More Vulnerable**	Less Vulnerable	Water Compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	† Exception Test required	✗	Exception Test required	✓	✓
Zone 3b*	* Exception Test required	✗	✗	✗	✓*

In accordance with Table 3 of the NPPF if the site is in Flood Zone 1, is classed as 'More Vulnerable', the development is appropriate.

7. The Sequential Test and Exception Test

7.1. Sequential and Exception Test Guidance

Paragraph 101 of the NPPG states that: *The aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower probability of flooding. The Strategic Flood Risk Assessment will provide the basis for applying this test. A sequential approach should be used in areas known to be at risk from any form of flooding.*

Paragraph 102 of the NPPG states that: *If, following application of the Sequential Test, it is not possible, consistent with wider sustainability objectives, for the development to be located in zones with a lower probability of flooding, the Exception Test can be applied if appropriate. For the Exception Test to be passed:*

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

7.2. Sequential and Exception Test Requirement for Development

The development site has passed the sequential and exception test as it is in Flood Zone 1, and in accordance with NPPF guidelines is classed as 'More Vulnerable', and therefore is an appropriate development.

8. Probability of Flooding

8.1. Fluvial Flooding

The EA and SFRA flood map data identifies the developed park area to be in Flood Zone 1. Therefore, the development is deemed to have a low probability of fluvial flooding.

8.2. Pluvial / Surface Water Flooding

The EA planning flood map shows the existing commercial building to have a very low probability of pluvial flooding, and the external yard area having a low probability of pluvial flooding.

The EA map sourced from Landmark Envirocheck shows that there is no pluvial flooding within the development boundary during the 30-year (high probability event), and 100-year return period (medium probability event), with pluvial flooding occurring in the existing yard area only for the 1000-year return period (low probability event) at a depth of between 0.00 to 0.15m.

As the depths in the yard are only occur during the 1000-year return period, it is deemed that the risk of pluvial flooding at the proposed development site will be low.

8.3. Ground Water Flooding

The Envirocheck / BGS flood data map indicates that the development site is outside any groundwater susceptibility areas, and the ESI groundwater flood map indicates that there is negligible risk of ground water flooding for the site.

However, the site investigation report does however state that the site is at risk from ground water flooding. The only structure partly below ground level will be the car park, which will be built from water resistant / resilient materials. The car park is not deemed to be a highly vulnerable area of the site, with minor flooding being acceptable.

The highly vulnerable habitable areas at ground floor level will be above the external levels, and therefore will mitigate against any ground water flooding.

8.4. Flooding from Drains and Sewers

There are existing surface and foul water sewers to the south of the development site within Tavistock Road. The Envirocheck and SFRA maps indicate that there has been no history of flooding from these networks near the site boundary. Therefore, the probability of flooding from drains and sewers is deemed to be low.

8.5. Canals, Reservoirs and Other Artificial Sources

In accordance with the flood map data, the nearest canal, reservoir, or artificial source to the site is the Grand Union Canal approximately 50m to the east of the site.

The EA and SFRA flood maps identify the site to be in an area affected by a reservoir failure. The reservoir is a main infrastructure, and will be maintained and managed to ensure that it does not fail, and no major flooding will occur from it. Therefore, as the map is a ‘worst case scenario’, and the likelihood of the failure is very low, the probability of flooding from a reservoir is deemed to be low.

The site is also in the canal coverage area, but is not in a canal failure area. Therefore, based on the data, the development is to have a low probability of flooding from canals or other artificial sources.

9. Flood Mitigation / Resistance / Resilience Measures

To ensure that the proposed development is not at risk from any future flooding (even though found to be low from all sources), and for the development will be safe for its lifetime for the occupants, there are to be flood mitigation, resistance, and reliance measures.

9.1. Finished Floor Levels

The flood map data identifies the pluvial flood levels of between 0.00m to 0.15m to the eastern areas of the existing yard area where the existing site levels are known.

As detailed on the topographical survey, levels in this area vary from 27.08m AOD to 26.82m AOD, and therefore it is calculated that the pluvial flood level of the site to be approximately 26.97m AOD (150mm above lowest level). This is reflected in the areas of the site higher than this level not being on an area of pluvial flooding.

In terms of the minimum level of the for the proposed building, it is recommended to be at 27.270m AOD, as this is 300mm higher than the anticipated maximum pluvial flood level.

It is also recommended that the back of footpath levels is raised at the car park entrance locations to at least 27.270m AOD, with the levels falling away from the opening towards Tavistock Road. This will prevent pluvial flooding from discharging into the car park area at the entrance location.

9.2. Safe Access and Egress

The pedestrian entrance to the new building is in areas where no flooding will occur from any source. Therefore, in the event of an extreme storm event, safe access and egress will be gained to the east of Tavistock Road.

9.3. Flood Flows / Water Displacement

Pluvial flood water is between 0.00m and 0.15m in the yard area for the 1000-year return period. The proposed building will displace the surface water for this return period. However, as the probability of this occurring is deemed to be low, and any displaced water being contained within Tavistock Road (due to kerb upstands and gradients), this would not increase the flood probability to any area near the development site.

10. Surface Water Management Principles

The surface water for the development site is to be managed so that it adheres to the current national regulations and local authority requirements.

10.1. Run-Off Destination

Surface water run-off is to discharge to one or more of the following in the order of priority shown:

- Discharge into the ground (infiltration);
- Discharge to a surface water body;
- Discharge to a surface water sewer, highway drain or other drain;
- Discharge to combined sewer.

10.2. The Management Train

A concept fundamental to implementing a successful SuDS scheme is the management train. This is a sequence of SuDS components that serve to reduce run-off rates and volumes and reduce pollution. The hierarchy of techniques that are to be used for the surface water management of the development are:

- Prevention - Prevention of run-off by good site design and reduction of impermeable areas;
- Source Control - Dealing with water where and when it falls (e.g. infiltration techniques);
- Site Control - Management of water in the local area (e.g. swales, detention basins);
- Regional Control - Management of run-off from sites (e.g. balancing ponds, wetlands).

10.3. Design Principles

The design principles for the surface water management of the development will be to:

- Ensure that people, property, and critical infrastructure are protected from flooding;
- Ensure that the development does not increase flood risk off site;
- Ensure that SuDS can be economically maintained for the development.

10.4. Peak Surface Water Flow

LBHC issued a planning notice letter on the 8th April 2019, which (in reference to the flood risk assessment and surface water management) states:

'All new development should incorporate sustainable drainage systems. The proposals need to include a clear drainage strategy that is reflected within the designs of the development. Policy 5.13 of the London Plan sets out a hierarchy to work towards, it also requires a greenfield run-off rate to be met. This means that simply suggesting that the run-off rate will not be increased is not sufficient.

You will need to demonstrate a greenfield run-off rate in a 1:100-year (+ climate change) storm event. This needs to set out quantities of run-off and pre and post development and include the methods of attenuation to reduce it down to a greenfield rate. If infiltration methods of SUDS are proposed, you will need to demonstrate the receiving subsoils will be adequate. You will also need to set out adoption and maintenance regimes which may require consideration within a subsequent Section 106 legal agreement'.

A pre-development response from Thames Water (TW) was received on 25th June following an application for the surface water discharge to the 225mm diameter surface water sewer within Tavistock Road. The letter (as shown in Appendix L) states:

TW would accept a stored and attenuated discharge of 1.10 l/s, as per your application, and if you agree that with the LA then that discharge can be accepted by both LA & TW'.

Therefore, based on LBHC and TW requirements, the surface water run-off form the post development site is to be restricted to maximum discharge rate of either the equivalent 100-year greenfield rate or 1.10 l/s (dependent on which is the lower of the two).

10.5. Flood Risk

The drainage system will be designed so that, unless an area is designed to hold and/or convey water, flooding does not occur on any part of the site for a 1 in 30-year rainfall event.

The drainage system will also be designed so that, unless an area is designed to hold and/or convey water, flooding does not occur during a 1 in 100-year rainfall event in any part of a building (including a basement) or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development.

The design of the site will ensure that flows resulting from rainfall more than a 1 in 100-year rainfall event are managed in exceedance routes that avoid risk to people and property both on and off site.

10.6. Pollution

The SuDS design for the development site will ensure that the quality of any receiving water body is not adversely affected and preferably enhanced in accordance with Ciria SuDS Manual C753, Chapter 4.

10.7. Designing for Exceedance

The development site design will be such that when SuDS features fail or are exceeded, exceedance flows do not cause flooding of properties on or off site. This will be achieved by designing suitable ground exceedance or flood pathways, and run-off will be completely contained within the drainage system (including areas designed to hold or convey water) for all events up to a 1 in 30-year event. The design of the site ensures that flows from rainfall more than a 1 in 100-year rainfall event are managed in exceedance routes that avoid risk to people and property both on and off site.

11. Surface Water Run-Off Destination

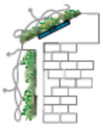
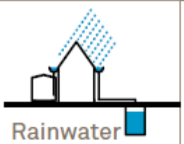
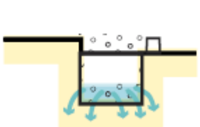
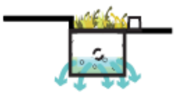
The destination of the surface water run-off from the post development site has been assessed against the prioritisation set by the Approved Document H (2010). The feasibility of the surface water run-off to the priority receptors are as follows:

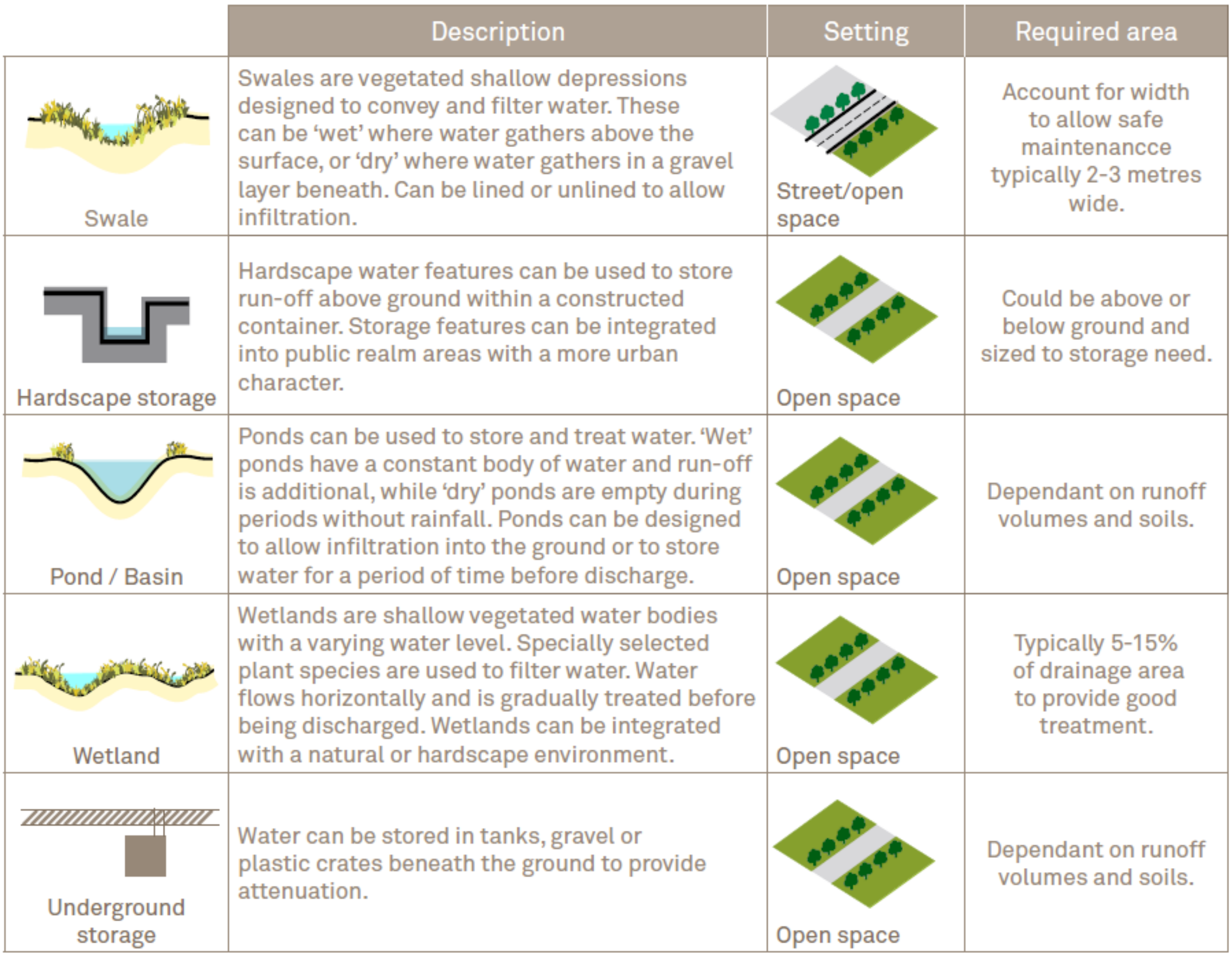
Run-Off Destination	**Feasible**	**Description**
Discharge to Ground	No	Based on the BGS data, it is deemed that the ground at the development site will have ground that predominantly consists of clay. Clay has an exceptionally low / no infiltration value, and therefore based on the soil conditions, discharge to ground is not feasible. Also, due to the nature of the development, where the proposed basement for the building covers the entire development area, it is deemed that soakaways or any infiltration structures will not be feasible. This is due to soakaways / infiltration structures to be a minimum 5m from boundaries and structures which cannot be achieved.
Discharge to Surface Water Body	No	There are no know waterbodies near the development site, and therefore discharge to a waterbody is not a feasible destination.
Discharge to Surface Water Sewer	**Yes**	There is a 225mm diameter surface water sewer within Tavistock Road (south of site). Due to the nature of the existing site (commercial building and external hard-standing areas), it is assumed that the surface water run-off from the pre-development site discharged to this sewer.
Discharge to Highway Drain or Other	No	There are no know highway drains near the development site, and therefore discharge to a highway drain is not a feasible destination.
Discharge to Combined Water Sewer	No	There are no know combined water sewers near the development site, and therefore discharge to a combined sewer is not a feasible destination.

12. SuDS Feasibility

To reduce the surface water run-off to the greenfield rate, SuDS methods are to be introduced to the post development design.

SuDS methods as per the Sustainable Drainage System (SuDS) hierarchy, and the Non-Statutory Technical Standards for Sustainable Drainage Systems – March 2015, that can be used are detailed below:

	Description	Setting	Required area
 Green roofs	A planted soil layer is constructed on the roof of a building to create a living surface. Water is stored in the soil layer and absorbed by vegetation.	 Building	Building integrated.
 Rainwater harvesting	Rainwater is collected from the roof of a building or from other paved surfaces and stored in an overground or underground tank for treatment and reuse locally. Water could be used for toilet flushing and irrigation.	 Building	Water storage (underground or above ground).
 Soakaway	A soakaway is designed to allow water to quickly soak into permeable layers of soil. Constructed like a dry well, an underground pit is dug filled with gravel or rubble. Water can be piped to a soakaway where it will be stored and allowed to gradually seep into the ground.	 Open space	Dependant on runoff volumes and soils.
 Filter Strip	Filter strips are grassed or planted areas that runoff is allowed to run across to promote infiltration and cleansing.	 Open space	Minimum length 5 metres.
Permeable paving	Paving which allows water to soak through. Can be in the form of paving blocks with gaps between solid blocks or porous paving where water filters through the block itself. Water can be stored in the sub-base beneath or allowed to infiltrate into ground below.	 Street/open space	Can typically drain double its area.
 Bioretention area	A vegetated area with gravel and sand layers below designed to channel, filter and cleanse water vertically. Water can infiltrate into the ground below or drain to a perforated pipe and be conveyed elsewhere. Bioretention systems can be integrated with tree-pits or gardens.	 Street/open space	Typically surface area is 5-10% of drained area with storage below.



	Description	Setting	Required area
Swale	Swales are vegetated shallow depressions designed to convey and filter water. These can be 'wet' where water gathers above the surface, or 'dry' where water gathers in a gravel layer beneath. Can be lined or unlined to allow infiltration.	Street/open space	Account for width to allow safe maintenancce typically 2-3 metres wide.
Hardscape storage	Hardscape water features can be used to store run-off above ground within a constructed container. Storage features can be integrated into public realm areas with a more urban character.	Open space	Could be above or below ground and sized to storage need.
Pond / Basin	Ponds can be used to store and treat water. 'Wet' ponds have a constant body of water and run-off is additional, while 'dry' ponds are empty during periods without rainfall. Ponds can be designed to allow infiltration into the ground or to store water for a period of time before discharge.	Open space	Dependant on runoff volumes and soils.
Wetland	Wetlands are shallow vegetated water bodies with a varying water level. Specially selected plant species are used to filter water. Water flows horizontally and is gradually treated before being discharged. Wetlands can be integrated with a natural or hardscape environment.	Open space	Typically 5-15% of drainage area to provide good treatment.
Underground storage	Water can be stored in tanks, gravel or plastic crates beneath the ground to provide attenuation.	Open space	Dependant on runoff volumes and soils.

The feasibility of the above SuDS methods for the post developed site are summarised in the table below:

SuDS Method	**Feasible Use**	**Description**
Blu-Roof Systems	**Yes**	It is proposed to have a blu-roof system to restrict and attenuate the surface water run-off at the ground floor, amenity, and roof level, within the system areas. Details of the typical blu-roof system to be used can be found in the appendices.
Rainwater Harvesting	**Potential**	In accordance with BS8515:2009 + A1:2013, the annual demand of the residential unit is likely to be greater than the annual rainwater yield. Therefore, the use of rainwater harvesting for use within the units is not a feasible SuDS method. However, water butts could be installed at amenity level rainwater pipe locations, where the water will be stored and used for future irrigation, of the above ground landscape areas.
Soakaway	No	As stated in the previous sections. Based on the BGS data, it is deemed that the ground at the development site will have ground that predominantly consists of clay. Clay has a very low / no infiltration value, and therefore based on the soil conditions, soakaways are not feasible.

		Also, due to the nature of the development, where the proposed basement for the building covers the entire development area, it is deemed that soakaways or any infiltration structures will not be feasible. This is due to soakaways / infiltration structures to be a minimum 5m from boundaries and structures which cannot be achieved.
Filter Strips	No	As the proposed building covers most of the development area, and the external areas are paved, filter strips will not be a feasible SuDS method.
Permeable Paving	**Yes**	There is potential to install permeable paving for the external areas around the proposed building. The permeable paving system will NOT be used as a soakaway due to unsuitable ground conditions, but will be used to attenuate the restricted surface water run-off. Surface water will percolate through the paving and to a 250mm deep sub-base consisting of 20mm no fines aggregate. The water from the sub-base will then be conveyed via a perforated pipe to the main below ground drainage network.
Swale	No	As the proposed building covers most of the development area, and the external areas are paved, swales will not be a feasible SuDS method.
Hardscape Storage	No	As the proposed building covers most of the development area, and the external areas are paved, hardscape storage will not be a feasible SuDS method.
Pond / Basin	No	As the proposed building covers most of the development area, and the external areas are paved, ponds / basins will not be a feasible SuDS method.
Underground Storage	**Yes**	The surface water run-off from the development site will be restricted to a peak rate of 1.10 l/s as agreed with Thames Water. Therefore, there will be a requirement to have underground storage for storm events up to 1 in 30-year; and to suitable sized so that the volume of water during the 1 in 100-year storm event is kept a minimum at surface level, where it can be contained on site.

13. Development Greenfield Run-Off Rate and Volumes

To minimise the surface water run-off from the new development areas of the site, it is preferred that the post development surface water run-off be restricted to the equivalent greenfield run-off rate and volumes.

13.1. Greenfield Run-Off Rate

The Flood Estimation Handbook (FEH) is often used for the calculation of the greenfield run-off rate, however, relevant documents state that to calculate the greenfield run-off rates on small catchments less than 25km², the IH 124 QBAR equation (and the equation for the instantaneous time to peak for the unit hydrograph approach) is to be used.

The IH method is based on the Flood Studies Report (FSR) approach and is developed for use on catchments less than 25km². It yields the Mean Annual Maximum Flood (QBAR). This reference also recommends the use Ciria C753 Table 24.2 to generate Growth Factors. These are used to convert QBAR to different return periods for different regions in the UK.

The input variables to establish QBAR are:

Return Period (years)	Results based on a range of return periods and the specified RP;
Area	Catchment Area (ha) which is adjusted to km2 for use in the equation;
SAAR	Average annual rainfall in mm (1941-1970) from FSR figure II.3.1;
Soil	Procedure Volume 3. Soil classes 1 to 5 have Soil Index values of 0.15, 0.3, 0.4, 0.45 and 0.5 respectively;
Urban	Proportion of area urbanised expressed as a decimal;
Region Number	Region number of the catchment based on FSR Figure I.2.4.

QBAR(l/s)

The output variables to establish QBAR are calculated using the following formula (equation yields m³/s):

$$\mathbf{QBAR = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}}$$

The IH 124 Variables (taken from FSR) that are specific to this site are as follows:

Area	=	50.00 ha (required area for calculation)
SAAR	=	600
Soil	=	0.300
Urban Factor	=	0.75 (actual 1.00, but 0.75 maximum for equation)
Region Number	=	6

The calculations in Appendix F, show the rate for 50.00ha is 282.8 l/s, but is to be reduced to reflect the surface water catchment area (0.068 ha) of the development site. Therefore, the QBAR (greenfield run-off) for development area has been calculated to be:

QBAR = **0.38 l/s (5.66 l/s/ha)**

Ciria C753 Table 24.2 identifies the growth factors for each of the storm events, based on the known QBAR figure. The growth factors from the table vary depending on the site location. In this case hydrometric area (Region Number) is 6.

Based on the figures shown in the table, the growth factors, and the existing greenfield run-off rates for each of the storm events for the development areas of the site are as follows:

Storm Event	QBAR	Growth Factor (C753 Table 24.2)	Greenfield Run-off Rate
Q_1	0.38 l/s	0.85	**0.32 l/s**
Q_{30}	0.38 l/s	2.40	**0.91 l/s**
Q_{100}	0.38 l/s	3.19	**1.21 l/s**

13.2. Greenfield Run-Off Volume

The greenfield run-off volume for the 100-year, 6-hour storm event has also been calculated in the MicroDrainage software using the data from the Flood Estimation Handbook (FEH), with the results shown in Appendix F.

The FEH data and variables used to calculate the greenfield run-off volume at the development site locations are as follows:

Site Location	=	GB 505750 180150 TQ 05750 80150
C (1km)	=	-0.025
D1 (1km)	=	0.318
D2(1km)	=	0.297
D3 (1km)	=	0.226
E (1km)	=	0.304
F (1km)	=	2.571
Areal Reduction Factor	=	1.000
Area	=	5482.750 ha
SAAR	=	661
CWI	=	97.980
SPR Host	=	48.460
URBTEXT	=	0.50 (actual 1.00, but 0.5 maximum for calculation)

Based on these variables, and the calculation results provided by the WinDes computer software (Appendix F), the greenfield run-off volume for the overall catchment area at the site location is:

$Q_{100\ (6\text{-Hour})}$

= 2,265,964.658m³

This figure is for the catchment area of 5482.750 ha, and is to be reduced to reflect the surface water catchment area of the development site which is 0.068 ha. Therefore, the greenfield run-off volume for the development site area has been calculated to be:

$Q_{100\ (6\text{-Hour})}$ = **28.10m³ (413.29m³/ha)**

14. Pre-Development Surface Water Run-Off Rates and Volume

The pre-development surface water run-off rates and volumes are to be calculated, so that the post development rates, and volume can be compared to them.

The calculations to determine the pre-development surface water run-off rates and volume are based on the pre-development surface water run-off area of 0.068 ha, and the data given by the Flood Estimation Handbook (FEH).

The pre-development surface water run-off rates and volume have also been simulated in the MicroDrainage software (Appendix G), where the variables used (FEH data) to calculate the surface water run-off rates and volumes are as follows:

Pre-Development Area	=	0.068 ha
Site Location	=	GB 505750 180150 TQ 05750 80150
C (1km)	=	-0.025
D1 (1km)	=	0.318
D2(1km)	=	0.297
D3 (1km)	=	0.226
E (1km)	=	0.304
F (1km)	=	2.571

Based on the above variables and computer software results, the pre-development surface water run-off rates will be as follows:

Q_1	=	9.50 l/s (15-minute storm duration*)
Q_{30}	=	30.70 l/s (15-minute storm duration*)
Q_{100}	=	44.10 l/s (15-minute storm duration*)

*The critical storm duration for each of the return period is 15 minutes.

Based on the above variables for the surface water run-off from the pre-development impermeable area, it has been calculated that the pre-development surface water discharge volume for the pre-development site (at 6-hour storm events) are as follows:

Q_{100}	=	38.90m³ (360-minute storm duration)

15. Surface Water Management Details and Calculations

15.1. Climate Change

The NPPF makes it a planning requirement to account for climate change in the proposed design. The recommended allowances are taken from the Environment Agency guidance (Table 2) summarised in Table 4 below.

Applies across all of England	Total change anticipated for the 2020's	Total change anticipated for the 2050's	Total change anticipated for the 2080's
Upper End	10%	20%	**40%**
Central	5%	10%	20%

The baseline year is 1961 to 1990. It is anticipated the life span of the proposed residential building will be approximately 80 years, and therefore will fall at least into the 2080's and will have rainfall intensity increase of 40%.

This increase in rainfall is to be taken into consideration for the surface water management of the proposed development site, to ensure that the probability of flooding remains low.

15.2. Surface Water Network Calculations

The FEH data and variables used to calculate the required below ground attenuation network and attenuation volumes at the development site are as follows:

SW Management Area = 0.068 ha

Site Location = GB 505750 180150 TQ 05750 80150

C (1km) = -0.025

D1 (1km) = 0.318

D2(1km) = 0.297

D3 (1km) = 0.226

E (1km) = 0.304

F (1km) = 2.571

15.3. Surface Water Drainage Management and Equivalent SW Run-Off Areas

As shown on the surface water management drawings in Appendix H, the main below ground surface water drainage network is to be within the loading area of the building, and is to consist 1200mm diameter manholes; 150mm and 225mm diameter pipes; a below ground attenuation tank; a 930mm diameter pollutant control chamber; and a 1200mm diameter flow control chamber.

The above ground surface water drainage will consist of blu-roof systems at first, sixth, seventh floors and the roof level, which is formed of a shallow 'crate storage' system being laid below the landscaping and decking areas. The surface water from these areas will be restricted at source by a vortex at roof level, and the attenuated water will be stored within the crates below the decking and landscape areas (refer to Appendix H and I for details).

The below ground drainage network will take the restricted surface water run-off from the blu-roof areas, the permeable paving system, hard-standing external areas via channel drains, and 'normal' roof areas via rainwater pipes.

The network will flow towards Tavistock Road, with the surface water passing through the attenuation tank, flow control and pollutant control chamber, prior to connection / discharge to the existing 225mm diameter surface water sewer.

The surface water run-off from the green / blu-roof areas for each floor will be as follows:

First Floor	-	0.008 ha	-	0.2 l/s
Sixth Floor	-	0.002 ha	-	0.1 l/s
Roof Level	-	0.020 ha	-	0.2 l/s
Total Above Ground Discharge			**-**	**0.60 l/s**

The average storm intensity for the site area is 0.014 l/s/m², and therefore, a discharge rate of 0.6 l/s is the equivalent of a 'normal' roof area of **40m²** (reduction from 300m² to 40m²).

The equivalent / reduced area of 40m², and the external ground floor (including permeable paving) and 'normal' roof area (not green / blu-roof area) of 380m², equates to a total SW catchment area of **420m² / 0.042 ha**, which is to be used to calculate the required attenuation volumes and discharge rates for the below ground drainage networks.

15.4. Surface Water Run-Off Rate

For the surface water run-off from the entire development site to be at the greenfield run-off rate, the impermeable areas of the site are to be restricted to 0.59 l/s for the 1 in 1-year storm event; 1.16 l/s for the 1 in 30-year storm event, and 1.41 l/s for the 1 in 100-year storm event including 40% rainfall intensity increase (climate change).

For the surface water run-off from the entire development site to be a betterment of the pre-development rates, the impermeable areas of the site are to be restricted to 1.90 l/s for the 1 in 1-year storm event; 5.90 l/s for the 1 in 30-year storm event, and 8.70 l/s for the 1 in 100-year storm event including 40% rainfall intensity increase (climate change).

Thames Water have stated that the maximum surface water discharge rate from the site to their 225mm diameter sewer is to be 1.1 l/s. Taking the guidance from Thames Water, the calculated greenfield rates, and the limited space for attenuation (car park area only) into consideration, the feasible surface water run-off rate from the site is to be **1.10 l/s**.

A summary of the post development surface water run-off rates compared to the greenfield and pre-development rates are as follows:

Greenfield Rate to Post Development Rate

Strom	**-**	**Greenfield**	**-**	**Post Dev**	**-**	**Difference**
Q_1	-	0.59 l/s	-	1.10 l/s	-	86% Increase
Q_{30}	-	1.16 l/s	-	1.10 l/s	-	5% Betterment
Q_{100}	-	1.41 l/s	-	1.10 l/s	-	22% Betterment

Pre-Development Rate to Post Development Rate

Strom	**-**	**Pre-Dev**	**-**	**Post Dev**	**-**	**Difference**
Q_1	-	1.90 l/s	-	1.10 l/s	-	42% Betterment
Q_{30}	-	5.90 l/s	`-	1.10 l/s	-	81% Betterment
Q_{100}	-	8.70 l/s	-	1.10 l/s	-	87% Betterment

Although the surface water run-off rates are greater than the equivalent 1-year greenfield rates, the post development rates are a 5% to 22% betterment of the 30-year and 100-year greenfield rates respectively, are between 42% to 87% betterment of the pre-development run-off rates, and meet the Thames Water requirements. Therefore, the probability of flooding of the surface water sewer is reduced.

15.5. Surface Water Run-Off Volume

The surface water run-off volumes for the post development site have also been calculated for 1 in 100-Year the 6-hour duration (Inc. 40% RII) within the MicroDrainage WinDes software (Appendix J). The surface water run-off volume for the post development site is:

Q_{100} - 28.70m³

The surface water run-off volume for the post development site exceed the greenfield volume, but is a betterment of the pre-development run-off volume. A summary of the post development run-off volumes compared to the greenfield and pre-development volumes are as follows:

Greenfield Volume to Post Development Volume

Strom	-	Greenfield	-	Post Dev	-	Difference
Q_{100}	-	22.23m³	-	37.60m³	-	1.29 x Greenfield

Pre-Development Volume to Post Development Volume

Strom	-	Pre-Dev	-	Post Dev	-	Difference
Q_{100}	-	36.70m³	-	37.60m³	-	Equivalent

The 'Non-Statutory Technical Standards for Sustainable Drainage Systems – March 2015' states that '*the post development surface water run-off rate should not exceed the pre-development greenfield rate, but where this is not reasonably practical the surface water run-off volume must be discharged at a rate that does not adversely affect flood risk.'*

Although the surface water run-off volume from the post development site exceeds the greenfield volume, it is the equivalent to the pre-development run-off volume and is up to a 95% betterment of the pre-development rates. Therefore, surface water run-off volume will not adversely affect flood risk areas within or near the site.

15.6. Surface Water Attenuation Calculations

As the surface water run-off from the post development area of the site is been restricted at roof level, and below ground, there will be a requirement for roof level and below ground attenuation to prevent flooding.

Ciria SuDS Manual 2015, Paragraph 10.2.4 where it states that: *'Exceedance flows (i.e. flows more than those for which the system is designed) should be managed safely in above-ground space such that risks to people and property are acceptable'.*

And PPS25 Practice Guidance Paragraph 5.51 that previously stated that: *'For events with return-period more than 30 years, surface flooding of open spaces such as landscaped areas or car parks is acceptable for short periods, but the layout and landscaping of the site should aim to route water away from any vulnerable property, and avoid creating hazards to access and egress routes. No flooding of property should occur as a result of a one in 100-year storm event (including an appropriate allowance for climate change)'.*

First Floor Blu-Roof System

As detailed in the MicroDrainage calculations in Appendix I, and shown on the drainage layout drawing in Appendix H, it is proposed to have a 100mm deep crate to attenuate the surface water at first floor level, when restricting the area of 0.008 ha to 0.2 l/s. The volume of storage therefore within the blu-roof system will equate to **8.00m³**. The results show that the depth of water to up **67mm**.

Therefore, the depth of 100m will be acceptable to attenuate the restricted surface water for all storms up to and including the 100-year+ 40% climate change storm event.

Sixth Floor Blu-Roof System

As detailed in the MicroDrainage calculations in Appendix I, and shown on the drainage layout drawing in Appendix H, it is proposed to have a 100mm deep crate to attenuate the surface water at Sixth Floor, when restricting the area of 0.002 ha to 0.1 l/s. The volume of storage therefore within the blu-roof system will equate to **2.00m³**. The results show that the depth of water to up **65mm**. Therefore, the depth of 100m will be acceptable to attenuate the restricted surface water for all storms up to and including the 100-year+ 40% climate change storm event.

Roof Level Blu-Roof System

As detailed in the MicroDrainage calculations in Appendix I, and shown on the drainage layout drawing in Appendix H, it is proposed to have a 100mm deep crate to attenuate the surface water at Sixth Floor, when restricting the area of 0.020 ha to 0.3 l/s. The volume of storage therefore within the blu-roof system will equate to **20.00m³**. The results show that the depth of water to up **75mm**. Therefore, the depth of 100m will be acceptable to attenuate the restricted surface water for all storms up to and including the 100-year+ 40% climate change storm event.

Below Ground Tank System

Also, as detailed in the MicroDrainage calculations in Appendix H, and shown on the drainage layout drawing in Appendix J, it is proposed to have a cellular unit structure below the car park area to attenuate the restricted surface water. The attenuation tank (cellular units) will be 6.00m x 5.00m x 0.80m deep, which equates to a total volume of attenuation of **24.00m³**. The results show that there will be no flooding for all storms up to and including the 100-year + climate change event with tanks this size, and therefore are deemed to be acceptable.

15.7. Surface Water Drain Down Time

The MicroDrainage calculations in Appendix I and J also show the drain down times for the above and below ground drainage systems / networks.

First Floor Blu-Roof System

The calculations in Appendix I show the half drain time from the First Floor blu-roof system (100-year + 40% climate change event) is 268-minutes is deemed to be acceptable (half drain time below 24-hours / 1440-minutes).

Sixth Floor Blu-Roof System

The calculations in Appendix I show the half drain time from the Sixth Floor blu-roof system (100-year + 40% climate change event) is 252-minutes is deemed to be acceptable (half drain time below 24-hours / 1440-minutes).

Roof Level Blu-Roof System

The calculations in Appendix I show the half drain time from the Roof Level blu-roof system (100-year + 40% climate change event) is 448-minutes is deemed to be acceptable (half drain time below 24-hours / 1440-minutes).

Below Ground Tank System

The calculations in Appendix J show the half drain time from the cellular units / attenuation tank (100-year + 40% climate change event) is 212-minutes, which is deemed to be acceptable (half drain time below 24-hours / 1440-minutes).

16. Maintenance Requirements

The extent of the drainage network and SuDS features for the development site are shown on the surface water management layouts in Appendix H.

Details of the maintenance required, and the parties to carry out the maintenance of all drainage aspects, to ensure that the SuDS methods are working affectively, and subsequently reducing the risk of flooding on the site are as follows:

The management and maintenance of the surface water blu-roof systems, permeable paving, cellular unit and below ground drainage will be by contractors appointed by the owners / occupiers of the new building, where payments of the works will form part of the property deeds and / or rental agreements. Details of the required management and maintenance work to be carried out will be as follows:

16.1. Below Ground Drainage Network and Cellular Units

Operation	Frequency
Inspect and identify any areas that are not operating correctly, if required, take remedial actions	Monthly for 3 months, then six monthlies
Debris removal from network (where may cause risk performance)	Monthly
Where rainfall into network from above, check surface or filter for blockage or silt, algae, or other matter by jetting	As required, but at least twice a year
Remove sediment from upstream surface water network by rodding.	Annually or as required
Repair/check all inlets and outlets	As required
Inspect/check all inlets and outlets, to ensure that they are in good condition and operating as designed	Annually and after large storms

16.2. Permeable Paving

Operation	Frequency
Inspect and identify any areas that are not operating correctly, if required, take remedial actions	Monthly for 3 months, then six monthlies
Debris removal from catchment on surface of paving (where may cause risk performance)	Monthly
Where rainfall infiltration into permeable paving, check surface for blockage or silt, algae, or other matter by jetting	As required, but at least twice a year

16.3. Green / Blu-Roof System

Operation	Frequency
Inspect and identify any areas that are not operating correctly, if required, take remedial actions	Monthly for 3 months, then six monthlies
Debris removal from on surface of green roof (where may cause risk performance)	Monthly
Where rainfall infiltration into green roof grass structure, lengths and ensure working effectively.	As required, but at least twice a year

16.4. Linked and Further Maintenance

The maintenance of the drainage network and SuDS features are to be linked with the wider site maintenance plan for the industrial estate.

16.5. Maintenance Activities

A log of all maintenance activities is to be kept and made available to the local planning authority (LPA) and / or the Lead Local Flood Authority (LLFA) on request.

17. Surface Water Design Exceedance

In the event of network exceedance (greater than 100-year + 40% CC), surface water to flood the external areas, prior to discharge onto Tavistock Road to the south of the site.

Flood water to discharges onto Tavistock Road before any flooding to any areas of the proposed building. Flood water to be contained within Tavistock Road, and surrounding roads by kerb up stands, and will not increase flood risk to neighbouring properties.

18. Water Quality / Pollutants

The source of any potential pollutants will be from the surface water run-off from the building roof areas and external paved areas. The blu-roof system will act as a pollutant control for surface water run-off from amenity / roof areas, and the permeable paving and grassed areas will reduce the pollutants at ground floor level.

Therefore, the based on the SuDS methods used, water quality will increase from the pre-development site.

19. Development Management and Construction Phase

Any existing drainage within the site, is to be maintained during the construction of the new buildings and external hard standing areas. The green and blu-roof systems at each floor will be built to restrict and attenuate the surface water during each stage / floor of the building. This will ensure that the surface water discharge from any phase of the network will discharge to ground.

20. Conclusion / Summary

20.1. Existing Flood Risk

An assessment of all current sources of flooding to the development site has found that the probability of flooding from all potential sources is low.

20.2. SuDS Principles

All feasible SuDS methods, and surface water discharge destination have been assessed, with the feasible SuDS methods being a blu-roof systems, permeable paving system, and cellular units; with the surface water destination being to a surface water sewer.

20.3. Peak Flow Control

The surface water run-off discharge from all the surface water management areas will be restricted to a total of 1.10 l/s for all storms up to and including the 100-year storm event (including climate change). The surface water run-off rates from the post development site exceeds the 1 in 1-year greenfield rate, but is a betterment of the 30-year greenfield, 100-year greenfield and pre-development rates. This rates also meets the requirement of Thames Water.

20.4. Volume Control

The total surface water run-off volume from all the surface water management areas will be restricted to 37.60m³, which greater than greenfield run-off, but the equivalent of the pre-development run-off volume for the equivalent 100-year, 6-hour storm event. However, as the post development surface water run-off rate for the 100-year storm event is less than the greenfield rate, the development will not adversely increase the risk of flooding.

20.5. Flood Risk within the Development

The above ground blu-roof and below ground cellular units will be suitably sized to prevent flooding for all storms up to and including the 100-year + 40% climate change event, when the surface water is to be restricted to the required rates. Therefore, all surface water will be contained within the development site, without increasing the probability of flooding to the proposed building or areas near the development site.

20.6. Construction

All existing drainage and sewers within the site that serves areas outside the site boundary are to be maintained and kept live throughout and post construction phase. The attenuation tank and flow control are to be the first items of drainage to be built to ensure the restricted surface water run-off rates are maintained.

20.7. Maintenance

The management and maintenance of the drainage and SuDS features will be by contractors appointed by the owners / occupiers of the new commercial and residential building, where payments of the works will form part of the property deeds and / or rental agreements.

20.8. Water Quality

The source of any potential pollutants will be from the surface water run-off from the building amenity, roof, and external paved areas. The green / blu-roof systems roof will act as a pollutant control for surface water run-off from amenity and roof areas, and the permeable paving system will reduce the pollutants discharging from the external areas into the main network.

Therefore, based on the SuDS methods used, water quality will increase from the pre-development site.