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**Residential Development at
Lawrence Street, Bury**

Title_

**Flood Risk Assessment and
Surface Water Management Report**

Project No_

1028

Date_

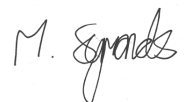
March 2024

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Author: Mark Symonds Date Issue: 26th March 2024 Sign:



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1. Introduction

Flo Consult UK Ltd have prepared this flood risk assessment and surface water management report, on behalf of Ecoscape UK Ltd, in support of an application for a residential development Lawrence Street, Bury, BL9 9US (hereafter referred to as 'the Site').

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)

And local policies including:

- Bury Council Preliminary Flood Risk Assessment (May 2011);
- Bury, Rochdale and Oldham Strategic Flood Risk Assessment (November 2009);
- Greater Manchester Surface Water Management Plan (January 2012);
- Bury Council Local Plan Topic Paper 6 – Flood Risk (October 2018).

Bury Metropolitan Borough Council (BMBC), acting as the lead local flood authority (LLFA), need to be satisfied that the design and drainage principles of the development will address the risk of flooding to the Site; will ensure that the drainage is maintained to prevent flooding; and in turn not to increase the risk of flooding to neighbouring land and property.

This flood risk statement and surface water management report has therefore been prepared to identify and evaluate the various possible sources of flood risk to which the Site might be subjected to; to identify any mitigation, protection or compensation measures deemed necessary or feasible; and to manage the surface water so it is 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 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 (FWMA) received royal assent in April 2010, aiming to create a simpler and more effective means of managing flood risk and coastal erosion. The FWMA incorporates and implements some of the recommendations from the Pitt Review (2008), following the severe flooding that affected a large area of the UK in 2007.

The FWMA also places several new duties and responsibilities on LLFAs regarding the management of local flood risk, to:

- Develop, maintain, apply, and monitor a Local Flood Risk Management Strategy.
- Approve, adopt, and maintain Sustainable Drainage Systems (SuDS) (yet to be implemented).
- Establish and maintain a flood risk Asset Register.
- Incidents of flooding (where appropriate) and publish the findings in a report.
- Ensure delivery of effective and joined up management of flood risk.

3. Site Setting and Description

3.1. Site Location

The Site is in a residential and commercial area of Bury, is approximately 3 km south of Bury town centre, approximately 2 km north of Whitefield tram station, as shown on the site location plan in Appendix A, is bound by Chelsea Street to the east, Lawrence Street to the south, a car dealership leading to Bury New Road to the west, parking areas leading to Leyton Drive to the north.

The nearest postcode to the Site is BL9 9US, with the co-ordinates of the centre of the Site being: Easting: 380720, Northing: 407985.

3.2. Existing Site and Topography

As detailed on the existing site plan in Appendix B, the Site, in a pre-development state, consists of a single storey commercial building (currently Travis Perkins), with external hard-standing (concrete) yard areas to the north and south. As all areas have been developed, it is deemed to be a '**Brownfield Site**'.

In terms topography, most of the Site is covered by the building, the levels are relatively flat, with a slight grade / fall in a southerly direction towards Lawrence Street.

3.3. Proposed Development

The proposed site plan is shown in Appendix C, with a full description of the Site being provided by the Architect. In brief, and relation to this report, the Site, in a post development state, will consist of the demolition of the commercial building, and the erection of a residential building in its place.

The residential building covers most of the Site with an undercroft car park (accessed from Lawrence Street) at ground floor, external areas with a bike and bin store to the north, and small areas of soft-landscaping to the south, and grassed / planning areas at roof level (terraces).

3.4. Ground Conditions

The ground conditions can be determined by the British Geological Survey (BGS) website, where it shows the Site to have superficial deposits of Till, Devensian (Diamicton), over bedrock consists of Pennine Middle Coal Measures Formation (mudstone).

The BGS website also have public borehole log data 150m west the Site (Crossfield Street), and in the same strata. The borehole logs, in Appendix D, show the ground to predominantly consist of clay.

3.5. Waterbodies

There are no known waterbodies in the direct vicinity of the Site, with the nearest being the River Roch approximately 150m to the east, and the River Irwell approximately 500m to the north-west.

3.6. Existing Drainage / Sewers

The United Utilities asset plan in Appendix E shows 225mm combined water Chelsea Street flowing a southerly direction, which connects to a 225mm turning into a 300mm combined water sewer in Lawrence Street.

A full existing drainage survey at the Site hasn't taken place yet. However, as the Site in a pre-development state consists of a single building with rainwater pipes, and external hard-standing areas, it is believed that the surface water run-off from all the Site are currently discharges to the combined water sewer system in Chelsea Street and Lawrence Street.

3.7. Development and Surface Water Management Areas

The Site boundary area is approximately 1080m² / **0.108 ha**.

Surface water run-off from all the Site, in a predevelopment state, discharges to sewer network, and therefore for the purpose of the report, the Site has a pre-development surface water run-off area of **0.108 ha**, and an urban factor of **1.0**.

The proposed residential building and external areas to the north (including bin and bike store) equate to 1040m² / 0.104 ha, with the soft-landscaping areas to the south equating to 40m² / 0.004 ha.

Surface water run-off from the proposed residential building and external areas to the north will discharge to below ground drainage network (via SuDS), with the surface water run-off from the soft-landing areas discharging off the Site at a natural / greenfield rate. Therefore, the surface water management area for the Site is **0.104 ha**.

4. Flood Risk Assessment - 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 is exceeded, or if there is, an infrastructure failure.

5. Flood Risk Assessment – Probability of Flooding

5.1. Fluvial Flooding

The fluvial flood zone map (Risk of Flooding from Rivers and Sea) on the EA website (see Figure 1 below) identifies that the all the Site lies within Flood Zone 1, which has a low probability of flooding (less than 1 in 1000 annual probability of river flooding in any year).

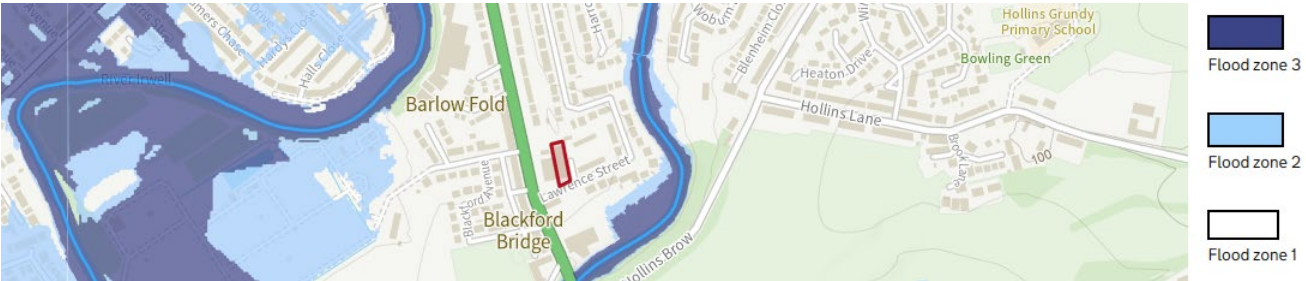


Figure 1 – EA Fluvial Flood Zone Map

The EA fluvial flood probability map shown in Figure 2, indicates the Site has a better than very low probability of fluvial / coastal flooding.

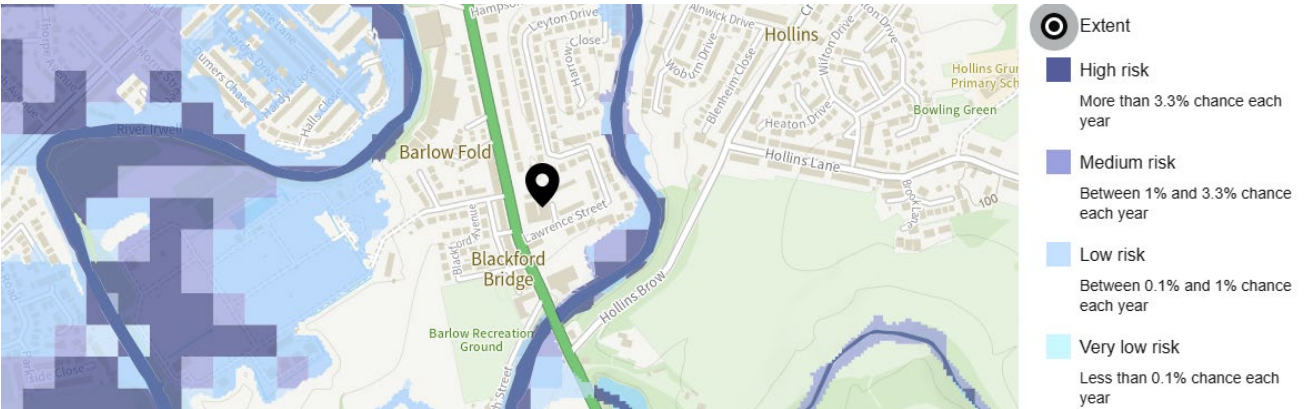


Figure 2 – EA Fluvial Flood Probability Map

Therefore, based on the flood map data, the probability of fluvial flooding is deemed to be low.

5.2. Pluvial Flooding

The EA pluvial flood probability map shown in Figure 3, indicates the Site has a very low probability of pluvial flooding.

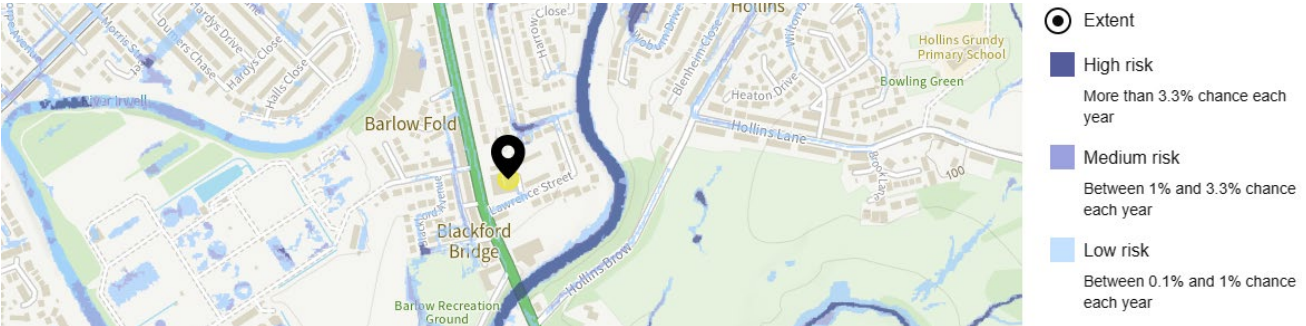


Figure 3 – EA Pluvial Flood Probability Map

Therefore, based on the flood map, the probability of pluvial flooding is deemed to be low.

5.3. Ground Water Flooding

There has been no known history of ground water flooding at the Site location, with the BGS public borehole logs showing the ground to predominantly consist of clay with groundwater strikes to depths of up to 6.20m bgl.

Based on this assessment, the risk of groundwater flooding at the Site is deemed to be low.

5.4. Flooding from Sewers

The nearest public sewer networks are the 225mm combined water Chelsea Street which connects to a 225mm turning into a 300mm combined water sewer in Lawrence Street.

There has been no known history of flooding from this sewer, and if flooding were to occur the flood water would not flow towards the Site (building ground floor entrance 150mm higher than Chelsea Street and Lawrence Street), with the flood water being contained within the road due to the presence of upstand kerbs and the road gradient (flood water flowing in channels).

Therefore, based on this assessment, the probability of flooding from sewers is deemed to be low.

5.5. Canals, Reservoirs and Other Artificial Sources

The EA extent of flooding from reservoirs map (see Figure 4) identifies that the Site is not in an area of reservoir flooding when the river levels are normal, but in an area of reservoir flooding when there is also flooding from rivers.

The Site is not in an area of river flooding. Also, reservoirs are a classed as main infrastructure assets, 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 also deemed to be low.

There are no other canals or artificial sources near to the Site, and therefore the probability of flooding from other artificial sources is also deemed to be low.

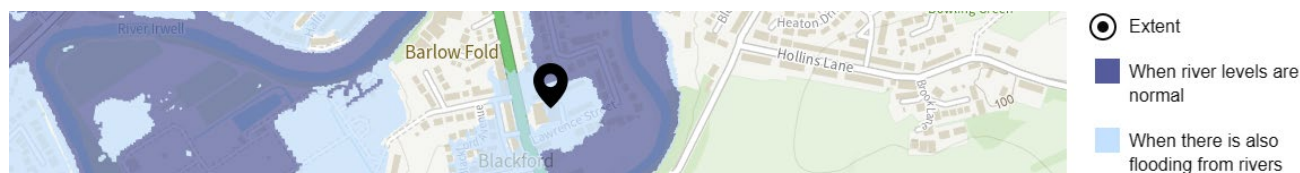


Figure 4 – EA Extents of Flooding from Reservoirs Map

6. Flood Risk and Vulnerability

The NPPG Paragraphs 077 to 078 set out the flood risk for the Site by assessing the flood zones, flood risk vulnerability classification, and flood risk vulnerability and flood zone 'compatibility'.

6.1. Flood Zones

NPPG Paragraph 077, Table 1 indicates that the flood zones are:

Flood Zones	
Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 0.1% annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map for Planning – all land outside Zones 2, 3a and 3b)
Zone 2 Medium Probability	Land having between a 1% and 0.1% annual probability of river flooding; or land having between a 0.5% and 0.1% 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)
Flood Zone 3b The Functional Flood Plain	This zone comprises land where water from rivers or the sea has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise: • land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively; or • land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding). 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 Site to be in Flood Zone 1, which has a low probability of flooding.

6.2. Flood Risk Vulnerability Classification

NPPG Paragraph 077, refers to NPPF Annex 3 where it states the flood risk vulnerability classifications as:

Flood Risk Vulnerability Classification
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 centres; 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; Ministry of Defence installations; Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation (excluding sleeping accommodation); Lifeguard and coastguard stations; Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms; Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

This development is classed as 'More Vulnerable' as Site is for will be used for residential units.

6.3. Flood Risk Vulnerability and Flood Zone ‘Compatibility’

NPPG Paragraph 078 Table 2, gives guidance on flood risk vulnerability compared with flood zones, to determine the compatibility.

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	X	Exception Test required	✓	✓
Zone 3b*	* Exception Test required	X	X	X	✓*

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

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

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

The Site is classed as ‘More Vulnerable’, but as it is in Flood Zone 1, Table 2 of the NPPG states that the Site is appropriate for development, with no exception test required.

7. The Sequential Test

7.1. The Guidance

Paragraph 162 of the NPPF 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*’.

7.2. The Test

The Site has passed the sequential test as it is Flood Zone 1 and has a low probability of flooding from all other sources.

8. Surface Water Management Principles

The surface water for the development site is to be managed so that it adheres to the current regulations, and local authority requirements, as detailed in previous sections of this report.

8.1. 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.

8.2. 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).

8.3. 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.

8.4. Peak Surface Water Flow

DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems states:

‘S3 For developments which were previously developed, the peak runoff rate from the development to any drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100-year rainfall event must be as close as reasonably practicable to the greenfield runoff rate from the development for the same rainfall event, but should never exceed the rate of discharge from the development prior to redevelopment for that event’.

8.5. Volume Control

DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems states:

‘S5 Where reasonably practicable, for developments which have been previously developed, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100-year, 6-hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event, but should never exceed the runoff volume from the development site prior to redevelopment for that event.

S6 Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body in accordance with S5 above, the runoff volume must be discharged at a rate that does not adversely affect flood risk’.

8.6. Flood Risk

DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems states:

'S7 The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the site for a 1 in 30-year rainfall event.

S8 The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, 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.

S9 The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100-year rainfall event are managed in exceedance routes that minimise the risks to people and property'.

8.7. 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.

8.8. 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 100-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.

9. Surface Water Run-Off Destination

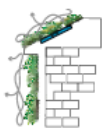
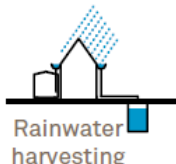
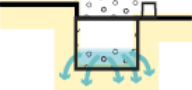
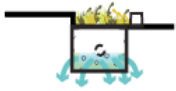
The destination of the surface water run-off from the Site, in a post development state, has been assessed against the prioritisation set by the Approved Document H (2010). The feasibility of the surface water run-off to the priority receptors are as follows:

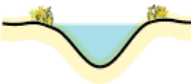
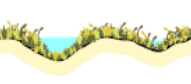
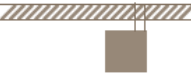
Run-Off Destination	Feasible / Required?	Description
Discharge to Ground	No	The BGS data identifies the ground at the Site to predominantly consist of clay. Clay is known to have exceptionally low or no infiltration value. Also, to adhere to Approved Document H, any soakaway needs to be at least 5m from a structure. Therefore, as the proposed the ground consists of clay, and the new residential buildings cover most of the Site, discharge to ground is unfeasible.
Discharge to Surface Water Body	No	There are no known surface waterbodies near the Site, and therefore this is not a feasible discharge destination.
Discharge to Surface Water Sewer	No	There are no known surface water sewers near the Site, and therefore this is not a feasible discharge destination.
Discharge to Highway Drain or Other	No	There are no known highway drains near the Site, and therefore this is not a feasible discharge destination.
Discharge to Combined Water Sewer	Yes	As the ground not suitable for infiltration, and there are no known waterbodies, surface water sewers or highway drains near the Site, the only alternative is to discharge the surface water to the existing 225mm combined water sewer network within Lawrence Street. This surface water discharge destination is believed to replicate the pre-development state.

10. SuDS Feasibility

To reduce the surface water run-off from the Site in a post development state, SuDS methods are to be introduced to the 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 maintenance 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
Living Roofs	Yes	It is proposed to have a garden and planting areas at the roof / terrace areas of the new building. The surface water from all the roof area can discharge to the rainwater pipes through the garden and planting areas and will therefore act as a living roof. The living roof will restrict and attenuate the surface water run-off, and will also act as a pollutant control while adding biodiversity to the Site. The surface water run-off from the roof discharging through the garden and planting equates to 900m² / 0.090 ha.
Rainwater Harvesting	Yes	In accordance with BS8515:2009 + A1:2013, the annual demand of the residential units is likely to be greater than the annual rainwater yield (relatively small area of roof compared to number of residential units). However, water butts could be installed at some rainwater pipe locations, at the terrace areas, where the water will be stored and used for future irrigation, of the above ground landscape areas.

Soakaway	No	The BGS data identifies the ground at the Site to predominantly consist of clay. Clay is known to have exceptionally low or no infiltration value. Also, to adhere to Approved Document H, any soakaway needs to be at least 5m from a structure. Therefore, as the proposed ground consists of clay, and the new residential buildings cover most of the Site, the use of soakaways is not feasible.
Filter Drains	No	There are no external areas where filter drain can be utilised (small landscape areas to the south for planting only). Therefore, due to limited areas within the site, filter strips will not be a feasible SuDS method
Permeable Paving	Yes	Permeable paving can be formed in the external areas to the north and south of the residential building / the Site. The surface water will not discharge to ground (for reasons stated above), but will be conveyed via a perforated pipe from the sub-base of the system, and into the main drainage network. A permeable paving will reduce the surface water run-off rate, attenuate restricted surface water run-off to prevent flooding, and will act as a pollutant control.
Swales / Ponds / Bioretention areas	No	There are no external areas where swales, ponds or bioretention areas can be utilised (small landscape areas to the south for planting only). Therefore, due to limited areas within the site, these will not be a feasible SuDS method
Hardscape Storage	No	As the new building covers most of the development area, with the external areas to the north and south being used for permeable paving, hardscape storage will not be a feasible SuDS method.
Underground Storage	Yes	The surface water run-off from the Site will be restricted. Therefore, there will be a requirement to have underground storage for storm events up to 1 in 30-year; and to suitably 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 the Site.

11. Development Greenfield Run-Off Rate and Volumes

To minimise the surface water run-off from the Site, it is preferred that the post development surface water run-off be restricted to the equivalent greenfield run-off rates and volume where possible.

11.1. 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):

QBAR = **0.00108 x AREA^{0.89} x SAAR^{1.17} x SOIL^{2.17}**

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

Area	=	50.00 ha
SAAR	=	1067
Soil	=	0.450
Urban Factor	=	0.75 (actual 1.00, but 0.75 highest for equation)
Region Number	=	10

Based on these variables, and the calculation results provided by the MicroDrainage computer software (Appendix F), the QBAR for a 50.00ha catchment area is:

QBAR = 846.9 l/s

This figure is for the catchment area of 50.00 ha, and is to be reduced to reflect the surface water management area (0.104 ha) of the Site. Therefore, the QBAR (greenfield run-off) for development area has been calculated to be:

QBAR = **1.76 l/s (16.94 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 10.

Based on the figures shown in the table, the growth factors, and the greenfield run-off rates for each of the storm events for the surface water management areas of the Site are as follows:

Storm Event	QBAR	Growth Factor (C753 Table 24.2)	Greenfield Run-off Rate
Q ₂	1.76 l/s	0.93	1.6 l/s
Q ₃₀	1.76 l/s	1.70	3.0 l/s
Q ₁₀₀	1.76 l/s	2.08	3.7 l/s

11.2. 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 FEH 2013, with the results shown in Appendix F.

The FEH 2013 data and variables used to calculate the greenfield run-off volume at the Site location area as follows:

Site Location	=	GB 380720 407985 SD 80720 07985
Area	=	0.104 ha
SAAR	=	1035
CWI	=	123.437
SPR Host	=	47.000
URBTEXT	=	0.50 (actual 1.00, but 0.50 highest for calculation)

Based on these calculation results (Appendix F), the greenfield run-off volume for the surface water management area of the Site is:

Q ₁₀₀ (6-Hour)	=	39.56m ³ (380.41m ³ /ha)
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12. Pre-Development Surface Water Run-Off Rates and Volume

The pre-development surface water run-off rates and volume are to be calculated, to establish the rate at which the surface water currently discharges off the Site, and for the post development to be a reduction of the rates, and not exceeding the volume to reduce the probability of flooding.

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 0.108 ha, the rainfall data given by the FEH 2013, and simulation / calculations in the MicroDrainage computer software (see Appendix G).

Based on the FEH 2013 data and computer software results, the pre-development surface water run-off rates are as follows:

Q ₂	=	14.7 l/s (15-minute storm duration)
Q ₃₀	=	36.6 l/s (15-minute storm duration)
Q ₁₀₀	=	48.3 l/s (15-minute storm duration)

Based on the FEH 2013 data and computer software results, the pre-development surface water run-off volume is as follows:

Q ₁₀₀	=	60.65m ³ (360-minute storm duration)
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13. Climate Change Allowance

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 summarised in Figure 5 below.

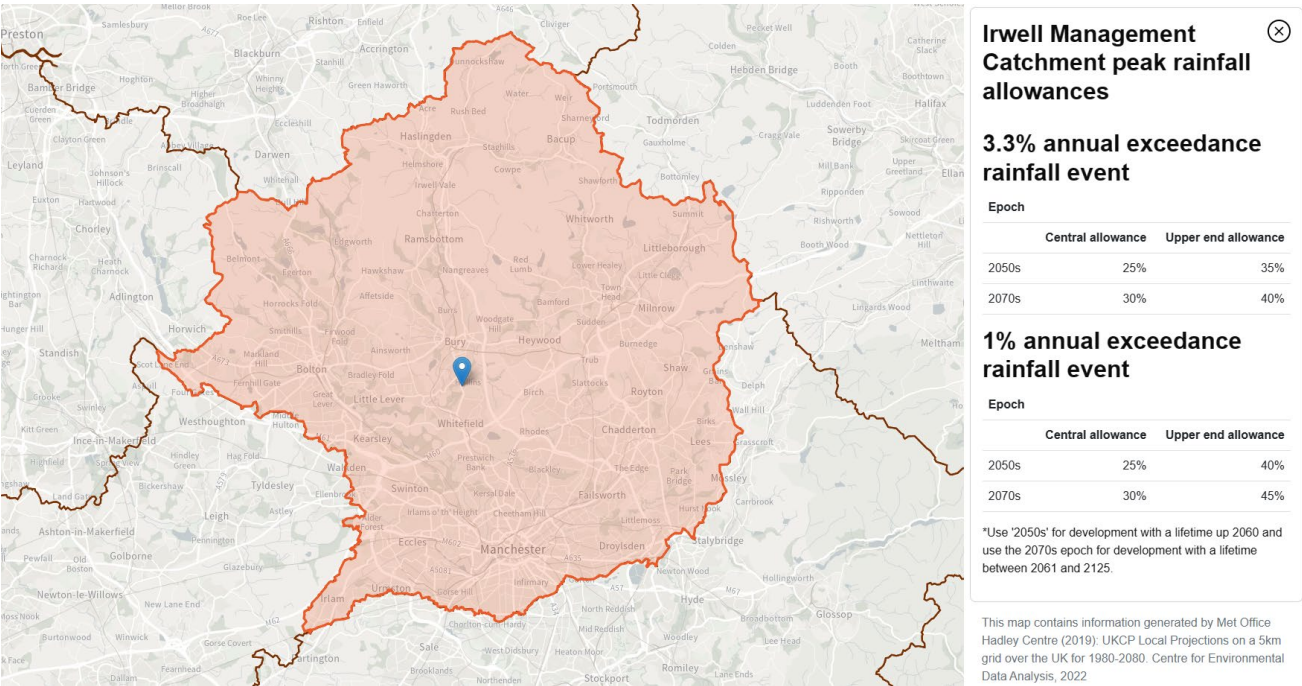


Figure 5 - DEFRA's Climate Change Allowances

The lifetime of the residential building is likely to be beyond 2061, and therefore the Epoch 2070's is to be used with Upper End Allowance. Therefore, the climate change allowance for the pre and post development surface water run-off will be **40%** and **45%** for the 30-year and 100-year storm respectively.

14. Drainage Networks and Surface Water Management Calculation

14.1. Surface Water Network Calculations

The calculations to determine the post development surface water run-off / management rates volume, are based on the post development surface water run-off area of 0.104 ha, and the rainfall data given by the FEH 2013.

14.2. Surface Water Drainage Network and Equivalent SW Run-Off Areas

As shown on the below ground drainage layout drawing in Appendix H, the main below ground surface water drainage network is to be within the undercroft car park (car park below residential building) and is to consist of 460mm diameter inspection and silt trap chamber, 150mm diameter solid and perforated pipes, permeable paving, a below ground attenuation tank, and a 1200mm diameter flow control chamber.

The surface water run-off from the roof areas will discharge to the main drainage network via water butts and living roofs (gardens and plating areas), and the surface water run-off from the external areas will discharge to the main drainage via permeable paving systems.

The surface water network (within the undercroft car park) will flow to the south of the Site, where it will pass through the flow control chamber, prior to discharge to the 225mm diameter combined water sewer in Lawrence Street. The restricted surface water will surcharge the drainage network and will be attenuated within the cellular units to prevent flooding.

14.3. Surface Water Run-Off Rates

For the surface water run-off from the entire development site to be at the greenfield run-off rate, they are to be restricted to 1.6 l/s for the 1 in 2-year storm event; 39.56 l/s for the 1 in 30-year storm event + 40% allowance, and 3.7 l/s for the 1 in 100-year storm event + 45% allowance.

For the surface water run-off to be a reduction of the pre-development rates, the post development run-off is to be restricted to at less than 14.7 l/s for the 1 in 2-year storm event; 36.6 l/s for the 1 in 30-year storm event + 40% allowance, and 48.3 l/s for the 1 in 100-year storm event + 45% allowance.

For the surface water run-off volume to be a betterment of, or equivalent to, the greenfield volume (100-year, 6-hour storm event), the surface water discharge rates need to be a maximum of 1.8 l/s ($39.56\text{m}^3 \times 1000 / 60 \times 60 \times 6$).

An assessment of the suitable flow control opening, and subsequent surface water discharge also needs to be assessed, where Ciria document C753 – The SuDS Manual states that: *‘the flow controls / orifice design should be designed so that it has simplicity on operation, and has resistance to clogging, blocking or mechanical failure’*.

The flow control (hydro-brake) therefore is to be a suitable diameter where the surface water run-off discharge from the development area of the site is as close to the greenfield rates as possible, at a rate where the run-off volume doesn't adversely affect flood risk, and sized where the likelihood of blockage and subsequent flooding is reduced.

For this development, and based on the guidance, the suitable / minimum size of the flow control opening is deemed to be 60mm. As shown in the below ground drainage calculation from the MicroDrainage computer software in Appendix I, if the hydro-brake opening is set at 60mm, a design head of 1.25m, and a design flow of 1.8 l/s (rate not to exceed greenfield volume), the maximum surface water run-off rates for each storm event will be as follows:

Storm	-	Rate	-	Critical Storm Event
Q ₂	-	1.4 l/s	-	240-minute winter storm duration
Q _{30 + 40%}	-	1.5 l/s	-	240-minute winter storm duration
Q _{100 + 45%}	-	1.8 l/s	-	240-minute winter storm duration

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

Greenfield Rate to Post Development Rate

Storm	-	QBAR	-	Post Dev	-	Difference
Q ₂	-	1.6 l/s	-	1.4 l/s	-	12% Reduction
Q _{30 + 40%}	-	3.0 l/s	-	1.5 l/s	-	50% Reduction
Q _{100 +}	-	3.7 l/s	-	1.8 l/s	-	51% Reduction

Pre-Development Rate to Post Development Rate

Storm	-	Pre-Dev	-	Post Dev	-	Difference
Q ₂	-	14.7 l/s	-	1.4 l/s	-	90% Reduction
Q _{30 + 40%}	-	36.6 l/s	-	1.5 l/s	-	96% Reduction
Q _{100 + 45%}	-	48.3 l/s	-	1.8 l/s	-	96% Reduction

The calculations show that the post development surface water run-off rates are between a 12% and 51% reduction of the greenfield rates, and between a 90% to 96% reduction of the pre-development rates. Therefore, the rates are acceptable as they adhere to DEFRA National Non-Statutory Technical Standards for Sustainable Drainage Systems (S3).

14.4. Surface Water Run-Off Volume

The surface water run-off volumes for 1 in 100-Year the 6-hour duration (Inc. 44% CC Allowance) are calculated using the peak surface water discharge rate. Therefore, the surface water run-off volume (during 6-hour period) is:

$$Q_{100} \quad - \quad 1.8 \text{ l/s} \times (6 \times 60 \times 60) \quad = \quad 38,880 \text{ litres} \quad - \quad 38.88\text{m}^3$$

A summary of the post development run-off volume compared to the greenfield and pre-development volume, are as follows:

Greenfield Volume to Post Development Volume

Storm	-	Greenfield	-	Post Dev	-	Difference
Q ₁₀₀	-	39.56m ³	-	38.88m ³	-	Equivalent

Pre-Development Volume to Post Development Volume

Storm	-	Pre-Dev	-	Post Dev	-	Difference
Q ₁₀₀	-	60.65m ³	-	38.88m ³	-	36% Reduction

The calculations show that the post development surface water run-off volume is equivalent to the greenfield and a 36% reduction of post development volume. Therefore, the discharge volume is deemed to be acceptable, as it meets the requirements of DEFRA National Non-statutory technical standards for sustainable drainage systems (S5-S6).

14.5. Surface Water Attenuation Calculations

As the surface water run-off from the development site is being restricted, there will be a requirement for 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’.*

The surface water attenuation for the development site will be within an attenuation tank in the form of cellular units. As detailed in the MicroDrainage calculations (Appendix I) and below ground drainage layout (Appendix H), the attenuation volume for this SuDS method is as follows:

Attenuation Tank (Cellular Units)

Tank Length	-	12.50m
Tank Width	-	4.00m
Tank Area	-	50.00m²
Tank Depth	-	1.20m
Overall Tank Volume	-	60.00m³
Tank Porosity	-	0.95
Attenuation Volume	-	57.00m³

The MicroDrainage calculations (Appendix H) show that with the cellular unit volume, no flooding will occur for all storms up to and including the 100-year + 45% storm event. Therefore, the attenuation volume is deemed to be acceptable, as they meet the requirements set out in the Non-Statutory Technical Standards for Sustainable Drainage Systems (S7-S9).

14.6. Surface Water Drain Down Time

The calculations in Appendix I show the half drain time from the cellular units / attenuation tank (100-year + 40% allowance) is **315-minutes**, which is deemed to be acceptable (half drain time below 24-hours / 1440-minutes).

15. Maintenance Requirements

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 effectively, and subsequently reducing the risk of flooding on the Site, are set out below.

15.1. Drainage Responsibilities

The management and maintenance of the surface water drainage networks and SuDS features within the Site will be by contractors appointed by the owners / residents of each of the new residential units, where payments of the works will form part of the property deeds and / or rental agreements. The management and maintenance of the drainage / SuDS will form part of the overall management of all the communal areas.

A copy of the drainage design layout / details and a drainage maintenance / management document will be handed to the occupants on completion of the property purchase, where they will be made aware of the features within the Site, and responsibility to maintain the drainage features shown on said drawings and details.

15.2. Maintenance and Management Document on Completion

The document produced, and handed to the owners of the new residential unit / owners, will state the following:

'The owners & parties with responsibilities for the surface water drainage system on this development will comprise of the following stakeholders:

Residential Unit Owners

All of which is clearly defined on the surface water drainage plan included within your handover pack & property deeds package.

As you are a residential unit owner on this development, you have responsibilities for the maintenance of the surface water drainage system which fall within the extent of Site as defined within the 'development boundary' (shown in red on surface water management drawing).

Failure to maintain or removal of surface water drainage features may result in civil litigation with neighbouring owners if flooding occurs as a result.

Surface water drainage pipes, inspection chambers, water butts, permeable paving, living roofs (in the form of garden and planting at terrace areas), flow control chamber and cellular units within the Site are owned by you. As you are the owner, you are responsible for maintenance / repairs and replacement of all drainage and SuDS items.

'The operation and frequency of the maintenance and management set out in this report and as shown on the drainage layout are to be carried out as follows:

Drainage Networks, Water Butts, Flow Control and Cellular Units

Operation	Frequency
<i>Inspect and identify any areas that are not operating correctly, if required, take remedial actions</i>	<i>Monthly for 3 months, then six monthlies</i>
<i>Debris removal from manholes (where may cause risk performance)</i>	<i>Monthly</i>
<i>Where rainfall into network from above, check surface or filter for blockage or silt, algae, or other matter by jetting</i>	<i>As required, but at least twice a year</i>
<i>Remove sediment from pipework by jetting.</i>	<i>Annually or as required</i>

<i>Repair/check all inlets, outlets, and overflow pipes</i>	<i>As required</i>
<i>Inspect/check all inlets, outlets, and overflow pipes to ensure that they are in good condition and operating as designed</i>	<i>Annually and after large storms</i>

Permeable Paving

Operation	Frequency
<i>Inspect and identify any areas that are not operating correctly, if required, take remedial actions</i>	<i>Monthly for 3 months, then six monthlies</i>
<i>Debris removal from on surface of permeable paving (where may cause risk performance)</i>	<i>Monthly</i>
<i>Rainfall infiltration into permeable paving is ensured working effectively.</i>	<i>As required, but at least twice a year</i>

Green Roofs (Terrace Garden and Planting Areas)

Operation	Frequency
<i>Inspections to identify any areas not operating correctly, eroded areas, hydrocarbon pollution, blocked outlets, and silt accumulation. Record any areas that are ponding and where water is lying more than 48 hours.</i>	<i>Monthly</i>
<i>Collect and remove from the site all extraneous rubbish that is detrimental to the operation of the SUDS feature and appearance of the site, including paper, packaging materials, bottles, cans, and similar debris.</i>	<i>Monthly</i>
<i>Maintain grass within the specified range. Ensure that the soil and grass does not become compacted. Do not cut during periods of drought or when ground conditions or grass are wet.</i>	<i>As required, but at least twice a year</i>
<i>Scarifying and spiking</i>	<i>As required</i>
<i>Reinstate design levels, repair eroded areas or damaged areas by returfing and reseeded.</i>	<i>As required</i>
<i>Seed or sod bare eroded areas.</i>	<i>As required</i>

15.3. Linked and Further Maintenance and Maintenance Activities

The maintenance of the drainage network and SuDS features are to be linked with the wider site maintenance plan for the development. A log of all maintenance activities is to be kept and made available to the local planning authority (LPA) and / or the LLFA on request.

16. Surface Water Exceedance Event

In an unlikely network exceedance event due to storms exceeding the designed 100-year + 45%, surface water will flow away from the new building, and will discharge into Lawrence Street via the entrance got the undercroft car park, where it will be contained due to the road's gradient and the roads having upstand kerbs.

Any flood water discharging off the Site for storm exceeding 1 in 100-year + 45% climate change will be lower volumes than the pre-development site volumes. This is due to the pre-development site having no surface water management system or below ground attenuation, and therefore, the probability of flooding to areas near the development site has been reduced from the pre-development site scenario.

17. Water Quality

The level of water treatment (for external areas subject to pollutants) is to be assessed against the details set out in Ciria SuDS Manual C753. Chapter 26 sets out the Pollution Hazard Indices for different land classifications, and how to calculate that against the SuDS mitigation indices to show suitable levels of treatment.

17.1. Roof and External Area Pollutant Hazard

Pollutant Area	=	Roof	-	External Area
C753 Table 26.2 Pollution Hazard Level	=	Very Low	-	Low
C753 Table 26.2 Pollution Hazard Index:				
• Total Suspended Solid (TSS)	=	0.2	-	0.5
• Metals	=	0.2	-	0.4
• Hydrocarbons	=	0.05	-	0.4
Pollution Hazard Index	=	<u>0.45</u>	-	<u>1.30</u>

17.2. Roof and External Area Pollutant Mitigation

Mitigation Measures:

- Green Roof and Permeable Paving

Pollutant Indices Areas	=	Roof	-	External Area
Permeable Surfacing / Paving Pollutant Mitigation Indices				
Total Suspended Solid (TSS)	=	0.4	-	0.7
Metals	=	0.4	-	0.6
Hydrocarbons	=	0.4	-	0.7
SuDS Mitigation Indices	=	<u>1.60</u>	-	<u>2.00</u>

The mitigation indices are greater than the pollution hazard index, and therefore suitable water quality is achieved.

18. Development Management and Construction Phase

All existing drainage networks within the development area are to be maintained during construction. The attenuation tank and flow control chamber are to be the first part of the drainage network to be built. This will ensure that the surface water discharge is suitably restricted without flooding.

18.1. Construction Environment Management Plan

Full details of the construction environment management plan (CEMP) has to be confirmed by the chosen contractor who have been appointed for the development. However, it will conform to the requirements of CIRIA 753 – The SuDS Manual – Chapter 31, and will include:

18.2. Construction Access

The main construction traffic will access the site from Lawrence Street (south of the Site).

18.3. Sediments and Traps

Sediment basins and traps are to be installed before any major site earthworks take place, with further sediment traps and silt fences being installed as the earthworks progresses. This will keep sediment contained on site at appropriate locations.

18.4. Run-Off Control Measures

Run-off control measures are to be used in conjunction with sediment traps to divert water around planned earthworks areas to remove silts. Any surface water upstream of the site is to be diverted around the development areas, and to discharge to the existing combined water system to the south and east of the Site. The surface water run-off destination for the diverted surface water will continue as existing.

18.5. Main Surface Water Run-Off Systems

The attenuation tank and flow control chamber are to be built prior to any construction of site. Surface water from each of the phased area is to discharge to the new drainage network, where the water is adequately restricted, and water quality maintained before discharging to the combined water sewer. Temporary inlet and outlet protection measures and appropriate silt traps are to be installed to prevent silt ingress into the main drainage network.

18.6. Clearing and Earthworks

Clearing and earthworks will only start when adequate erosion and sediment control measures are in place. Once the development areas are cleared, earthworks will follow immediately to ensure that the ground cover can be re-established quickly. Adjacent land to that being developed will be left undisturbed for as long as possible.

18.7. Surface Stabilisation Measures

Surface stabilisation measures will be applied to completed areas, channels ditches and other disturbed areas after the land is cleared and profiled. Permanent stabilisation measures will be installed as soon as possible after final profiling.

18.8. Construction of Permeable Paving

Construction of permeable paving system is to be left to the later stages of construction. Unsuitable sediment is to be removed from surfacing prior to installation of sand binder layer and paving.

19. Conclusion / Summary

19.1. Flood Probability – Existing Sources

All potential sources of flooding to the Site have assessed, and it is deemed that the probability of flooding from all existing sources is low. In accordance with NPPG, the site is More vulnerable, but as it is in Flood Zone 1 it is appropriate for development with no requirement for an exception test.

As the risk of flooding from all sources is deemed to be low, the Site has passed the sequential test.

19.2. Discharge Destination and SuDS Principles

All feasible SuDS methods, and surface water discharge destination have been assessed, with the feasible SuDS methods being living roofs, water butts, permeable paving systems, a flow control manhole, and an attenuation tank in the form of cellular units. with the surface water destination being a combined water sewer.

19.3. Peak Flow Control

The post development surface water run-off volume is equivalent to the greenfield and a 36% reduction of post development volume. Therefore, the discharge volume is deemed to be acceptable, as it meets the requirements of DEFRA National Non-statutory technical standards for sustainable drainage systems (S5-S6).

19.4. Surface Water Run-Off Volume

The post development surface water run-off volume is equivalent to the greenfield and a 36% reduction of post development volume. Therefore, the discharge volume is deemed to be acceptable, as it meets the requirements of DEFRA National Non-statutory technical standards for sustainable drainage systems (S5-S6).

19.5. Flood Risk within the Development

with the cellular unit volume of 57.00m³, no flooding will occur for all storms up to and including the 100-year + 45% storm event. Therefore, the attenuation volume is deemed to be acceptable, as they meet the requirements set out in the Non-Statutory Technical Standards for Sustainable Drainage Systems (S7-S9).

19.6. Management and Maintenance

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

19.7. Surface Water Exceedance Design

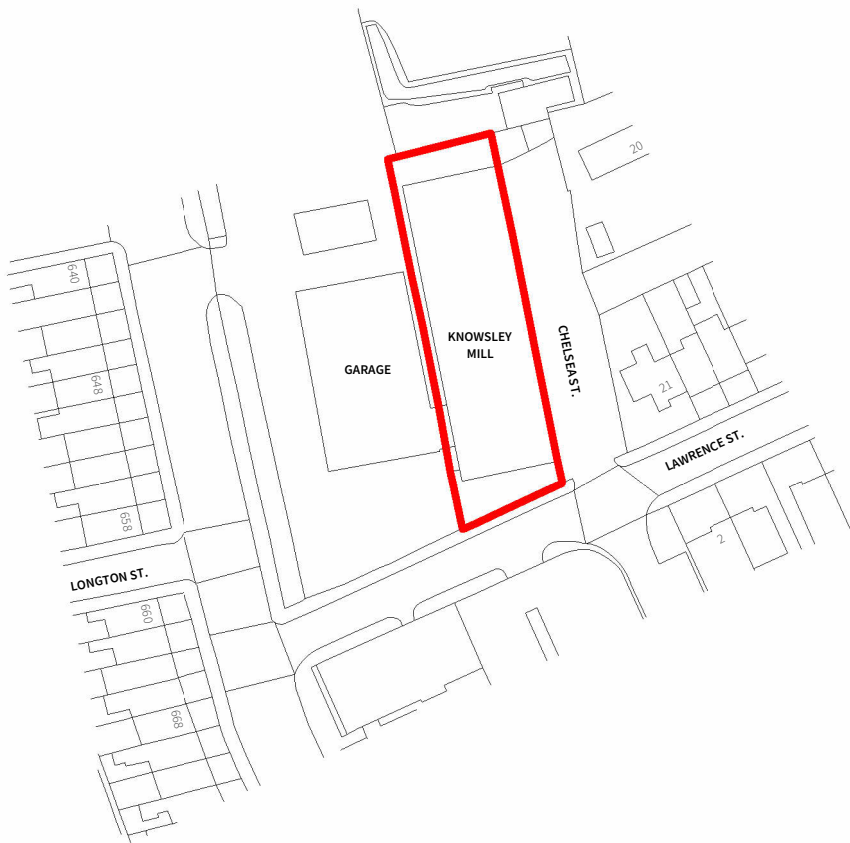
In an unlikely network exceedance event due to storms exceeding the designed 100-year + 45%, surface water will flow away from the new building, and will discharge into Lawrence Street via the entrance to the undercroft car park, where it will be contained due to the road's gradient and the roads having upstand kerbs.

Any flood water discharging off the Site for storm exceeding 1 in 100-year + 45% climate change will be lower volumes than the pre-development site volumes. This is due to the pre-development site having no surface water management system or below ground attenuation, and therefore, the probability of flooding to areas near the development site has been reduced from the pre-development site scenario.

19.8. Water Quality

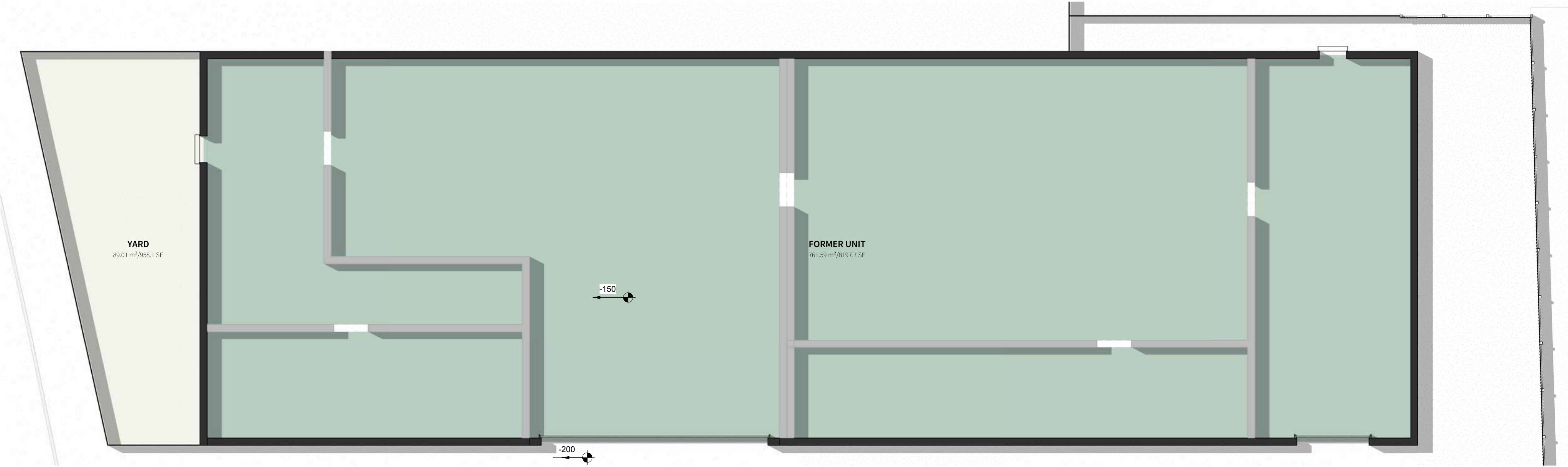
The level of water treatment is to be assessed against the details set out in Ciria SuDS Manual C753. Chapter 26 sets out the Pollution Hazard Indices for different land classifications, and how to calculate that against the SuDS mitigation indices to show suitable levels of treatment. The mitigation indices are greater than the pollution hazard index, and therefore suitable water quality is achieved.

F	Project Title: PROPOSED RESIDENTIAL SCHEME	Status: PLANNING	
	Location: LAWRENCE ST / CHELSEA ST BURY	Date: FEB' 24	
	Sheet Name: LOCATION PLAN	Job Number: 23-028	Sheet Number: FA-DR-03-100



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1 GROUND FLOOR PLAN
1:100



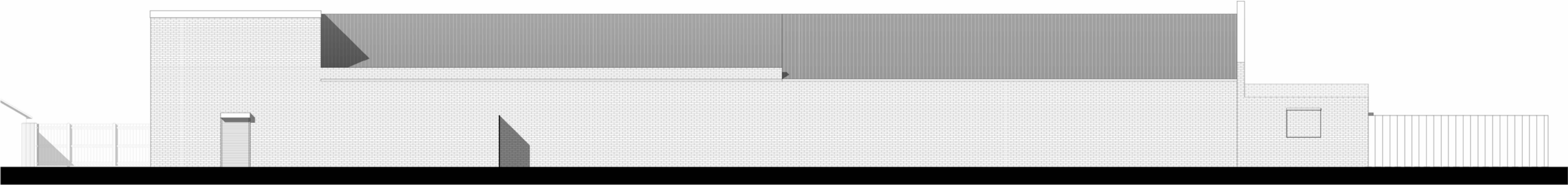
2 ELEVATION EAST - CHELSEA STREET
1:100



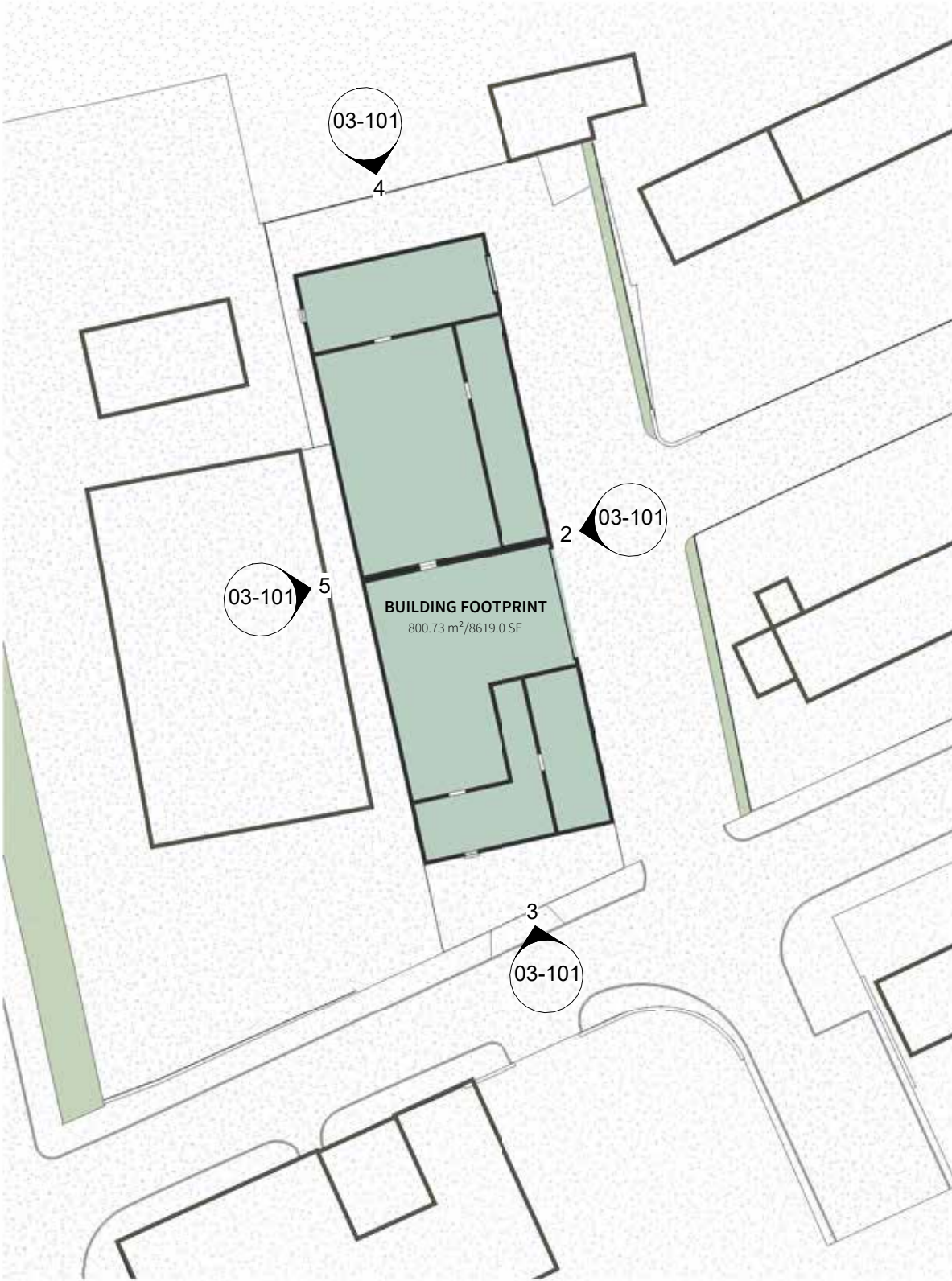
3 ELEVATION SOUTH - LAWRENCE STREET
1:100



4 ELEVATION NORTH
1:100



5 ELEVATION WEST - REAR
1:100

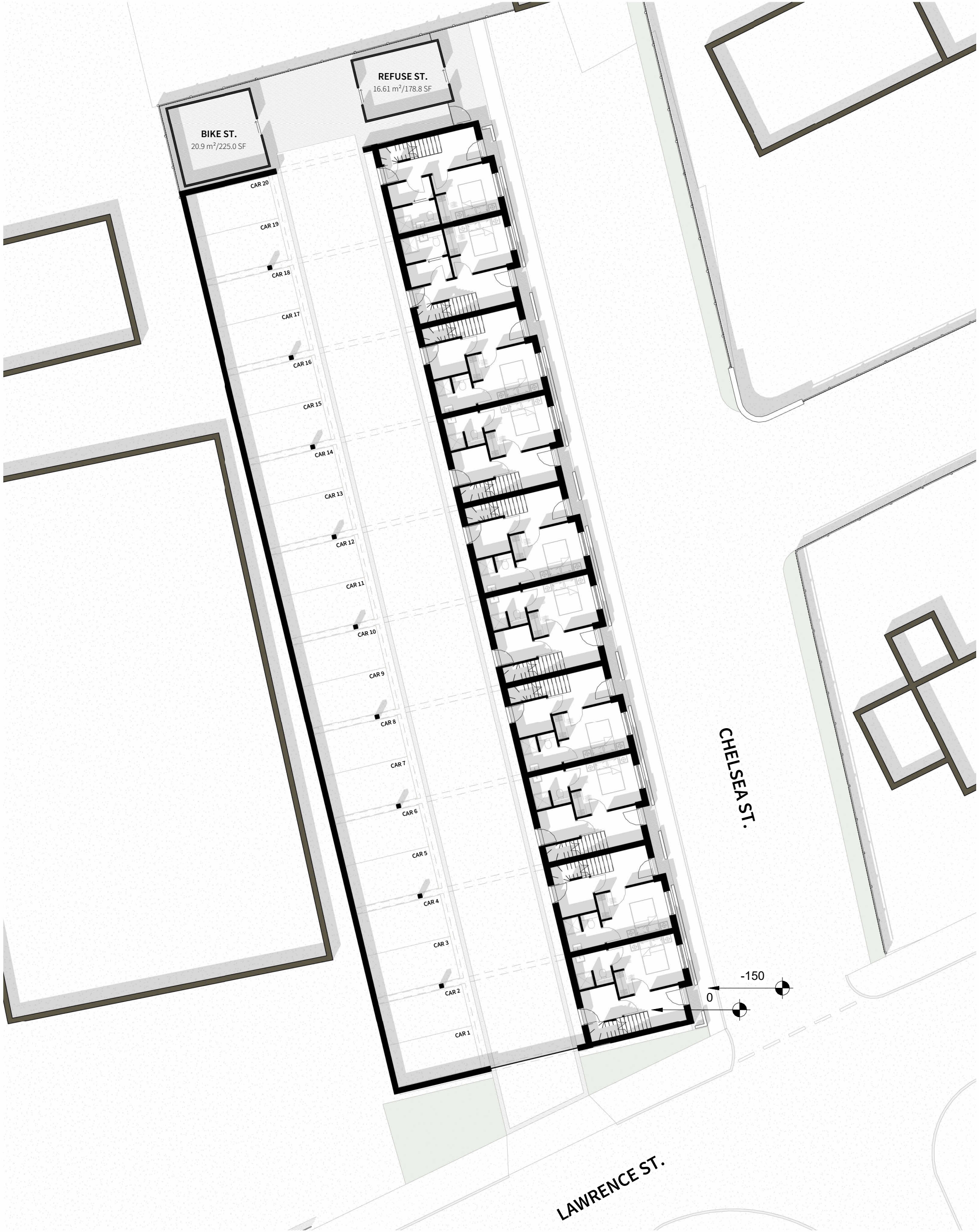


6 BUILDING FOOTPRINT AREA
1:500



7 DEMOLITION PLAN
1:500

F Four Architects 113 Portland Street, Manchester, M1 6DW Tel. 01614707969 Email. info@fourarchitects.co.uk	Project Title: PROPOSED RESIDENTIAL SCHEME		Status: PLANNING	
	Location: LAWRENCE ST / CHELSEA ST BURY		Date: FEB' 24	
	Sheet Name: PROPOSED - SITE PLAN_GROUND FLOOR		Job Number: 23-028	Sheet Number: FA-DR-03-103



F Four Architects 113 Portland Street, Manchester, M1 6DW Tel. 01614707969 Email. info@fourarchitects.co.uk	Project Title: PROPOSED RESIDENTIAL SCHEME		Status: PLANNING	
	Location: LAWRENCE ST / CHELSEA ST BURY		Date: FEB' 24	
	Sheet Name: PROPOSED - SITE PLAN_ROOF		Job Number: 23-028	Sheet Number: FA-DR-03-102



RECORD OF BOREHOLE No: 33A

Location : BLACKFORD BRIDGE, BURY

SHEET ...1.. OF ...1....

Contract No. : CFC69/1400

Borehole Dia : 0.20m

Type of Boring : Shell and Auger

Casing : 0.20m to 1.30m

Date (started) : 16th July 1975

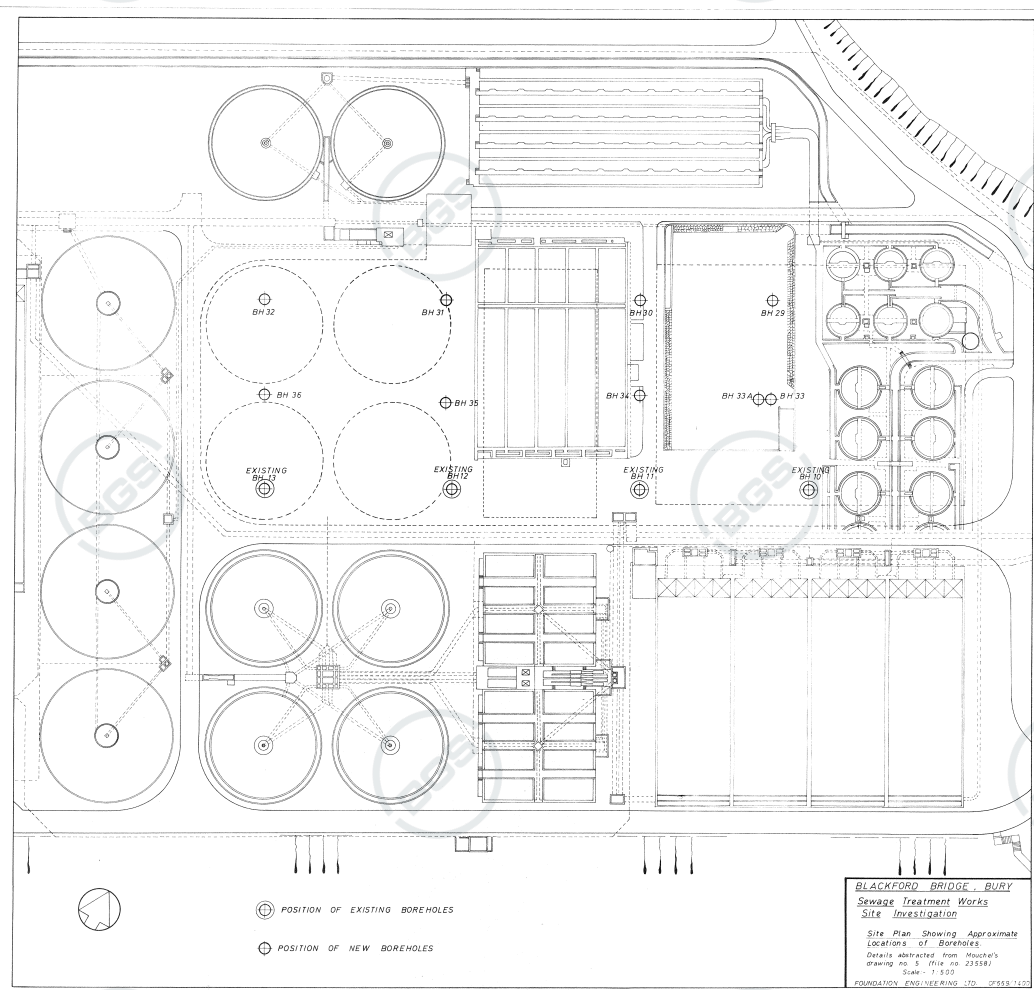
Ground Level : 62.96m O.D

Date & Time	Depth of Casing	Water Level	SAMPLES			STRATA			DESCRIPTION OF STRATA
			Depth	Type	No.	Legend	Depth	Thickness	
0.20	1.30	DRY					0.00	0.15	62.96
0.40							0.15		62.81
0.60								0.85	
0.80			0.70	D	1				
1.00			1.10	D	2		1.00		61.96
1.20			1.30 - 1.75	U	3				
1.40								1.70	
1.60									
1.80			1.80	D	4				
2.00			2.05	D	5				
2.20									
2.40									
2.60			2.80 - 3.25	U	6		2.70		60.26
2.80	1.30	DRY							
3.00									
3.20			3.25	D	7				
3.40			3.55	D	8				
3.60									
3.80									
4.00								2.30	
4.20			4.30 - 4.75	U	9				
4.40									
4.60			4.80	D	10				
4.80			5.05	B	11		5.00		57.96
5.00			5.40	D	12				
5.20			(N=40/init 150mm)						
5.40								1.60	
5.60									
5.80									
6.00									
6.20									
6.40									
6.60			6.60	D	13		6.60		56.36
6.80			(N=50/init 75mm)						
7.00									
7.20									
7.40									
7.60									
7.80									
8.00									
8.20									
8.40									
8.60									
8.80									
9.00									
9.20									
9.40									
9.60									
9.80									
10.00									

REMARKS: At BH 33 position, chiselling for 1 1/2 hrs produced no progress beyond 0.30m.
Rig set up at BH 33A, 3m distant from BH 33. Seepage noted at 0.10m.
Chisel utilised between G.L and 1.00m to break up concrete and from 5.40m to 6.60m to penetrate hard silt and siltstone.
Borehole backfilled with granular materials.

SCALE 1 : 50

Foundation Engineering Ltd.



RECORD OF BOREHOLE No: 36

Location : BLACKFORD BRIDGE, BURY

SHEET ...1.. OF ...1....

Contract No. : CF669/1400

Borehole Dia : 0.20m

Type of Boring : Shell and Auger

Casing : 0.20m to 10.00m

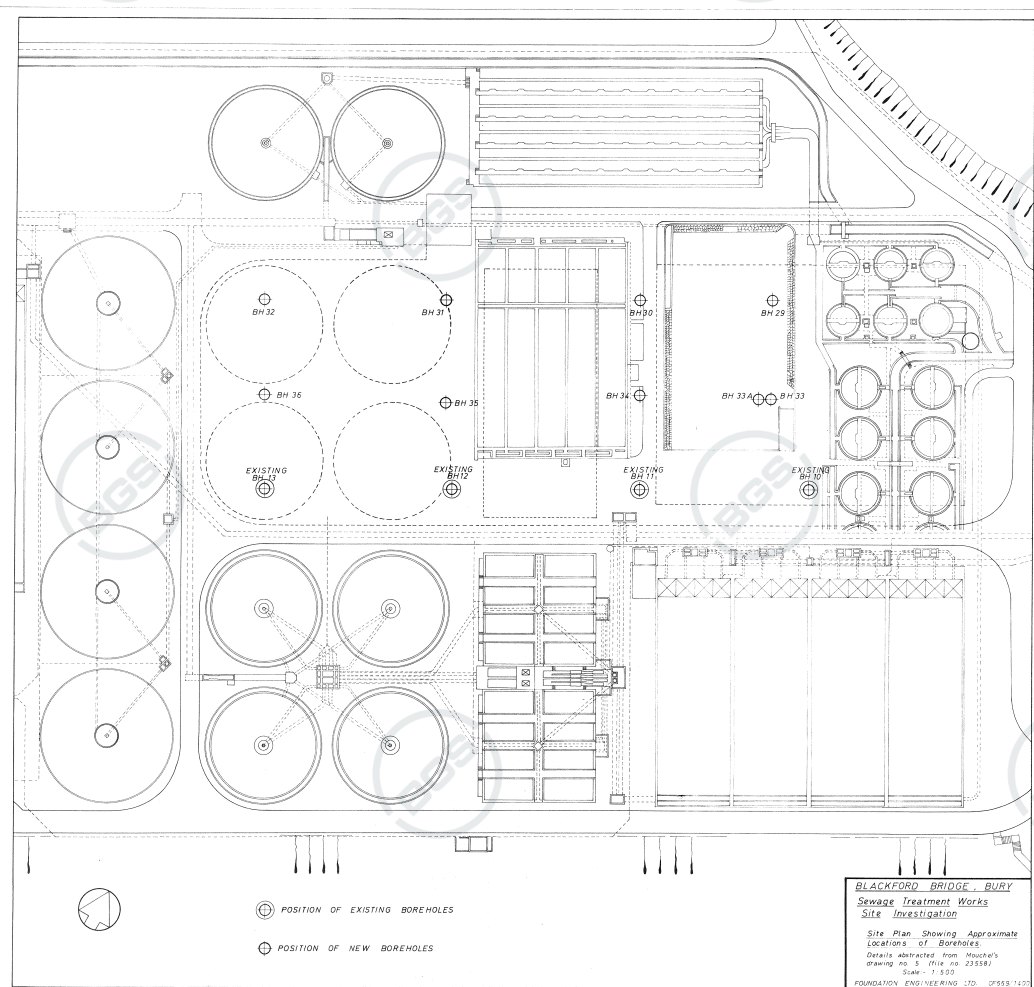
Date (started) : 10th July 1975

Ground Level : 65.18m OD

Date & Time	Depth of Casing	Water Level	SAMPLES			STRATA			DESCRIPTION OF STRATA
			Depth	Type	No.	Legend	Depth	Thickness	
10.7.75							0.00	65.18	MADE GROUND
0.20									(Soft dark grey brown
0.40									silty clay with cmf
0.60									gravel, brick rubble
0.80									and concrete)
1.00			0.50	D	1			1.55	
1.20									
1.40			1.20	D	2				
1.60			(N=8)						
1.80			1.60	B	3		1.55	63.63	(Soft to firm dark brown
2.00									and red-brown silty clay
2.20			2.00 - 2.30	U	4				with fine rounded gravel
2.40			2.30	D	5			1.35	and inclusions of coal
2.60									and ash at 2.80m.
2.80			2.90	D	6		2.90	62.28	Boulder at 2.30m)
3.00									
3.20									
3.40			3.50 - 3.95	U	7				Stiff grey brown silty
3.60									CLAY with cmf sub-
3.80									rounded gravel, cobbles
4.00			4.00	D	8				and small inclusions of
4.20			4.25	D	9				coal. Below 4.00m
4.40									becomes fissured with
4.60								3.20	a high content of
4.80									rounded gravel and
5.00			5.00 - 5.45	U	10				cobble of yellow sand-
5.20									stone at 5.50m
5.40			5.50	D	11				
5.60			5.75	D	12				
5.80									
6.00			6.20	D	13		6.10	59.08	Stiff brown CLAY with
6.20									cmf rounded gravel
6.40			6.50 - 6.95	U	14		6.50	58.68	Stiff dark grey and brown
6.60								0.40	sandy silty CLAY with
6.80									inclusions of highly
7.00	1800	DRY	7.00	D	15				weathered sandstone and
7.20	11.7.75	6.20	7.00	D	16			1.00	cmf rounded gravel.
7.40	0800		7.25	D	17				
7.60			7.50	D	18		7.50	57.68	Very dense light brown
7.80			7.60	D	19				subangular to subrounded
8.00			(N=30/first 113mm)						mf GRAVEL with pockets
8.20								1.45	of brown sandy silty
8.40			8.35	B	20				clay, cobbles and pieces
8.60									of yellow sandstone.
8.80									
9.00			9.00	D	21		8.95	56.23	V.Stiff brown silty sandy
9.20			9.15	D	22				CLAY with cmf sub-
9.40			(N=16)					1.05	rounded gravel, cobbles
9.60									and boulders and pieces
9.80			9.90	D	23		10.00	55.18	of sandstone at 9.15m
10.00	13.30	8.30							and 9.90m.
	13.30	4.60				E O B			

REMARKS: Large concrete obstruction in the made ground had to be dug out.
Chisel utilised between 2.30m and 2.90m to break up boulder and from 9.15m to
10.00m to advance hole beyond sandstone boulders.
Groundwater seepage observed at 7.50m. Piezometer installed at 10.00m in a gravel
surround to 7.50m with puddled clay to 6.50m. Borehole backfilled with granular
SCALE 1 : 50 material.

Foundation Engineering Ltd.





Scale: 1:1250
Date: 26/03/2024

SEWER RECORDS



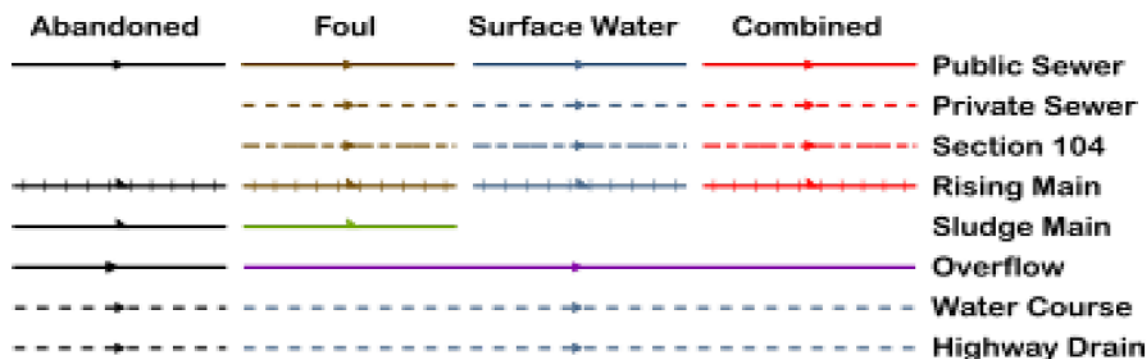
Water for the North West

Address or Site Reference: Lawrence Street
Printed by: Property Searches

The position of the underground apparatus shown on this plan is approximate only and is given in accordance with the best information currently available. United Utilities Water will not accept liability for any loss or damage caused by the actual position being different from those shown.

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Wastewater Symbolology



All point assets follow the standard colour convention: **red** – combined **brown** - foul
blue – surface water **purple** - overflow

Manhole	Side Entry Manhole
Head of System	Outfall
Extent of Survey	Screen Chamber
Rodding Eye	Inspection Chamber
Inlet	Bifurcation Chamber
Discharge Point	Lamp Hole
Vortex	T Junction / Saddle
Penstock	Catchpit
Washout Chamber	Valve Chamber
Valve	Vent Column
Air Valve	Vortex Chamber
Non Return Valve	Penstock Chamber
Soakaway	Network Storage Tank
Gully	Sewer Overflow
Cascade	Ww Treatment Works
Flow Meter	Ww Pumping Station
Hatch Box	Septic Tank
Oil Interceptor	Control Kiosk
Summit	
Drop Shaft	Change of Characteristic
Orifice Plate	

Flo Consult UK Ltd		Page 1
4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Lawrence Street Greenfiled Run-Off Volume Calculations	
Date 26/03/2024	Designed by MDS	
File	Checked by MDS	
Innovyze	Source Control 2020.1.3	
IH 124 Mean Annual Flood Input Return Period (years)2Soil0.450 Area (ha) 50.000Urban0.750 SAAR (mm)1067Region NumberRegion 10 Results1/s QBAR Rural359.7 QBAR Urban846.9 Q2 years865.2 Q1 year736.8 Q2 years865.2 Q5 years1038.3 Q10 years1118.9 Q20 years1192.4 Q25 years1211.4 Q30 years1226.4 Q50 years1265.4 Q100 years1334.0 Q200 years1429.4 Q250 years1458.3 Q1000 years1639.6		
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4 Market Square	Lawrence Street																											
Old Amersham	Greenfield Run-Off																											
Buckinghamshire, HP7 0DQ	Rate Calculations																											
Date 26/03/2024	Designed by MDS																											
File	Checked by MDS																											
Innovyze		Source Control 2020.1.3																										
<u>Greenfield Runoff Volume</u> FEH Data <table> <tr> <td>Return Period (years)</td> <td>100</td> </tr> <tr> <td>Storm Duration (mins)</td> <td>360</td> </tr> <tr> <td>FEH Rainfall Version</td> <td>2013</td> </tr> <tr> <td>Site Location</td> <td>GB 380720 407985 SD 80720 07985</td> </tr> <tr> <td>Data Type</td> <td>Point</td> </tr> <tr> <td>Areal Reduction Factor</td> <td>1.00</td> </tr> <tr> <td>Area (ha)</td> <td>0.104</td> </tr> <tr> <td>SAAR (mm)</td> <td>1032</td> </tr> <tr> <td>CWI</td> <td>123.437</td> </tr> <tr> <td>SPR Host</td> <td>47.000</td> </tr> <tr> <td>URBEXT (USER)</td> <td>0.5000</td> </tr> </table> Results <table> <tr> <td>Percentage Runoff (%)</td> <td>56.92</td> </tr> <tr> <td>Greenfield Runoff Volume (m³)</td> <td>39.563</td> </tr> </table>			Return Period (years)	100	Storm Duration (mins)	360	FEH Rainfall Version	2013	Site Location	GB 380720 407985 SD 80720 07985	Data Type	Point	Areal Reduction Factor	1.00	Area (ha)	0.104	SAAR (mm)	1032	CWI	123.437	SPR Host	47.000	URBEXT (USER)	0.5000	Percentage Runoff (%)	56.92	Greenfield Runoff Volume (m³)	39.563
Return Period (years)	100																											
Storm Duration (mins)	360																											
FEH Rainfall Version	2013																											
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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Lawrence Street Greenfield Run-Off Rate Calculations	
Date 26/03/2024	Designed by MDS	
File	Checked by MDS	
Innovyze	Network 2020.1.3	

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FEH Rainfall Model

Return Period (years)	2
FEH Rainfall Version	2013
Site Location	GB 380720 407985 SD 80720 07985
Data Type	Point
Maximum Rainfall (mm/hr)	50
Maximum Time of Concentration (mins)	30
Foul Sewage (l/s/ha)	0.000
Volumetric Runoff Coeff.	0.750
PIMP (%)	100
Add Flow / Climate Change (%)	0
Minimum Backdrop Height (m)	0.200
Maximum Backdrop Height (m)	1.500
Min Design Depth for Optimisation (m)	1.200
Min Vel for Auto Design only (m/s)	1.00
Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m ³ /ha Storage	2.000
Hot Start (mins)	0	Inlet Coefficient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0
Number of Online Controls 0 Number of Storage Structures 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
FEH Rainfall Version	2013
Site Location	GB 380720 407985 SD 80720 07985
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Storm Duration (mins)	30

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ		Lawrence Street Greenfield Run-Off Rate Calculations	
Date 26/03/2024 File		Designed by MDS Checked by MDS	
Innovyze		Network 2020.1.3	

2 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coefficient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0
Number of Online Controls 0 Number of Storage Structures 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FEH
FEH Rainfall Version	2013
Site Location	GB 380720 407985 SD 80720 07985
Data Type	Point
Cv (Summer)	0.750
Cv (Winter)	0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years) 2, 30, 100
Climate Change (%) 0, 0, 0

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
1.000	1	15 Winter	2	+0%	100/15 Summer				10.080
1.001	2	15 Winter	2	+0%	30/15 Summer				10.059

PN	US/MH Name	Depth (m)	Volume (m³)	Flow / Cap. (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Level Exceeded
1.000	1	-0.145	0.000	0.27		8.5	OK
1.001	2	-0.116	0.000	0.47		14.7	OK

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ		Lawrence Street Greenfield Run-Off Rate Calculations							
Date 26/03/2024		Designed by MDS							
File		Checked by MDS							
Innovyze			Network 2020.1.3						
100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm									
Simulation Criteria									
Areal Reduction Factor 1.000		Additional Flow - % of Total Flow 0.000							
Hot Start (mins) 0		MADD Factor * 10m³/ha Storage 2.000							
Hot Start Level (mm) 0		Inlet Coefficient 0.800							
Manhole Headloss Coeff (Global) 0.500		Flow per Person per Day (l/per/day) 0.000							
Foul Sewage per hectare (l/s) 0.000									
Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0 Number of Online Controls 0 Number of Storage Structures 0 Number of Real Time Controls 0									
Synthetic Rainfall Details									
Rainfall Model		FEH							
FEH Rainfall Version		2013							
Site Location		GB 380720 407985 SD 80720 07985							
Data Type		Point							
Cv (Summer)		0.750							
Cv (Winter)		0.840							
Margin for Flood Risk Warning (mm) 300.0		DVD Status OFF							
Analysis Timestep		Fine Inertia Status OFF							
DTS Status		ON							
Profile(s)		Summer and Winter							
Duration(s) (mins) 15, 30, 60, 120, 240, 360, 480, 960, 1440									
Return Period(s) (years) 2, 30, 100									
Climate Change (%) 0, 0, 0									
Water									
PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Level (m)
1.000	1	15 Winter	100	+0%	100/15 Summer				10.259
1.001	2	15 Winter	100	+0%	30/15 Summer				10.236
Surcharged Flooded						Half Drain Pipe			
PN	US/MH Name	Depth (m)	Volume (m³)	Flow / Cap.	Overflow (l/s)	Time (mins)	Flow (l/s)	Status	Level Exceeded
1.000	1	0.034	0.000	0.80			25.3	SURCHARGED	
1.001	2	0.061	0.000	1.53			48.3	SURCHARGED	
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4 Market Square	Lawrence Street	
Old Amersham	Greenfield Run-Off	
Buckinghamshire, HP7 0DQ	Rate Calculations	
Date 26/03/2024	Designed by MDS	
File	Checked by MDS	
Innovyze	Network 2020.1.3	
<u>Simulation Criteria for Storm</u> Volumetric Runoff Coeff 0.750 Additional Flow - % of Total Flow 0.000 Areal Reduction Factor 1.000 MADD Factor * 10m³/ha Storage 2.000 Hot Start (mins) 0 Inlet Coefficient 0.800 Hot Start Level (mm) 0 Flow per Person per Day (l/per/day) 0.000 Manhole Headloss Coeff (Global) 0.500 Run Time (mins) 60 Foul Sewage per hectare (l/s) 0.000 Output Interval (mins) 1 Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0 Number of Online Controls 0 Number of Storage Structures 0 Number of Real Time Controls 0 <u>Synthetic Rainfall Details</u> Rainfall Model FEH Return Period (years) 2 FEH Rainfall Version 2013 Site Location GB 380720 407985 SD 80720 07985 Data Type Point Summer Storms Yes Winter Storms Yes Cv (Summer) 0.750 Cv (Winter) 0.840 Storm Duration (mins) 30		
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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Lawrence Street Greenfield Run-Off Rate Calculations	
Date 26/03/2024	Designed by MDS	
File	Checked by MDS	
Innovyze	Network 2020.1.3	

Summary Wizard of 360 minute 100 year Winter I+0% for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coefficient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	0	Number of Storage Structures	0	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FEH
FEH Rainfall Version	2013
Site Location	GB 380720 407985 SD 80720 07985
Data Type	Point
Cv (Summer)	0.750
Cv (Winter)	0.840

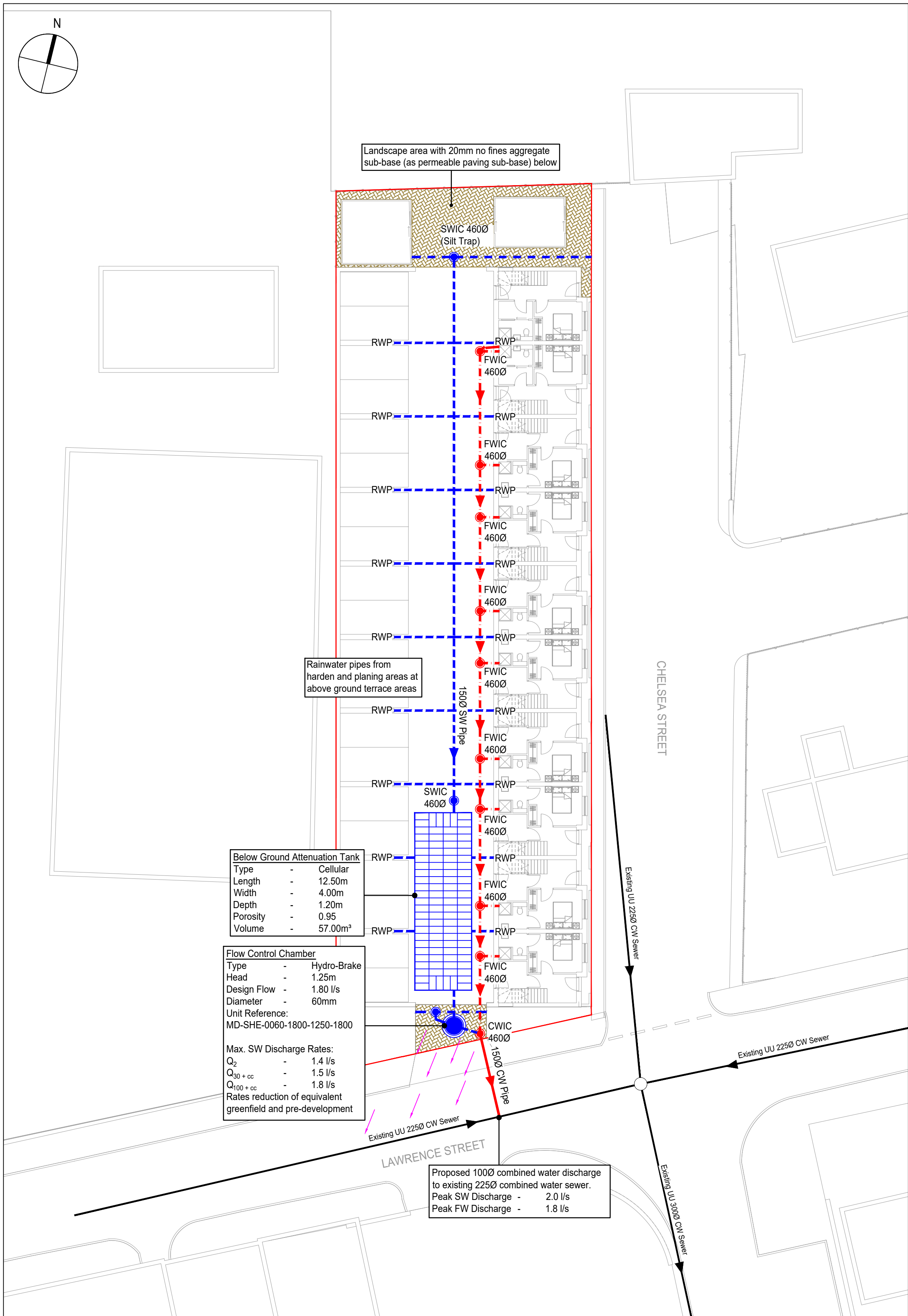
Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	ON		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	2, 30, 100
Climate Change (%)	0, 0, 0

			Water Surcharged Flooded					
US/MH			US/CL	Level	Depth	Volume	Flow /	Overflow
PN	Name	Event	(m)	(m)	(m)	(m³)	Cap.	(l/s)
1.000	1	360 minute 100 year Winter I+0%	12.000	10.052	-0.173	0.000	0.12	
1.001	2	360 minute 100 year Winter I+0%	12.000	10.022	-0.153	0.000	0.22	

			Half Drain Pipe		
US/MH	Discharge		Time	Flow	
PN	Name	Vol (m³)	(mins)	(l/s)	Status
1.000	1	32.563		3.8	OK
1.001	2	60.649		7.1	OK

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BELOW GROUND DRAINAGE STRATEGY



ABOVE GROUND SURFACE WATER MANAGEMENT LAYOUT

Drainage Key:

- Surface Water Pipe
- Foul Water Pipe
- Combined Water Pipe
- Existing Combined Water Sewer
- Permeable Paving
- Living Roof (Garden / Planting)
- SW Exceedance Route
- Development Boundary

Drainage Exceedance Notes

In an unlikely network exceedance event due to storms exceeding the designed 100-year + 45%, surface water will flow away from the new building, and will discharge into Lawrence Street via the entrance got the undercroft car park, where it will be contained due to the road's gradient and the roads having upstand kerbs.

Any flood water discharging off the Site for storm exceeding 1 in 100-year + 45% climate change will be lower volumes than the pre-development site volumes. This is due to the pre-development site having no surface water management system or below ground attenuation, and therefore, the probability of flooding to areas near the development site has been reduced from the pre-development site scenario.

P1	ISSUED FOR APPROVAL	MDS	NC	26.03.24
Rev	Description	Drm	Chk	Date

Client
ECOSCAPE UK LIMITED

Project
RESIDENTIAL DEVELOPMENT
LAWRENCE STREET, BURY

Drawing
SURFACE WATER
MANAGEMENT LAYOUT

Scale	Date	Drawn by	Checked
1:200@A1	26.03.24	MDS	NC

Status
APPROVAL

Flo

Chiltern View Studio
Buslins Lane, Chesham
Buckinghamshire, HP5 2XD
m.07772 033 937
e.mark@flo-consult.co.uk
www.flo-consult.co.uk

Job No.	Drg. No.	Rev
1028	DR-100	P1

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Lawrence Street Surface Water Management Calculations	
Date 26/03/2024	Designed by MDS	
File Lawrence Street - SW Man...	Checked by MDS	
Innovyze	Source Control 2020.1.3	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
FEH Rainfall Version	2013
Site Location	GB 380720 407985 SD 80720 07985
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+0

Green Roof

Area (m³)	900	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)	From: To:	(ha)	From: To:	(ha)
0 4	0.016355	32 36	0.003302	64 68	0.000667	96 100	0.000135
4 8	0.013390	36 40	0.002703	68 72	0.000546	100 104	0.000110
8 12	0.010963	40 44	0.002213	72 76	0.000447	104 108	0.000090
12 16	0.008976	44 48	0.001812	76 80	0.000366	108 112	0.000074
16 20	0.007349	48 52	0.001484	80 84	0.000300	112 116	0.000060
20 24	0.006017	52 56	0.001215	84 88	0.000245	116 120	0.000050
24 28	0.004926	56 60	0.000995	88 92	0.000201		
28 32	0.004033	60 64	0.000814	92 96	0.000164		

Time Area Diagram

Total Area (ha) 0.018

Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)
0 4	0.009	4 8	0.009

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Lawrence Street Surface Water Management Calculations	
Date 26/03/2024	Designed by MDS	
File Lawrence Street - SW Man...	Checked by MDS	
Innovyze	Source Control 2020.1.3	

Model Details

Storage is Online Cover Level (m) 72.000

Cellular Storage Structure

Invert Level (m) 70.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	50.0	0.0	2.600	0.0	0.0
0.200	50.0	0.0	2.800	0.0	0.0
0.400	50.0	0.0	3.000	0.0	0.0
0.600	50.0	0.0	3.200	0.0	0.0
0.800	50.0	0.0	3.400	0.0	0.0
1.000	50.0	0.0	3.600	0.0	0.0
1.200	50.0	0.0	3.800	0.0	0.0
1.400	0.0	0.0	4.000	0.0	0.0
1.600	0.0	0.0	4.200	0.0	0.0
1.800	0.0	0.0	4.400	0.0	0.0
2.000	0.0	0.0	4.600	0.0	0.0
2.200	0.0	0.0	4.800	0.0	0.0
2.400	0.0	0.0	5.000	0.0	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference MD-SHE-0060-1800-1250-1800
Design Head (m) 1.250
Design Flow (l/s) 1.8
Flush-Flo™ Calculated
Objective Minimise upstream storage
Application Surface
Sump Available Yes
Diameter (mm) 60
Invert Level (m) 70.500
Minimum Outlet Pipe Diameter (mm) 75
Suggested Manhole Diameter (mm) 1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.250	1.8	Kick-Flo®	0.536	1.2
Flush-Flo™	0.263	1.5	Mean Flow over Head Range	-	1.4

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ			Lawrence Street Surface Water Management Calculations				
Date 26/03/2024 File Lawrence Street - SW Man...			Designed by MDS Checked by MDS				
Innovyze			Source Control 2020.1.3				
<u>Summary of Results for 30 year Return Period (+40%)</u>							
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max E Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	70.563	0.063	0.0	1.0	1.0	3.0	O K
15 min Winter	70.782	0.282	0.0	1.5	1.5	13.4	O K
30 min Winter	70.939	0.439	0.0	1.5	1.5	20.8	O K
60 min Winter	71.113	0.613	0.0	1.5	1.5	29.1	O K
120 min Winter	71.235	0.735	0.0	1.5	1.5	34.9	O K
180 min Winter	71.289	0.789	0.0	1.5	1.5	37.5	O K
240 min Winter	71.308	0.808	0.0	1.5	1.5	38.4	O K
360 min Winter	71.300	0.800	0.0	1.5	1.5	38.0	O K
480 min Winter	71.280	0.780	0.0	1.5	1.5	37.0	O K
600 min Winter	71.251	0.751	0.0	1.5	1.5	35.7	O K
720 min Winter	71.216	0.716	0.0	1.5	1.5	34.0	O K
960 min Winter	71.137	0.637	0.0	1.5	1.5	30.3	O K
1440 min Winter	70.944	0.444	0.0	1.5	1.5	21.1	O K
2160 min Winter	70.746	0.246	0.0	1.5	1.5	11.7	O K
2880 min Winter	70.646	0.146	0.0	1.4	1.4	6.9	O K
4320 min Winter	70.579	0.079	0.0	1.2	1.2	3.8	O K
5760 min Winter	70.564	0.064	0.0	1.0	1.0	3.0	O K
7200 min Winter	70.556	0.056	0.0	0.8	0.8	2.6	O K
8640 min Winter	70.551	0.051	0.0	0.8	0.8	2.4	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
10080 min Summer	1.124	0.0	129.4	5136			
15 min Winter	104.224	0.0	18.8	55			
30 min Winter	70.067	0.0	27.0	70			
60 min Winter	44.917	0.0	35.9	94			
120 min Winter	26.909	0.0	43.9	136			
180 min Winter	19.902	0.0	49.1	184			
240 min Winter	16.061	0.0	53.2	236			
360 min Winter	11.870	0.0	59.3	316			
480 min Winter	9.573	0.0	63.9	384			
600 min Winter	8.098	0.0	67.7	460			
720 min Winter	7.060	0.0	70.9	536			
960 min Winter	5.678	0.0	76.0	686			
1440 min Winter	4.184	0.0	83.8	948			
2160 min Winter	3.109	0.0	93.0	1284			
2880 min Winter	2.533	0.0	100.4	1600			
4320 min Winter	1.917	0.0	112.6	2240			
5760 min Winter	1.586	0.0	122.9	2936			
7200 min Winter	1.375	0.0	131.9	3632			
8640 min Winter	1.230	0.0	140.2	4416			
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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Lawrence Street Surface Water Management Calculations	
Date 26/03/2024	Designed by MDS	
File Lawrence Street - SW Man...	Checked by MDS	
Innovyze	Source Control 2020.1.3	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	2013
Site Location	GB 380720 407985 SD 80720 07985
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Green Roof

Area (m³)	900	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)	From: To:	(ha)	From: To:	(ha)
0 4	0.016355	32 36	0.003302	64 68	0.000667	96 100	0.000135
4 8	0.013390	36 40	0.002703	68 72	0.000546	100 104	0.000110
8 12	0.010963	40 44	0.002213	72 76	0.000447	104 108	0.000090
12 16	0.008976	44 48	0.001812	76 80	0.000366	108 112	0.000074
16 20	0.007349	48 52	0.001484	80 84	0.000300	112 116	0.000060
20 24	0.006017	52 56	0.001215	84 88	0.000245	116 120	0.000050
24 28	0.004926	56 60	0.000995	88 92	0.000201		
28 32	0.004033	60 64	0.000814	92 96	0.000164		

Time Area Diagram

Total Area (ha) 0.018

Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)
0 4	0.009	4 8	0.009

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Lawrence Street Surface Water Management Calculations	
Date 26/03/2024	Designed by MDS	
File Lawrence Street - SW Man...	Checked by MDS	
Innovyze	Source Control 2020.1.3	

Model Details

Storage is Online Cover Level (m) 72.000

Cellular Storage Structure

Invert Level (m) 70.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	50.0	0.0	2.600	0.0	0.0
0.200	50.0	0.0	2.800	0.0	0.0
0.400	50.0	0.0	3.000	0.0	0.0
0.600	50.0	0.0	3.200	0.0	0.0
0.800	50.0	0.0	3.400	0.0	0.0
1.000	50.0	0.0	3.600	0.0	0.0
1.200	50.0	0.0	3.800	0.0	0.0
1.400	0.0	0.0	4.000	0.0	0.0
1.600	0.0	0.0	4.200	0.0	0.0
1.800	0.0	0.0	4.400	0.0	0.0
2.000	0.0	0.0	4.600	0.0	0.0
2.200	0.0	0.0	4.800	0.0	0.0
2.400	0.0	0.0	5.000	0.0	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference MD-SHE-0060-1800-1250-1800
Design Head (m) 1.250
Design Flow (l/s) 1.8
Flush-Flo™ Calculated
Objective Minimise upstream storage
Application Surface
Sump Available Yes
Diameter (mm) 60
Invert Level (m) 70.500
Minimum Outlet Pipe Diameter (mm) 75
Suggested Manhole Diameter (mm) 1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.250	1.8	Kick-Flo®	0.536	1.2
Flush-Flo™	0.263	1.5	Mean Flow over Head Range	-	1.4

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ				Lawrence Street Surface Water Management Calculations				
Date 26/03/2024 File Lawrence Street - SW Man...				Designed by MDS Checked by MDS				
Innovyze				Source Control 2020.1.3				
<u>Summary of Results for 100 year Return Period (+45%)</u> Half Drain Time : 315 minutes.								
Storm Event		Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer		70.880	0.380	0.0	1.5	1.5	18.1	O K
30 min Summer		71.091	0.591	0.0	1.5	1.5	28.1	O K
60 min Summer		71.306	0.806	0.0	1.5	1.5	38.3	O K
120 min Summer		71.454	0.954	0.0	1.6	1.6	45.3	O K
180 min Summer		71.519	1.019	0.0	1.6	1.6	48.4	O K
240 min Summer		71.542	1.042	0.0	1.7	1.7	49.5	O K
360 min Summer		71.538	1.038	0.0	1.6	1.6	49.3	O K
480 min Summer		71.520	1.020	0.0	1.6	1.6	48.4	O K
600 min Summer		71.495	0.995	0.0	1.6	1.6	47.3	O K
720 min Summer		71.468	0.968	0.0	1.6	1.6	46.0	O K
960 min Summer		71.410	0.910	0.0	1.6	1.6	43.2	O K
1440 min Summer		71.298	0.798	0.0	1.5	1.5	37.9	O K
2160 min Summer		71.151	0.651	0.0	1.5	1.5	30.9	O K
2880 min Summer		70.993	0.493	0.0	1.5	1.5	23.4	O K
4320 min Summer		70.777	0.277	0.0	1.5	1.5	13.2	O K
5760 min Summer		70.675	0.175	0.0	1.5	1.5	8.3	O K
7200 min Summer		70.623	0.123	0.0	1.4	1.4	5.8	O K
8640 min Summer		70.595	0.095	0.0	1.3	1.3	4.5	O K
Storm Event		Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
15 min Summer		141.831	0.0	23.9	60			
30 min Summer		96.511	0.0	34.2	77			
60 min Summer		62.457	0.0	45.8	96			
120 min Summer		37.144	0.0	55.2	138			
180 min Summer		27.345	0.0	61.4	188			
240 min Summer		21.987	0.0	66.1	242			
360 min Summer		16.152	0.0	73.1	310			
480 min Summer		12.953	0.0	78.3	376			
600 min Summer		10.904	0.0	82.5	442			
720 min Summer		9.468	0.0	86.0	510			
960 min Summer		7.570	0.0	91.6	646			
1440 min Summer		5.519	0.0	99.9	922			
2160 min Summer		4.052	0.0	109.5	1324			
2880 min Summer		3.275	0.0	117.3	1704			
4320 min Summer		2.452	0.0	130.3	2364			
5760 min Summer		2.015	0.0	141.3	3048			
7200 min Summer		1.739	0.0	150.9	3744			
8640 min Summer		1.548	0.0	159.8	4416			
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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ			Lawrence Street Surface Water Management Calculations				
Date 26/03/2024			Designed by MDS				
File Lawrence Street - SW Man...			Checked by MDS				
Innovyze			Source Control 2020.1.3				
Summary of Results for 100 year Return Period (+45%)							
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max E Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	70.582	0.082	0.0	1.2	1.2	3.9	O K
15 min Winter	70.949	0.449	0.0	1.5	1.5	21.4	O K
30 min Winter	71.183	0.683	0.0	1.5	1.5	32.5	O K
60 min Winter	71.421	0.921	0.0	1.6	1.6	43.8	O K
120 min Winter	71.589	1.089	0.0	1.7	1.7	51.7	O K
180 min Winter	71.667	1.167	0.0	1.7	1.7	55.4	O K
240 min Winter	71.700	1.200	0.0	1.8	1.8	57.0	O K
360 min Winter	71.699	1.199	0.0	1.8	1.8	57.0	O K
480 min Winter	71.673	1.173	0.0	1.7	1.7	55.7	O K
600 min Winter	71.641	1.141	0.0	1.7	1.7	54.2	O K
720 min Winter	71.602	1.102	0.0	1.7	1.7	52.4	O K
960 min Winter	71.518	1.018	0.0	1.6	1.6	48.3	O K
1440 min Winter	71.349	0.849	0.0	1.5	1.5	40.3	O K
2160 min Winter	71.119	0.619	0.0	1.5	1.5	29.4	O K
2880 min Winter	70.859	0.359	0.0	1.5	1.5	17.0	O K
4320 min Winter	70.646	0.146	0.0	1.4	1.4	6.9	O K
5760 min Winter	70.585	0.085	0.0	1.2	1.2	4.0	O K
7200 min Winter	70.571	0.071	0.0	1.1	1.1	3.4	O K
8640 min Winter	70.563	0.063	0.0	1.0	1.0	3.0	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
10080 min Summer	1.409	0.0	168.2	5136			
15 min Winter	141.831	0.0	27.4	63			
30 min Winter	96.511	0.0	38.9	78			
60 min Winter	62.457	0.0	51.8	98			
120 min Winter	37.144	0.0	62.5	140			
180 min Winter	27.345	0.0	69.4	186			
240 min Winter	21.987	0.0	74.6	240			
360 min Winter	16.152	0.0	82.6	338			
480 min Winter	12.953	0.0	88.4	394			
600 min Winter	10.904	0.0	93.1	470			
720 min Winter	9.468	0.0	97.1	546			
960 min Winter	7.570	0.0	103.4	696			
1440 min Winter	5.519	0.0	112.8	992			
2160 min Winter	4.052	0.0	123.7	1428			
2880 min Winter	3.275	0.0	132.7	1740			
4320 min Winter	2.452	0.0	147.6	2344			
5760 min Winter	2.015	0.0	160.3	2952			
7200 min Winter	1.739	0.0	171.4	3672			
8640 min Winter	1.548	0.0	181.7	4344			
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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Lawrence Street Surface Water Management Calculations	
Date 26/03/2024	Designed by MDS	
File Lawrence Street - SW Man...	Checked by MDS	
Innovyze	Source Control 2020.1.3	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 380720 407985 SD 80720 07985
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+45

Green Roof

Area (m³)	900	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)	From: To:	(ha)	From: To:	(ha)
0 4	0.016355	32 36	0.003302	64 68	0.000667	96 100	0.000135
4 8	0.013390	36 40	0.002703	68 72	0.000546	100 104	0.000110
8 12	0.010963	40 44	0.002213	72 76	0.000447	104 108	0.000090
12 16	0.008976	44 48	0.001812	76 80	0.000366	108 112	0.000074
16 20	0.007349	48 52	0.001484	80 84	0.000300	112 116	0.000060
20 24	0.006017	52 56	0.001215	84 88	0.000245	116 120	0.000050
24 28	0.004926	56 60	0.000995	88 92	0.000201		
28 32	0.004033	60 64	0.000814	92 96	0.000164		

Time Area Diagram

Total Area (ha) 0.018

Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)
0 4	0.009	4 8	0.009

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4 Market Square Old Amersham Buckinghamshire, HP7 0DQ	Lawrence Street Surface Water Management Calculations	
Date 26/03/2024	Designed by MDS	
File Lawrence Street - SW Man...	Checked by MDS	
Innovyze	Source Control 2020.1.3	

Model Details

Storage is Online Cover Level (m) 72.000

Cellular Storage Structure

Invert Level (m) 70.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	50.0	0.0	2.600	0.0	0.0
0.200	50.0	0.0	2.800	0.0	0.0
0.400	50.0	0.0	3.000	0.0	0.0
0.600	50.0	0.0	3.200	0.0	0.0
0.800	50.0	0.0	3.400	0.0	0.0
1.000	50.0	0.0	3.600	0.0	0.0
1.200	50.0	0.0	3.800	0.0	0.0
1.400	0.0	0.0	4.000	0.0	0.0
1.600	0.0	0.0	4.200	0.0	0.0
1.800	0.0	0.0	4.400	0.0	0.0
2.000	0.0	0.0	4.600	0.0	0.0
2.200	0.0	0.0	4.800	0.0	0.0
2.400	0.0	0.0	5.000	0.0	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference MD-SHE-0060-1800-1250-1800
Design Head (m) 1.250
Design Flow (l/s) 1.8
Flush-Flo™ Calculated
Objective Minimise upstream storage
Application Surface
Sump Available Yes
Diameter (mm) 60
Invert Level (m) 70.500
Minimum Outlet Pipe Diameter (mm) 75
Suggested Manhole Diameter (mm) 1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.250	1.8	Kick-Flo®	0.536	1.2
Flush-Flo™	0.263	1.5	Mean Flow over Head Range	-	1.4

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

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