Sustainable Drainage Systems (SuDS) and Flood Risk Assessment (FRA) Report

Revision 1

Our Ref: BE0969

DATE: 17 July 2017

Prepared in support of:

New 4 storey building to provide 3 commercial units; 16 residential flats; terraced areas; cycle store; and bin store at:
1 Hampshire Street,
Camden,
London,
NW5 2TE

Prepared on behalf of:

Redtree (North London) Ltd,
44 Great Eastern Street,
London,
EC2A 3EP

Table of Contents

1.0 Summary of Context and Objective of the Report

1.1 Context

It is proposed to erect a new 4 storey building to provide 3 commercial units; 16 residential flats; terraced areas; cycle store; and bin store at a site currently occupied by Hampshire Street Video, Film and Photography studio.

The Proposed Site Location Plan is included as Figure 1. Please see Figures 2 and 3 for the Existing and Proposed Site Layout Plans and Figures 4-8 for the Floor Plans.

Please see Figure 9 for the Proposed Sustainable Drainage Plan.

1.2 Aim

The aim of this report is to ensure:

- the best scheme for the management of surface water run-off from the development, maximising opportunities for Sustainable Drainage Systems (SuDS) and utilising existing surface water drainage pipework/routes where possible; and,
- that either there is a low risk of flooding from all sources or that the development is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed.

1.3 Objective

The objective of this report is to provide a Sustainable Drainage Systems (SuDS) and Flood Risk Assessment (FRA) Report at the planning stage that details:

- How flood risk on and off site has been evaluated;
- The scope of SUDS measures appropriate for the site;
- How the SUDS system will meet local and national standards;
- Surface Water Drainage Plan);
- Maintenance arrangements / management plan for the lifetime of the development.

2.0 Summary of Site Characteristics and Setting

2.1 Site Details

The development site is located at Hampshire Street Studio, 1 Hampshire Street, Camden (Photograph 1).

Photograph 1

The development site is approximately 30m long by 20m wide; circa 0.05ha in area; and the National Ordnance Survey (OS) Grid Reference is 529716,184954. The Proposed Site Location Plan is included as Figure 1.

The site appears to fall moderately towards the southwest (Photograph 1).

2.2 Site Visit

A site visit was undertaken on Tuesday 4 April 2017.

The development site comprises almost entirely of the Hampshire Street Studio building (Figure 2).

The development site is bounded up gradient and to the north by similar residential flatted development as that proposed (Photograph 2).

Photograph 2

The development site is bounded to the east by the rear gardens of three storey semi detached commercial / residential buildings and further afield by Camden Road (Figure 1). The development site is bounded to the south by two storey terraced residential buildings (Photograph 3).

Photograph 3

The footpath; vehicle access and pedestrian access that bound the site to the west fall towards Hampshire Street - which in turn falls towards Torriano Avenue further to the south (Photograph 4).

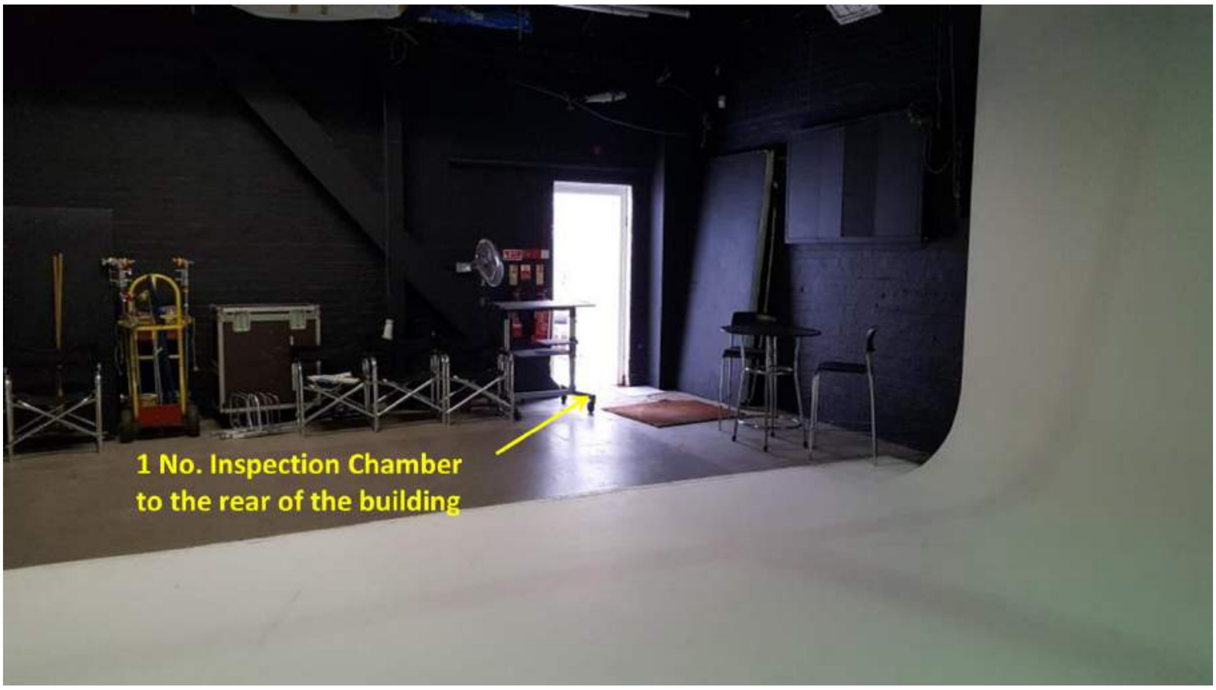
Photograph 4

Within the footprint of the existing building, two inspection chamber covers were noted

(Photographs 5 and 6). Both covers were centrally located, one to the front of the building and one to the rear. Downpipes serving the building roof (Photographs 7-9) were noted close to both these locations (100mm diameter / maximum flow rate 21.40 l/s[1]), indicating these inspection chambers are part of a combined sewer system, taking both surface water and foul water.

Photograph 5

[1] RAINWATER DRAINAGE DESIGN BS EN12056:3-2000 REVISED VERSION, MGMA Information Sheet No 03, July 2012



Photograph 6

Photograph 7

Photograph 8

Photograph 9

A further three roof drains (Photographs 10-12) and corresponding outlets (Photographs 13-15) were noted external to the building. Two of the three outlets appeared to discharge to adjacent ground (Photographs 13-14), with the remaining outlet (50mm diameter / maximum flow rate 1.70 l/s[2]) discharging to the sewer (Photograph 15).

[2] RAINWATER DRAINAGE DESIGN BS EN12056:3-2000 REVISED VERSION, MGMA Information Sheet No 03, July 2012

Photograph 10

Photograph 11

Photograph 12

Photograph 13

Photograph 14

Photograph 15

2.3 Information Obtained from Thames Water Developer Services

Information obtained from Thames Water Developer Services indicates that a combined sewer is located underneath Hampshire Street to the west.

2.4 Ground Conditions

Cranfield Soil and Agrifood Institute (CSAI) Soilscapes Map provides information on the soil underlying the site - 'Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils'[3].

The BGS Geoindex website also provides information on the bedrock geology underlying the site - 'silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay'[4].

The nearest available borehole log on the BGS Geoindex website is 85m west of the site. TQ28SE1049[5] - 46.27m Above Ordnance Datum (AOD) - encountered Topsoil to around 0.80m below ground level (bgl) and CLAY to approximately 2.45m bgl. 'Water was not encountered at the time of digging in April 1970'[6].

Groundwater beneath the site location is not associated with a source protection zone[7].

The hydrological characteristics of the site location are:

- Average annual rainfall (AAR) mm 629
- Soil runoff coefficient (SPR) 0.47
- Growth curve factor 1 0.85
- Growth curve factor 30 2.3
- Growth curve factor 100 3.19
- Hydrological region (R) 6[8].

[3] http://www.landis.org.uk/soilscapes/
[4] http://www.bgs.ac.uk/lexicon/lexicon.cfm?pub=LC
[5] http://scans.bgs.ac.uk/sobi_scans/boreholes/592630/images/12216756.html
[6] http://scans.bgs.ac.uk/sobi_scans/boreholes/592630/images/12216756.html
[7] http://maps.environment-agency.gov.uk/wiyby/wiybyController?value=NW5+2TE&lang=_e&ep=map&topic=groundwater&layerGroups=default&scale=9&textonly=off&submit.x=11&submit.y=11
[8] http://www.uksuds.com/surfacewaterstorage_js.htm

3.0 Flood Risk Assessment (FRA)

3.1 Flooding from Rivers and Sea

The lowest point at the site appears to be around 46.5m AOD and the site has a fall of circa 1 in 25 towards the southwest[9].

A review of the Environment Agency (EA) Flood Map for Planning (from Rivers and the Sea)[10] indicates that the:

- site lies within Flood Zone 1 i.e. land assessed as having less than a 0.1 per cent (1 in 1000) chance of flooding occurring each year; and,
- nearest area that could be affected by river flooding is around 3.3m AOD[11] approximately 4.25km northeast of the site. This area lies within Flood Zone 3 i.e. land assessed as having a 1 per cent (1 in 100) or greater chance of river flooding occurring each year.

3.2 Flooding from Land

A review of the EA's risk of flooding from surface water map indicates a very low risk - less than 1 in 1000 (0.1%) chance of flooding each year - both in the location of the development site and the up gradient commercial / residential flatted development[12].

A review of the EA's risk of flooding from surface water map indicates a low risk - between 1 in 1000 (0.1%) and 1 in 100 (1%) chance of flooding each year - in the adjacent Hampshire Street and rear gardens locations[13]. Where a low risk is indicated, the surface water depth is below 300mm and 300mm to 900mm respectively[14] and the surface water velocity is over

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[9] https://www.freemaptools.com/elevation-finder.htm
[10] https://flood-map-for-planning.service.gov.uk/summary/529723/184961
[11] https://www.freemaptools.com/elevation-finder.htm
[12] https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=529715&northing=184956&address=5020916
[13] https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=529715&northing=184956&address=5020916
[14] https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=529715&northing=184956&address=5020916

0.25 m/s[15].

3.3 Flooding from Groundwater

Figure 4e Rev 1 of the London Borough of Camden (LBC) Strategic Flood Risk Assessment (SFRA)[16] indicates that the site is not located in an area of increased susceptibility to elevated groundwater. Figure 4e Rev 1 also indicates the nearest recorded EA groundwater flood incident is circa 300m northwest of the site.

3.4 Flooding from Sewers

Figure 5a Rev 1 and 5b Rev 1 of the LBC SFRA[17] indicates that the number of internal and external sewer flooding incidents recorded by Thames Water in the site location in the last 10 years is 0.

3.5 Flooding from Reservoirs, Canals and Other Artificial Sources

The site is not located in an area at risk of inundation should large reservoir flooding occur[18].

3.6 Conclusion

The development site is situated in Flood Zone 1 (i.e. land assessed as having less than a 0.1 per cent (1 in 1000) chance of river flooding occurring each year as defined in Planning Policy Guidance (PPG) Flood Risk and Coastal Change[19]) and the FRA indicates that there is a low risk of flooding from all sources.

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[15] https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=529715&northing=184956&address=5020916

[16] URS, London Borough of Camden Strategic Flood Risk Assessment, Revision 2, July 2014.

[17] URS, London Borough of Camden Strategic Flood Risk Assessment, Revision 2, July 2014.

[18] https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=529715&northing=184956&address=5020916

[19] http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

4.0 SuDS Selection

The development site comprises almost completely of the Hampshire Street Studio building (Figure 2). Post development, the site will similarly comprise almost completely of the proposed new commercial / residential flatted building, with terraced areas to the front and rear.

Within the footprint of the existing building, two inspection chamber covers were noted (Photographs 5 and 6). Both covers were centrally located, one to the front of the building and one to the rear. Downpipes noted close to both these locations (Photographs 7-9) indicate these inspection chambers are part of a combined sewer system, taking both surface water and foul water.

Information obtained from Thames Water Developer Services indicates that a combined sewer is located underneath Hampshire Street to the west.

Characteristics were reviewed to allow appropriate selection of SuDS components for the site. The main constraints/opportunities driving SuDS selection are summarised below and based on Table 5.4 of CIRIA C697[20].

Characteristic	Constraint/Opportunity
Soils (low permeability)	Opportunity for retention, wetland, filtration and source control.
Area draining to a single SUDS component (<2ha)	
Groundwater (>1m bgl)	
Site topographic characteristics (0-5%)	
Available head (0-1m)	
Available space (low)	

Initially, there appears to be opportunities for surface water runoff to discharge to the public surface water sewerage system via retention (subsurface storage), wetland (pocket wetland with surface baseflow), filtration (perimeter sand filter, filter trench) and source control (green roof, rainwater harvesting system, permeable pavement).

[20] CIRIA C697, The SuDS Manual, 2007

Table 5.9 of CIRIA C697[21] indicates:

- retention (subsurface storage) requires low maintenance, has high community acceptability, requires medium cost and has low habitat creation potential;
- wetland (pocket wetland with surface baseflow) requires high maintenance, has medium community acceptability, requires high cost and has high habitat creation potential;
- filtration (perimeter sand filter) requires medium maintenance, has low community acceptability, requires high cost and has low habitat creation potential;
- filtration (filter trench) requires medium maintenance, has medium community acceptability, requires high cost and has low habitat creation potential;
- source control (green roof) requires high maintenance, has high community acceptability, requires high cost and has high habitat creation potential;
- source control (rainwater harvesting system) requires high maintenance, has medium community acceptability, requires high cost and has low habitat creation potential;
- source control (permeable pavement) requires medium maintenance, has medium community acceptability, requires medium cost and has low habitat creation potential.

The disruptive aspects of incorporating source control (rainwater harvesting, permeable pavements) and wetland (pocket wetland with surface baseflow) into the development design - coupled with the high maintenance and high cost - indicates that there are no opportunities for these SuDS techniques.

There are opportunities for the following SuDS techniques:

- retention (subsurface storage) prior to release at a controlled rate;
- filtration (perimeter sand filter, filter trench); and,
- source control (green roof).

[21] CIRIA C697, The SuDS Manual, 2007

5.0 Planning and Agreement of Design Criteria

5.1 Hydraulic Design Criteria

- discharges from the site to be limited to pre development flow rates;
- attenuation storage volume required to cater for the 100 year critical event;
- long term storage required to prevent increase in downstream flood risk;
- uplift on extreme rainfall intensities of 40% when designing for the '2080s' (2070 to 2115)[22]; and,
- risk associated with blockage at key locations to be identified and accommodated appropriately.

'For small areas with less than 4000m^2 of impermeable surface, Thames Water expects developers to produce a peak flow surface water design using a constant rate rainfall approach (50mm/hr) as recommended in BSEN752 NA 4.2.2. Whist it is acceptable to use this approach on larger sites it is acknowledged that a more economic drainage design is likely to be achieved using a more complex method such as a computer simulation model'[23].

5.1.1 Intensive Green Roof

Please see Section 12.4 of CIRIA C753, The SuDS Manual, 2015 for Hydraulic Design Requirements for Green Roofs.

5.2 Water Quality Design Criteria

In accordance with CIRIA C753, The SuDS Manual, 2015[24] runoff discharged from the site should be of an acceptable water quality to protect surface water and groundwaters effectively (Section 4.2.2 of CIRIA 753, 2015) and the SuDS treatment design should take into account the potential impacts of climate change on the system processes and associated performance (Section 4.2.3 of CIRIA 753, 2015).

[22] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[23] Thames Water Addendum to Sewers for Adoption 7th Edition Nov 2012
[24] CIRIA C753, The SuDS Manual, 2015

5.2.1 Intensive Green Roof

Please see Section 12.5 of CIRIA C753, The SuDS Manual, 2015 for Treatment Design Requirements for Green Roofs.

5.3 Amenity Design Criteria

Indicators can be used to evaluate the extent to which the amenity design criteria are being delivered by a SuDS design. The amenity design criteria and example indicators are presented in Table 5.2 of CIRIA 753, 2015[25].

5.3.1 Intensive Green Roof

Please see Section 12.6 of CIRIA C753, The SuDS Manual, 2015 for Amenity Design Requirements for Green Roofs.

5.4 Biodiversity Design Criteria

Indicators can be used to evaluate the extent to which the amenity design criteria are being delivered by a SuDS design. The amenity design criteria and example indicators are presented in Table 6.1 of CIRIA 753, 2015[26].

5.4.1 Intensive Green Roof

Please see Section 12.7 of CIRIA C753, The SuDS Manual, 2015[27] for Biodiversity Design Requirements for Green Roofs.

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[25] CIRIA C753, The SuDS Manual, 2015
[26] CIRIA C753, The SuDS Manual, 2015
[27] CIRIA C753, The SuDS Manual, 2015

6.0 Management of Surface Water Run-off

6.1 Site Information

The site area is circa 545m^2.

The percentage impermeable area (PIMP) of the site pre and post development is 100%.

6.2 Peak Rate and Volume of Runoff

Calculations for Peak Discharge Rates and required Storage Volumes Post Development in line with London Borough of Camden Councils Surface Water Drainage Pro-forma for new developments (Appendix A) are included in Appendices B-D.

The discharge rates have been set as low as possible while also ensuring that there is not a risk to the development in case of blockage (see section 6.2.1 and 6.2.2 below).

6.2.1 Intensive Green Roof

Please see Figure 9 Sustainable Drainage Plan.

It is proposed the 380m^2 green roof will comprise of a 300mm substrate (general planting) with an underlying 60mm drainage mat filled with Bauder Mineral Drain[28] or similar. The substrate will be recycled crushed brick, expanded clay shale and composted pine bark or similar[29]. Based on maximum roof cross sectional area dimensions of 28.05x0.30m; a Sandy GRAVEL composition[30]; and a flat roof with a pitch of 1:80[31], the flow capacity of this filter media is estimated to be 3.16 l/s.

Once the drainage mat is full and the substrate is saturated, rainwater from the green roof will discharge to 3 x 62mm diameter roof drain outlets with guards (maximum flow rate of 4.95 l/s). The maximum flow rate is based on a flat roof with a pitch of less than 1:80 and

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[28] http://www.bauder.co.uk/green-roofs/accessible-green-roofs-gardens/soft-and-hard-landscaping/full-garden-planting-scheme
[29] http://www.bauder.co.uk/assets/b/a/bauder-intensive-substrate.pdf
[30] CIRIA C753, The SuDS Manual, 2015
[31] FarBo® drainage outlets - technical data sheet

FarBo® FO-FLO 62mm outlets with FO-UG Universal Leafguards that can drain 60-160m^2 of roof area at a rate of 1.65 l/s[32]. 'A modular system for creating an inspection chamber around outlets and irrigation points in a living roof system'[33] will also be required.

The 3 x 62mm diameter roof drain outlets will discharge to 2 x 63mm diameter downpipes (maximum flow rate of 6.2 l/s[34]).

It is recommended that the minimum height of the perimeter raised roof edge system is 25mm above the green roof substrate surface level.

Because the use of intensive green roofs and roof drain flow controls may result in full drainage mats and saturated substrates on the roof during extreme rainfall events (e.g. the 100 year + 30% CC), a structural engineer must design the roof structures to handle the additional loads.

6.2.2 Terraced Areas

Please see Figure 9 Sustainable Drainage Plan and Appendix D for proposed 150mm diameter surface water sewer pipe MicroDrainage Calculation in relation to 1 in 100 + 30% CC peak discharge flow rate from the ground floor terrace.

Exposed terraced areas are proposed to the front (fourth storey) and to the rear (ground floor).

Rainwater from the fourth storey terrace (around 60m^2) will discharge to 8 x 50mm diameter roof drain outlets with guards and sumps on the basis that each of the 4 flats terraces require two roof drain outlets in case of blockage (maximum flow rate of 13.60 l/s). The maximum flow rate is based on a terrace with a pitch of less than 1:80 and FarBo® FO-FLO 50mm outlets with FO-BG Bacony Leafguards and 50mm sumps that can drain 50-90m^2 of terrace area at a rate of 1.70 l/s[35].

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[32] FIXFAST, Flat Roof Drainage Systems, Product Overview
[33] http://www.fixfast.com/ProductGrp/JacBox

[34] RAINWATER DRAINAGE DESIGN BS EN12056:3-2000 REVISED VERSION, MGMA Information Sheet No 03, July 2012
[35] FIXFAST, Flat Roof Drainage Systems, Product Overview

The 8 x 50mm diameter roof drain outlets will discharge to a 63mm diameter downpipe (maximum flow rate of 3.1 l/s[36]).

Rainwater from the ground floor terrace (around 55m^2) will discharge to 4 x 50mm diameter roof drain outlets with guards and sumps on the basis each terrace requires two roof drain outlets in case of blockage (maximum flow rate of 6.80 l/s). The maximum flow rate is based on a terrace with a pitch of less than 1:80 and FarBo® FO-FLO 50mm outlets with FO-BG Bacony Leafguards and 50mm sumps that can drain 50-90m^2 of terrace area at a rate of 1.70 l/s[37].

The 4 x 50mm diameter roof drain outlets will discharge to a proposed 150mm diameter surface water sewer pipe with minimum 1 in 150 fall towards Hampshire Street combined public sewer (1 in 100 +CC peak discharge flow rate from ground floor terrace equals 1.1 l/s).

6.3 Management and Maintenance Requirements

Responsibility for the management and maintenance of the roof and terrace drainage will rest with the buildings maintenance manager or similar.

Periodic inspection is essential and should be carried out to ensure that the roofs and terrace drainage infrastructure is free from debris which could impair its performance.

Inspection and cleaning of silt and other debris from the roofs, terraces, inlets, outlets and filters should be undertaken annually and after severe storms/poor performance.

6.3.1 Intensive Green Roof

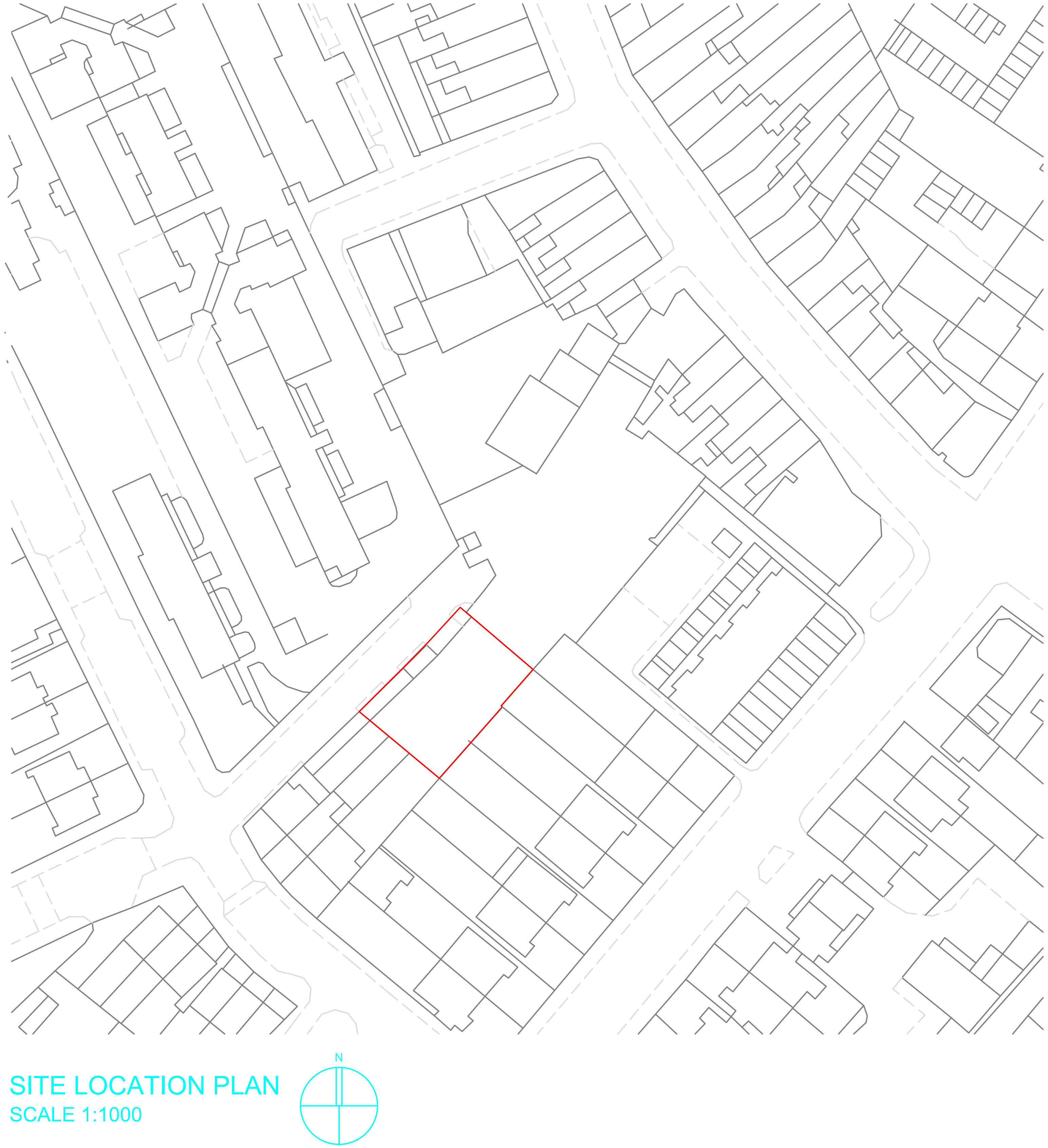
Please see Section 12.12 of CIRIA C753, The SuDS Manual, 2015 for Operation and Maintenance Requirements for Intensive Green Roofs.

[36] RAINWATER DRAINAGE DESIGN BS EN12056:3-2000 REVISED VERSION, MGMA Information Sheet No 03, July 2012

[37] FIXFAST, Flat Roof Drainage Systems, Product Overview

Figures

NOTES



SITE LOCATION PLAN
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SITE BOUNDARY

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revision:	description:	date:
P.01	Issued for PLANNING	23.01.17

P L A N N I N G

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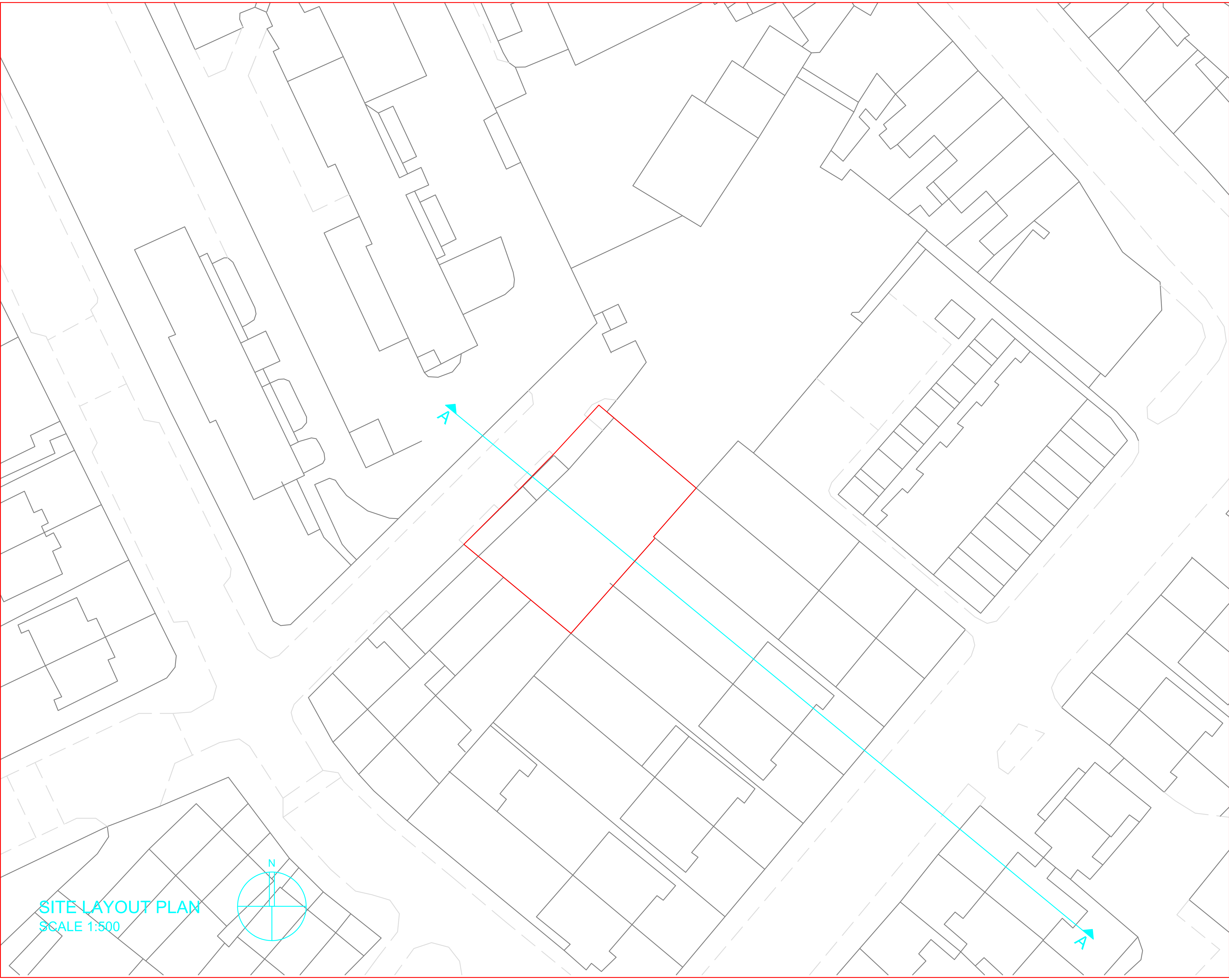

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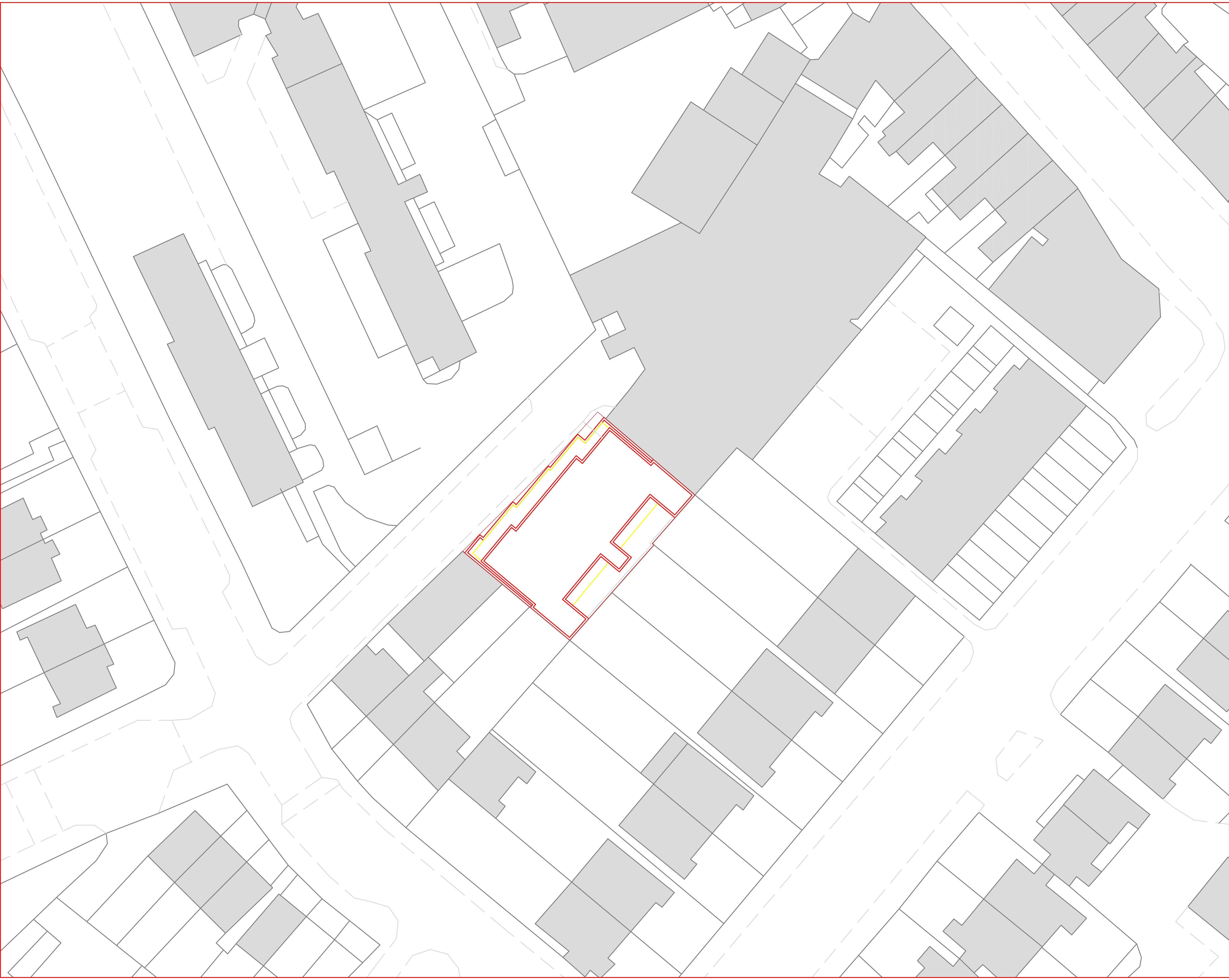

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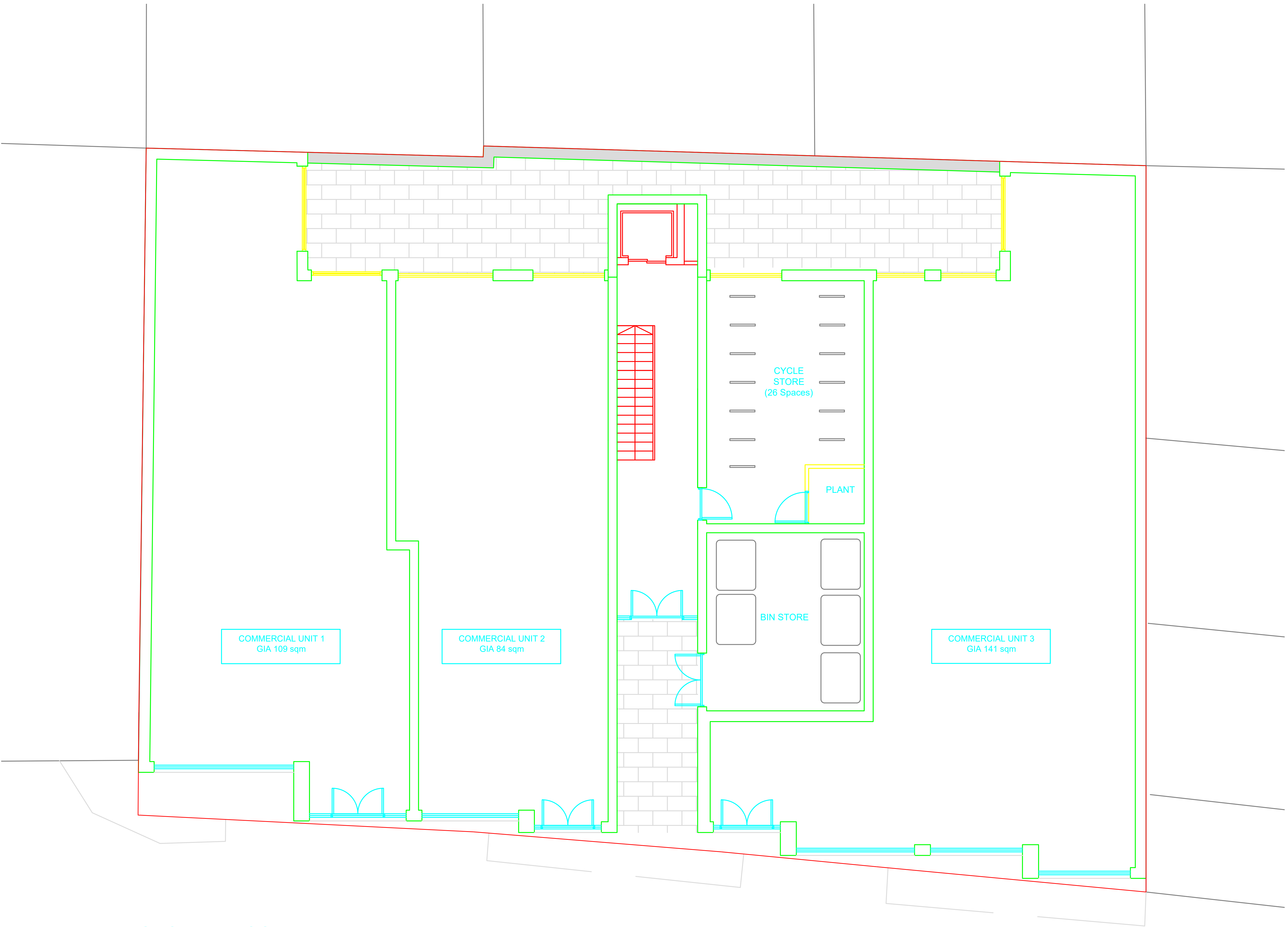

GROUND FLOOR PLAN

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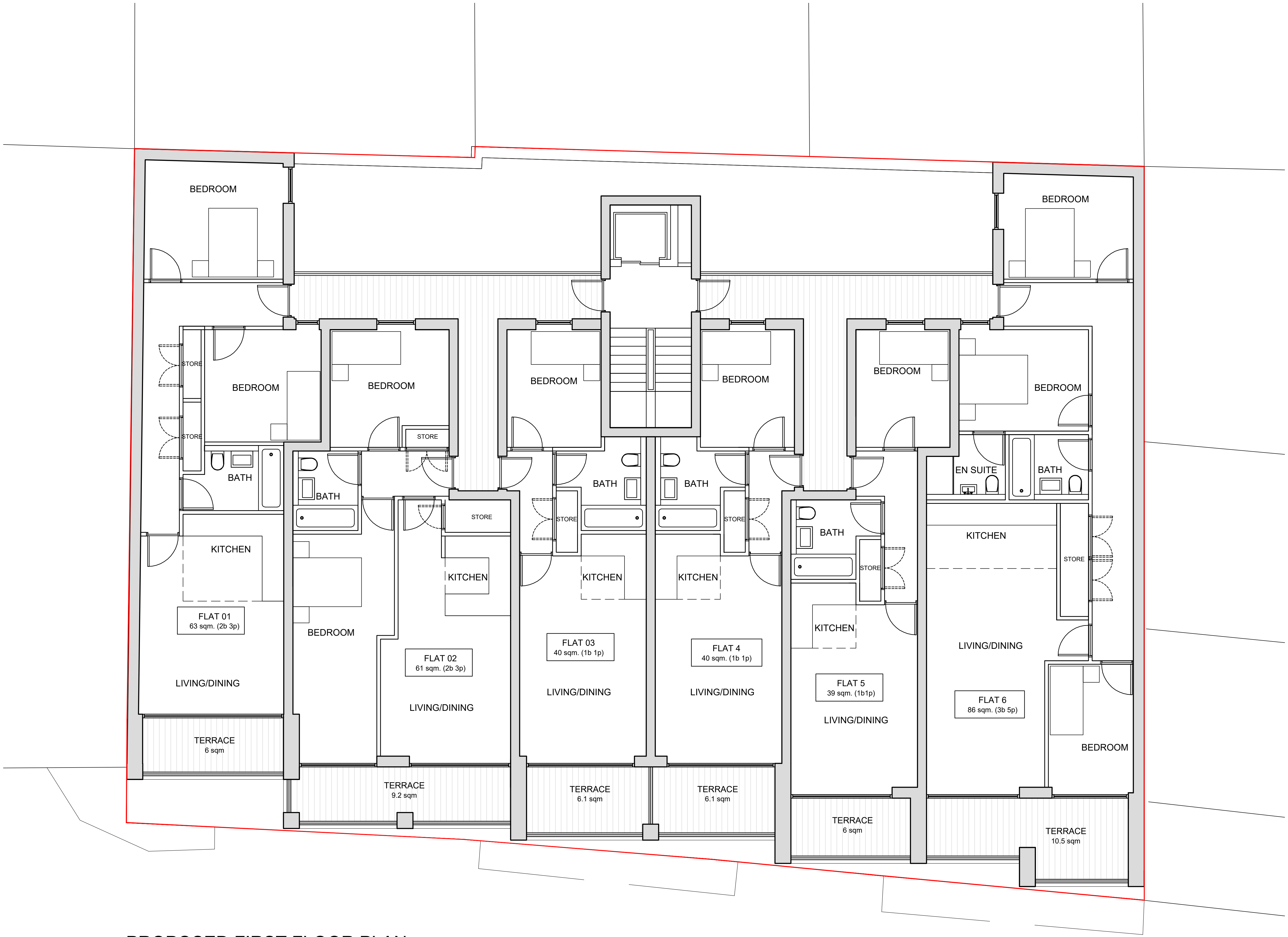

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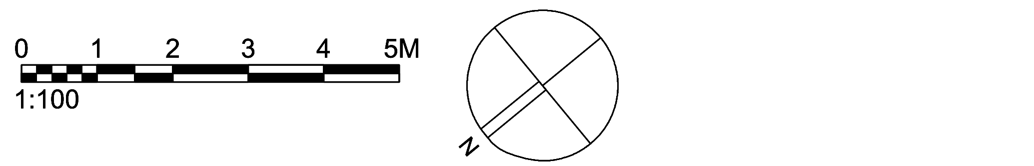

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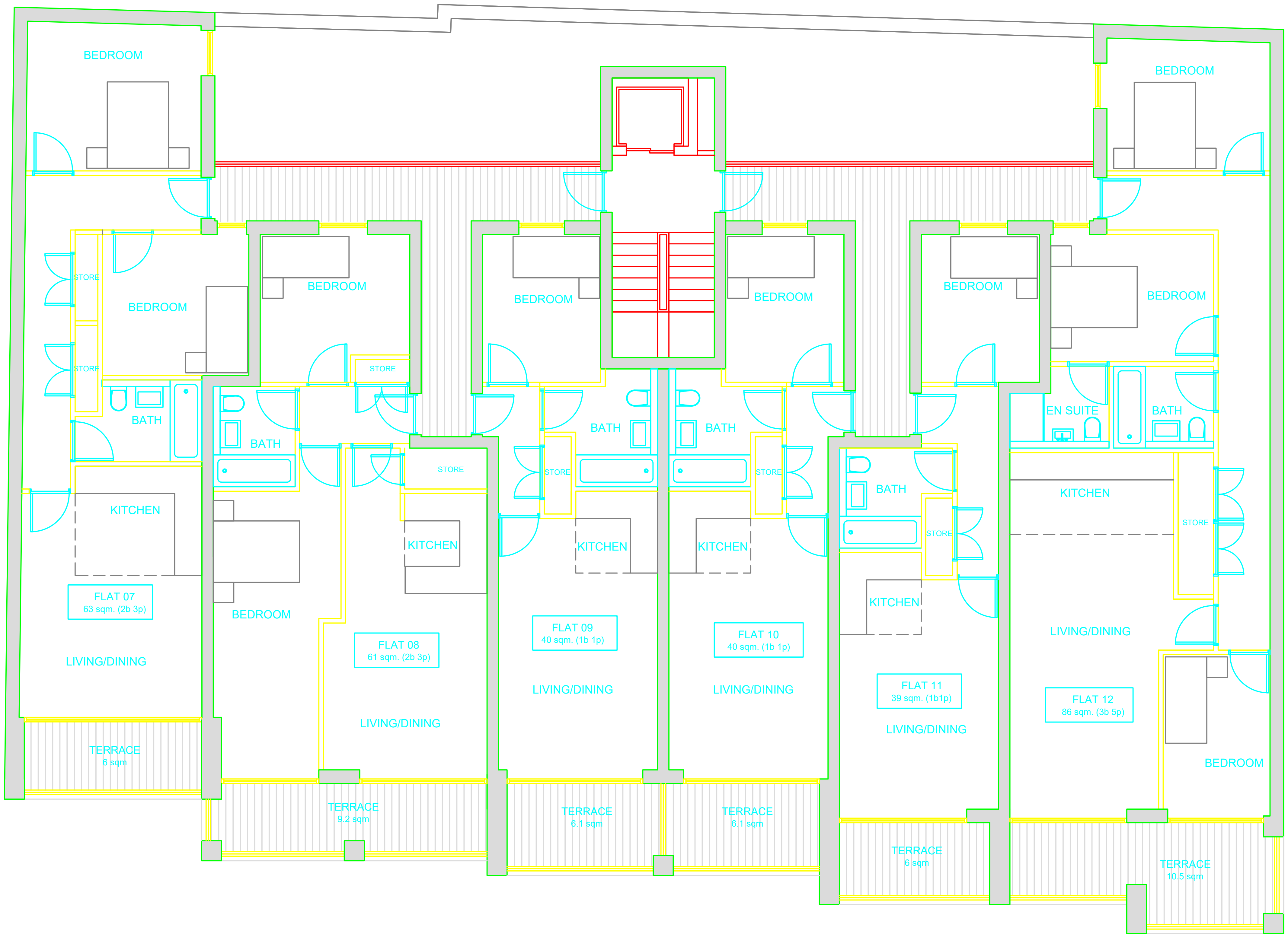

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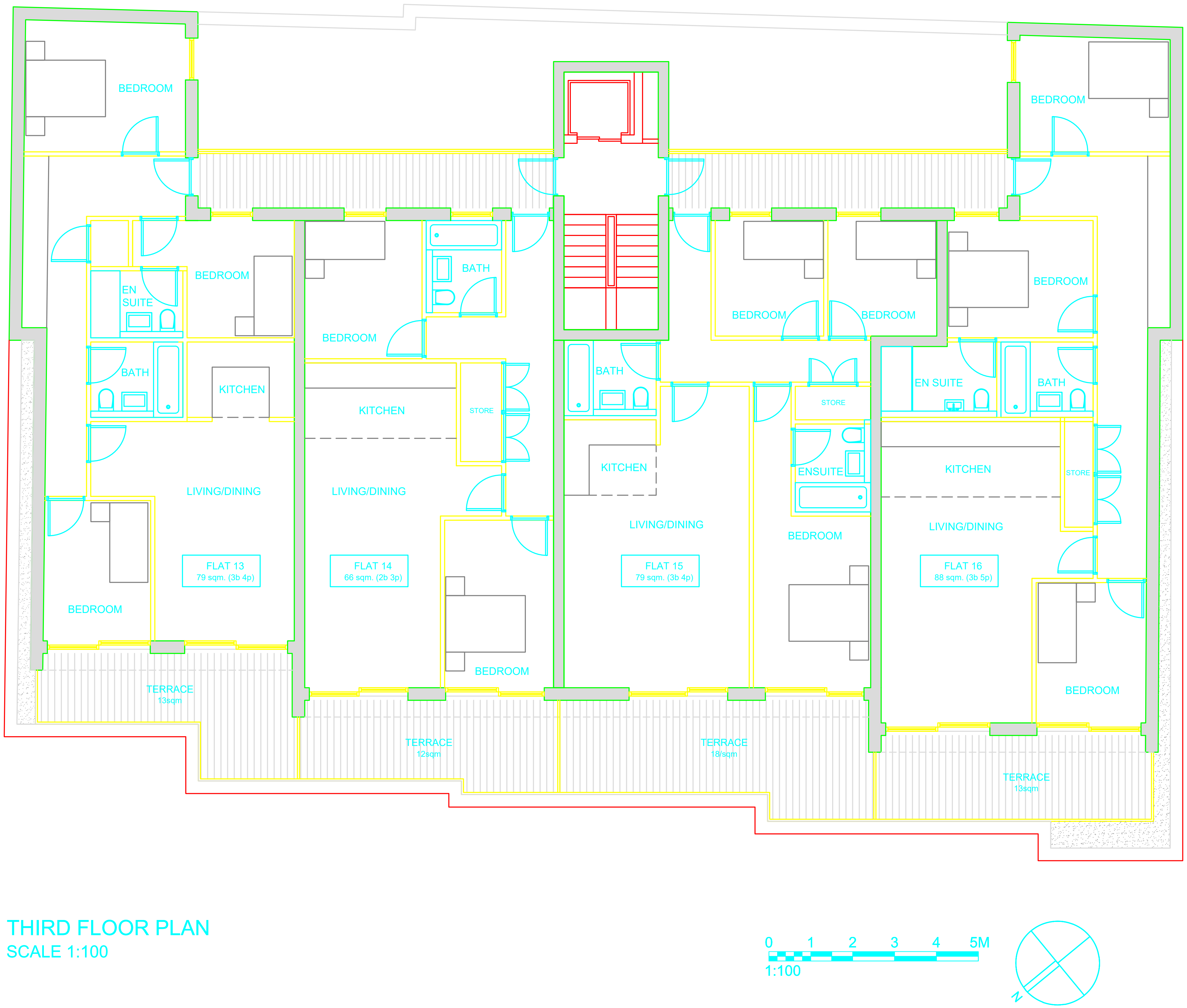

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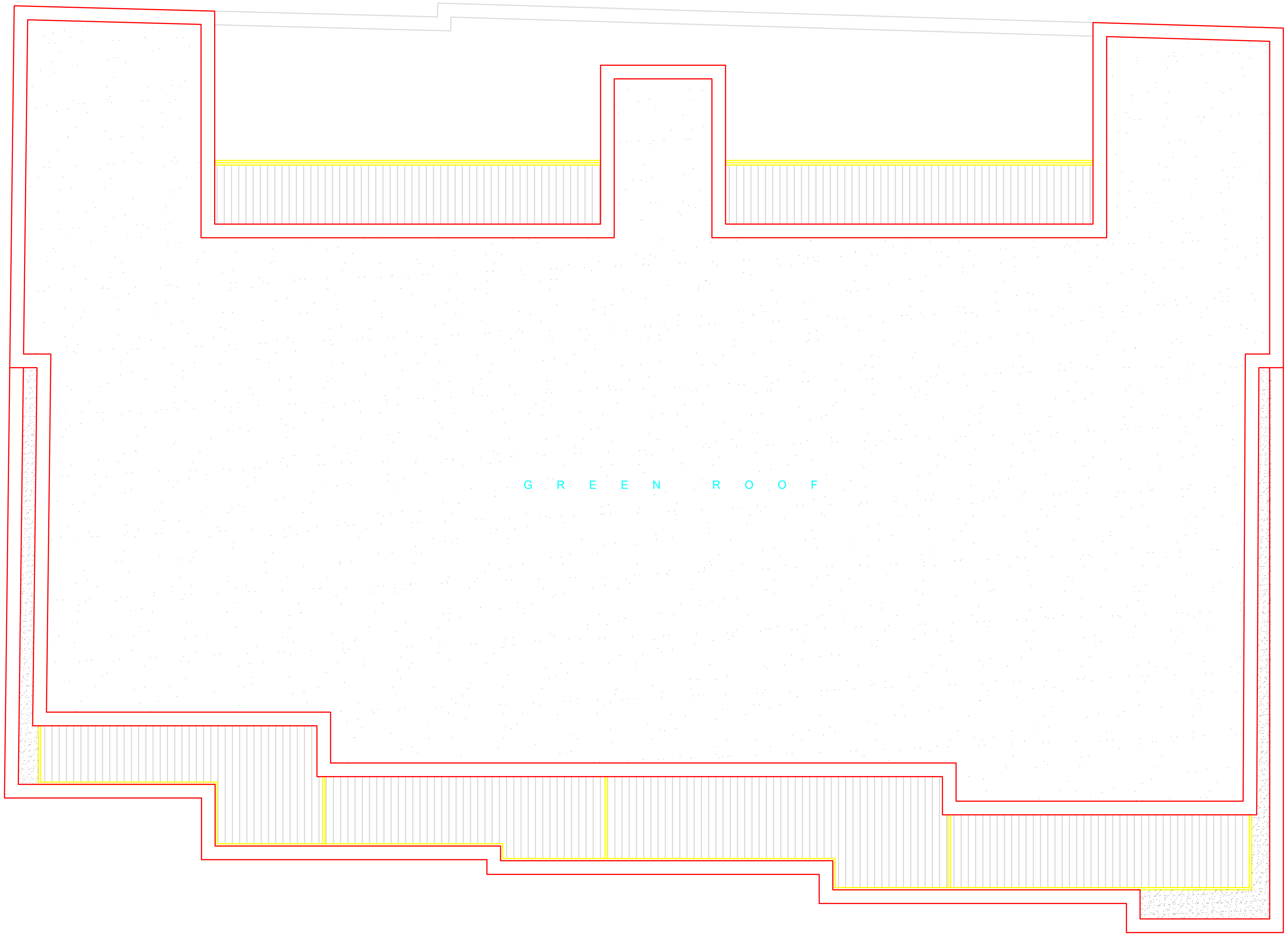
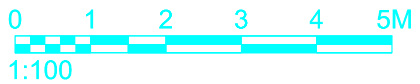
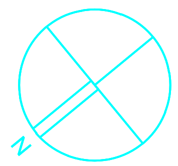


ROOF PLAN
SCALE 1:100





drawing status:	PLANNING

revision:	description:	date:
P.01	Issued for INFORMATION	23.01.17

PLANNING

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project:	**17-010** - 2 Hampshire Street, Camden		
drawing:	PROPOSED ROOF PLAN		
date:	18.04.17	drawn by: LM	check: CC
scale:	1:100@A3	drwg no.: 304	rev. no.: P.01

build energy

compliance
testing
consulting

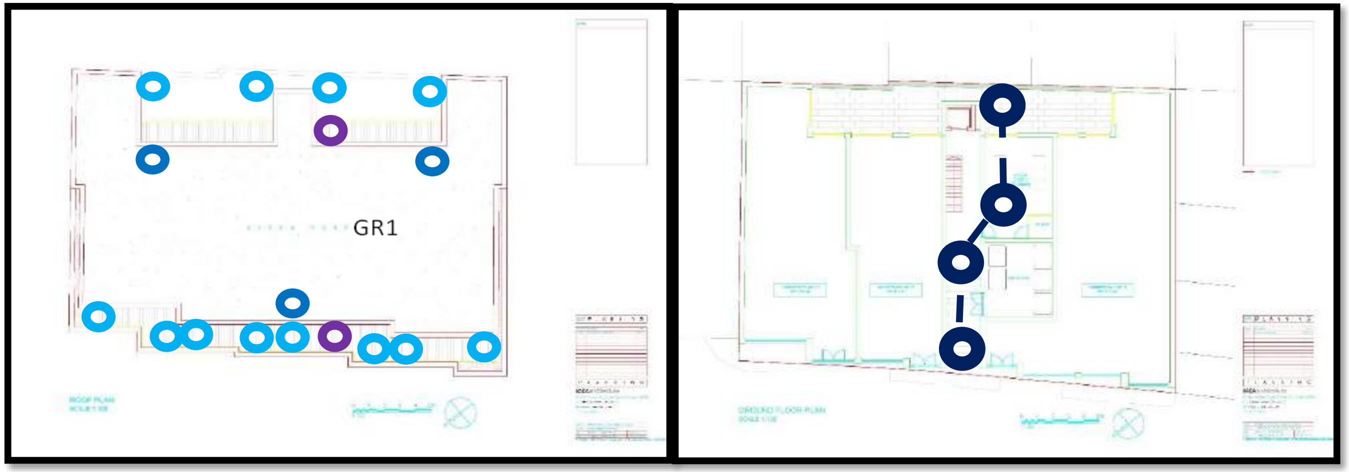

Figure 9 Proposed Sustainable Drainage Plan

Key

- (light blue circle) Approximate Location of Proposed 50mm Diameter Terrace Drain With FarBo® FO-BG Balcony Leafguards and sumps or Similar
- (dark blue circle) Approximate Location of Proposed 62mm Diameter Roof Drain With FarBo® FO-UG Universal Leafguards and Modular System for Creating an Inspection Chamber Around Outlet or Similar
- (purple circle) Approximate Location of Proposed 63mm Diameter Downpipe

GR1 Green roof comprising of 300mm substrate (general planting) with underlying 60mm drainage mat filled with Bauder Mineral Drain or similar

(dashed line) Approximate route of proposed 150mm diameter surface water sewer pipe with minimum 1 in 150 fall towards Hampshire Street combined public sewer

(navy circle) Proposed surface water inspection chamber

Notes

It is recommended that the minimum height of the perimeter raised roof edge system is 25mm above the green roof substrate surface level.

Appendices

Appendix A London Borough of Camden Councils Surface Water Drainage Pro-forma

Advice Note on contents of a Surface Water Drainage Statement

London Borough of Camden

1. Introduction

1.1 The Government has strengthened planning policy on the provision of sustainable drainage and new consultation arrangements for 'major' planning applications will come into force from 6 April 2015 as defined in the Written Ministerial Statement (18th Dec 2014).

1.2 The new requirements make Lead Local Flood Authorises statutory consultees with respect to flood risk and SuDS for all major applications. Previously the Environment Agency had that statutory responsibility for sites above 1ha in flood zone 1.

1.3 Therefore all 'major' planning applications submitted from 6 April 2015 are required demonstrate compliance with this policy and we'd encourage this is shown in a **Surface Water Drainage Statement**.

1.4 The purpose of this advice note is to set out what information should be included in such statements.

2. Requirements

2.1 It is essential that the type of Sustainable Drainage System (SuDS) for a site, along with **details of its extent and position**, is identified within the planning application to clearly demonstrate that the proposed SuDS can be accommodated within the development.

2.2 It will now not be acceptable to leave the design of SuDs to a later stage to be dealt with by planning conditions.

2.3 The NPPF paragraph 103 requires that developments do not increase flood risk elsewhere, and gives priority to the use of SuDS. Major developments must include SuDS for the management of run-off, unless demonstrated to be inappropriate. The proposed minimum standards of operation must be appropriate and as such, a **maintenance plan** should be included within the Surface Water Drainage Statement,clearly demonstrating that the SuDS have been designed to ensure that the maintenance and operation requirements are economically proportionate Planning Practice Guidance suggests that this should be considered by reference to the costs that would be incurred by consumers for the use of an effective drainage system connecting directly to a public sewer.

2.4 Camden Council will use planning conditions or obligations to ensure that there are clear arrangements in place for ongoing maintenance over the lifetime of the development.

2.5 Within Camden, SuDS systems must be designed in accordance with London Plan policy 5.13. This requires that developments should utilise sustainable urban drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve **greenfield run-off rates** and ensure that surface water run-off is managed as close to its source as possible in line with the following **drainage hierarchy**:

1 store rainwater for later use
2 use infiltration techniques, such as porous surfaces in non-clay areas
3 attenuate rainwater in ponds or open water features for gradual release
4 attenuate rainwater by storing in tanks or sealed water features for gradual release
5 discharge rainwater direct to a watercourse
6 discharge rainwater to a surface water sewer/drain
7 discharge rainwater to the combined sewer.

2.6 The hierarchy above seeks to ensure that surface water run-off is controlled as near to its source as possible to mimic natural drainage systems and retain water on or near to the site, in contrast to traditional drainage approaches, which tend to pipe water off-site as quickly as possible.

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

2.8 Best practice guidance within the non-statutory technical standards for the design, maintenance and operation of sustainable drainage systems will also need to be followed. Runoff volumes 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.

2.9 Camden Development Policy 23 (Water) requires developments to reduce pressure on combined sewer network and the risk of flooding by limiting the rate of run-off through sustainable urban drainage systems. This policy also requires that developments in areas known to be at risk of surface water flooding are designed to cope with being flooded. Camden's SFRA surface water flood maps, updated SFRA figures 6 (LFRZs), and 4e (increased susceptibility to elevated groundwater) , as well as the Environment Agency updated flood maps for surface water (ufmfsw), should be referred to when determining whether developments are in an area at risk of flooding.

2.10 Camden Planning Guidance 3 (CPG3) requires developments to achieve a greenfield run off rate once SuDS have been installed. Where it can be demonstrated that this is not feasible, a minimum 50% reduction in run off rate across the development is required. Further guidance on how to reduce the risk of flooding can be found in CPG3 paragraphs 11.4-11.8.

2.11 Where an application is part of a larger site which already has planning permission it is essential that the new proposal does not compromise the drainage scheme already approved.

3. Further information and guidance

3.1 Applicants are strongly advised to discuss their proposals with the Lead Local Flood Authority at the pre-application stage to ensure that an acceptable SuDS scheme is submitted.

3.2 For general clarification of these requirements please Camden's Local Planning Authority or Lead Local Flood Authority

Surface Water Drainage Pro-forma for new developments

This pro-forma accompanies our advice note on surface water drainage. Developers should complete this form and submit it to the Local Planning Authority, referencing from where in their submission documents this information is taken. The pro-forma is supported by the Defra/EA guidance on Rainfall Runoff Management and uses the storage calculator on www.UKsuds.com. This pro-forma is based on current industry best practice and focuses on ensuring surface water drainage proposals meet national and local policy requirements. The pro-forma should be considered alongside other supporting SuDS Guidance.

1. Site Details

Site	1 Hampshire Street, Camden, NW5 2TE
Address & post code or LPA reference	2017/2883/P
Grid reference	529716,184954
Is the existing site developed or Greenfield?	Developed
Is the development in a LFRZ or in an area known to be at risk of surface or ground water flooding? If yes, please demonstrate how this is managed, in line with DP23?	No
Total Site Area served by drainage system (excluding open space) (Ha)*	0.0545

***** The Greenfield runoff off rate from the development which is to be used for assessing the requirements for limiting discharge flow rates and attenuation storage from a site should be calculated for the area that forms the drainage network for the site whatever size of site and type of drainage technique. Please refer to the Rainfall Runoff Management document or CIRIA manual for detail on this.

2. Impermeable Area

	Existing	Proposed	Difference (Proposed-Existing)	Notes for developers
Impermeable area (ha)	0.0545	0.0545	0	If the proposed amount of impermeable surface is greater, then runoff rates and volumes will increase. Section 6 must be filled in. If proposed impermeability is equal or less than existing, then section 6 can be skipped and section 7 filled in.
Drainage Method (infiltration/sewer/watercourse)	sewer	sewer	N/A	If different from the existing, please fill in section 3. If existing drainage is by infiltration and the proposed is not, discharge volumes may increase. Fill in section 6.

3. Proposing to Discharge Surface Water via

	Yes	No	Evidence that this is possible	Notes for developers
Existing and proposed MicroDrainage calculations				Please provide MicroDrainage calculations of existing and proposed run-off rates and volumes in accordance with a recognised methodology or the results of a full infiltration test (see line below) if infiltration is proposed.
Infiltration				e.g. soakage tests. Section 6 (infiltration) must be filled in if infiltration is proposed.
To watercourse				e.g. Is there a watercourse nearby?
To surface water sewer				Confirmation from sewer provider that sufficient capacity exists for this connection.
Combination of above				e.g. part infiltration part discharge to sewer or watercourse. Provide evidence above.
Has the drainage proposal had regard to the SuDS hierarchy?				Evidence must be provided to demonstrate that the proposed Sustainable Drainage strategy has had regard to the SuDS hierarchy as outlined in Section 2.5 above.
Layout plan showing where the sustainable drainage infrastructure will be located on site.				Please provide plan reference numbers showing the details of the site layout showing where the sustainable drainage infrastructure will be located on the site. If the development is to be constructed in phases this should be shown on a separate plan and confirmation should be provided that the sustainable drainage proposal for each phase can be constructed and can operate independently and is not reliant on any later phase of development.

4. Peak Discharge Rates – This is the maximum flow rate at which storm water runoff leaves the site during a particular storm event.

	Existing Rates (l/s)	Proposed Rates (l/s)	Difference (l/s) (Proposed-Existing)	% Difference (difference /existing x 100)	Notes for developers
Greenfield QBAR		N/A	N/A	N/A	QBAR is approx. 1 in 2 storm event. Provide this if Section 6 (QBAR) is proposed.
1 in 1	5.61	1.77	3.84	68	Proposed discharge rates (with mitigation) should aim to be equivalent to greenfield rates for all corresponding storm events. As a minimum, peak discharge rates must be reduced by 50% from the existing sites for all corresponding rainfall events.
1 in 30	14.39	4.55	9.84	68	
1in 100	21.05	6.65	14.4	68	
1 in 100 plus climate change	N/A	6.65	14.4	68	The proposed 1 in 100 +CC peak discharge rate (with mitigation) should aim to be equivalent to greenfield rates. As a minimum, proposed 1 in 100 +CC peak discharge rate must be reduced by 50% from the existing 1 in 100 runoff rate sites.

5. Calculate additional volumes for storage –The total volume of water leaving the development site. New hard surfaces potentially restrict the amount of stormwater that can go to the ground, so this needs to be controlled so not to make flood risk worse to properties downstream.

	Greenfield runoff volume (m^3)	Existing Volume (m^3)	Proposed Volume (m^3)	Difference (m^3) (Proposed-Existing)	Notes for developers
1 in 1					Proposed discharge volumes (with mitigation) should be constrained to a value as close as is reasonably practicable to the greenfield runoff volume wherever practicable and as a minimum should be no greater than existing volumes for all corresponding storm events. Any increase in volume increases flood risk elsewhere. Where volumes are increased section 6 must be filled in.
1 in 30					
1in 100 6 hour	2.13	60.59	19.15	41.44	
1 in 100 6 hour plus climate change	2.13	60.59	19.15	41.44	The proposed 1 in 100 +CC discharge volume should be constrained to a value as close as is reasonably practicable to the greenfield runoff volume wherever practicable. As a minimum, to mitigate for climate change the proposed 1 in 100 +CC volume discharge from site must be no greater than the existing 1 in 100 storm event. If not, flood risk increases under climate change.

6. Calculate attenuation storage – Attenuation storage is provided to enable the rate of runoff from the site into the receiving watercourse to be limited to an acceptable rate to protect against erosion and flooding downstream. The attenuation storage volume is a function of the degree of development relative to the greenfield discharge rate.

		Notes for developers
Storage Attenuation volume (Flow rate control) required to meet greenfield run off rates (m^3)		Volume of water to attenuate on site if discharging at a greenfield run off rate. Can't be used where discharge volumes are increasing
Storage Attenuation volume (Flow rate control) required to reduce rates by 50% (m^3)		Volume of water to attenuate on site if discharging at a 50% reduction from existing rates. Can't be used where discharge volumes are increasing
Storage Attenuation volume (Flow rate control) required to meet [OTHER RUN OFF RATE (as close to greenfield rate as possible] (m^3)		Volume of water to attenuate on site if discharging at a rate different from the above – please state in 1st column what rate this volume corresponds to. On previously developed sites, runoff rates should not be more than three times the calculated greenfield rate. Can't be used where discharge volumes are increasing
Storage Attenuation volume (Flow rate control) required to retain rates as existing (m^3)		Volume of water to attenuate on site if discharging at existing rates. Can't be used where discharge volumes are increasing
Percentage of attenuation volume stored above ground,		Percentage of attenuation volume which will be held above ground in swales/ponds/basins/green roofs etc. If 0, please demonstrate why.

7. How is Storm Water stored on site?

Storage is required for the additional volume from site but also for holding back water to slow down the rate from the site. This is known as attenuation storage and long term storage. The idea is that the additional volume does not get into the watercourses, or if it does it is at an exceptionally low rate. You can either infiltrate the stored water back to ground, or if this isn't possible hold it back with on site storage. Firstly, can infiltration work on site?

			Notes for developers
Infiltration	**State the Site's Geology and known Source Protection Zones (SPZ)**	London Clay	Avoid infiltrating in made ground. Infiltration rates are highly variable and refer to Environment Agency website to identify and source protection zones (SPZ)
	Are infiltration rates suitable?	No (< 3x10-8 m/s).	Infiltration rates should be no lower than $1x10^{-6}$ m/s.
	State the distance between a proposed infiltration device base and the ground water (GW) level	No site specific information	Need 1m (min) between the base of the infiltration device & the water table to protect Groundwater quality & ensure GW doesn't enter infiltration devices. Avoid infiltration where this isn't possible.

	Were infiltration rates obtained by desk study or infiltration test?	Desktop study i.e. BGS Geoindex website and reference to Table 25.1 of CIRIA C753, The SuDS Manual, 2015.	Infiltration rates can be estimated from desk studies at most stages of the planning system if a back up attenuation scheme is provided..
	Is the site contaminated? If yes, consider advice from others on whether infiltration can happen.	Not applicable	Advice on contaminated Land in Camden can be found on our supporting documents webpage Water should not be infiltrated through land that is contaminated. The Environment Agency may provide bespoke advice in planning consultations for contaminated sites that should be considered.
In light of the above, is infiltration feasible?	**Yes/No? If the answer is No, please identify how the storm water will be stored prior to release**	No. Intensive Green Roof.	If infiltration is not feasible how will the additional volume be stored?. The applicant should then consider the following options in the next section.

Storage requirements

The developer must confirm that either of the two methods for dealing with the amount of water that needs to be stored on site.

Option 1 Simple – Store both the additional volume and attenuation volume in order to make a final discharge from site at the greenfield run off rate. This is preferred if no infiltration can be made on site. This very simply satisfies the runoff rates and volume criteria.

Option 2 Complex – If some of the additional volume of water can be infiltrated back into the ground, the remainder can be discharged at a very low rate of 2 l/sec/hectare. A combined storage calculation using the partial permissible rate of 2 l/sec/hectare and the attenuation rate used to slow the runoff from site.

		Notes for developers
Please confirm what option has been chosen and how much storage is required on site.	Option 1 Simple. Storage required on site is 38.90 m3	The developer at this stage should have an idea of the site characteristics and be able to explain what the storage requirements are on site and how it will be achieved.

8. Please confirm

		Notes for developers
Which Drainage Systems measures have been used, including green roofs?	Intensive Green Roof	SUDS can be adapted for most situations even where infiltration isn't feasible e.g. impermeable liners beneath some SUDS devices allows treatment but not infiltration. See CIRIA SUDS Manual C697.
Drainage system can contain in the 1 in 30 storm event without flooding	Yes	This a requirement for sewers for adoption & is good practice even where drainage system is not adopted.
Will the drainage system contain the 1 in 100 +CC storm event? If no please demonstrate how buildings and utility plants will be protected.	Yes	National standards require that the drainage system is designed so that 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.
Any flooding between the 1 in 30 & 1 in 100 plus climate change storm events will be safely contained on site.	Yes	**Safely:** not causing property flooding or posing a hazard to site users i.e. no deeper than 300mm on roads/footpaths. Flood waters must drain away at section 6 rates. Existing rates can be used where runoff volumes are not increased.
How will exceedance events be catered on site without increasing flood risks (both on site and outside the development)?	Minimum height of the perimeter raised roof edge system will be 25mm above the green roof substrate surface level.	**Safely:** not causing property flooding or posing a hazard to site users i.e. no deeper than 300mm on roads/footpaths. Flood waters must drain away at section 6 rates. Existing rates can be used where runoff volumes are not increased. Exceedance events are defined as those larger than the 1 in 100 +CC event.
How are rates being restricted (vortex control, orifice etc)	300mm Intensive Green Roof substrate	Detail of how the flow control systems have been designed to avoid pipe blockages and ease of maintenance should be provided.
Please confirm the owners/adopters of the entire drainage systems throughout the development. Please list all the owners.	Buildings maintenance manager	If these are multiple owners then a drawing illustrating exactly what features will be within each owner's remit must be submitted with this Proforma.
How is the entire drainage system to be maintained?	Periodic inspection is essential and should be carried out to ensure that the roofs and terrace drainage infrastructure is free from debris which could impair its performance. Inspection and cleaning of silt and other debris from the roofs, terraces, inlets, outlets and filters should be undertaken annually and after severe storms/poor performance. Please see Section 12.12 of CIRIA C753, The SuDS Manual, 2015 for Operation and Maintenance Requirements for Extensive Green Roofs.	If the features are to be maintained directly by the owners as stated in answer to the above question please answer yes to this question and submit the relevant maintenance schedule for each feature. If it is to be maintained by others than above please give details of each feature and the maintenance schedule. Clear details of the maintenance proposals of all elements of the proposed drainage system must be provided. Details must demonstrate that maintenance and operation requirements are economically proportionate. Poorly maintained drainage can lead to increased flooding problems in the future.

9. Evidence Please identify where the details quoted in the sections above were taken from. i.e. Plans, reports etc. Please also provide relevant drawings that need to accompany your proforma, in particular exceedance routes and ownership and location of SuDS (maintenance access strips etc

Pro-forma Section	Document reference where details quoted above are taken from	Page Number
Section 2	Build Energy SuDS and FRA Report Revision 1 17072017 Section 2, Section 6, Figure 2 and Figure 3	5,7, 9,10,13, 21,Figures
Section 3	Drainage method same as existing. Not required to fill in this section based on notes for developers contained Section 2.	
Section 4	Build Energy SuDS and FRA Report Revision 1 17072017 Section 2, Section 6, Appendix B	8, 10, 22, 23,App B + D
Section 5	Build Energy SuDS and FRA Report Revision 1 17072017 Appendix B	Appendix B
Section 6	Poposed impermeability is equal to existing, Not required to fill in this section based on notes for developers contained in Section 2.	
Section 7	Build Energy SuDS and FRA Report Revision 1 17072017 Section 2 and Section 4	14,17-18
Section 8	Build Energy SuDS and FRA Report Revision 1 17072017 Section 3, Section 6 and Figure 9	15-16,21-24,Figures

The above form should be completed using evidence from the Flood Risk Assessment and site plans. It should serve as a summary sheet of the drainage proposals and should clearly show that the proposed rate and volume as a result of development will not be increasing. If there is an increase in rate or volume, the rate or volume section should be completed to set out how the additional rate/volume is being dealt with.

This form is completed using factual information from the Flood Risk Assessment and Site Plans and can be used as a summary of the surface water drainage strategy on this site.

Form Completed By Chris Gray……………………………………………………………………………………………

Qualification of person responsible for signing off this pro-forma B.Sc. Honours in Earth Science with 13 years post graduate experience

Company Gray Environmental Ltd……………………………………………………………………………………………

On behalf of (Client's details) Redtree (North London) Ltd……………………………………………………………

Date: 17/072017……………………………………

Appendix B Rate and Volume of Runoff Calculations

GREENFIELD ESTIMATION OF PEAK FLOW RATE OF RUNOFF

No.	ASV1	Abbreviation	Calculations	Value			
1	Hydrological Region	R		6			
2	(SOIL) type (1-5)	S		4			
3	Development Size	A		0.05	ha		
4	Method of Greenfield Analysis			If development area is 200+ ha a full FEH analysis is recommended to obtain a more accurate estimate of greenfield runoff characteristics			
No.	**ASV2**	**Abbreviation**	**Calculations**	**Value**			
5	Area	A		0.05	ha		
6	Annual Rainfall	SAAR		629	mm		
7	Soil runoff coefficient	SPR		0.47			
8	Development mean annual peak flow rate	QBAR	213.00	0.23	l/s		
9	Mean annual peak flow per unit area	QBAR/A	4.26	4.26	l/s/ha		
10	Minimum limit of discharge	Qthrottle		Minimum sizes of an orofice may limit the minimum hydraulic control flow rate. This allows the derivation of an equivalent value of a QBAR/A	l/s		
10.1	100 year flow rate per unit area	Qthrottle/A			l/s/ha		
10.2	Equivalent mean annual peak flow per unit area	Qthrottle/3.5A			l/s/ha		
11	1yr, 30 yr and 100yr peak discharge rate of runoff per unit area			Use the larger of the 2 values of item 9 and 10.2 for calculating 11.1 to 11.3			
11.1		Q1yr		3.62	l/s/ha	0.20	l/s
		Q2yr		3.75	l/s/ha	0.20	l/s
		Q5yr		5.45	l/s/ha	0.30	l/s
		Q10yr		6.90	l/s/ha	0.38	l/s
11.2		Q30yr		9.29	l/s/ha	0.51	l/s
11.3		Q100yr		13.59	l/s/ha	0.74	l/s

BROWNFIELD ESTIMATION OF PEAK FLOW RATE OF RUNOFF

No.	ASV1	Abbreviation	Calculations	Value			
1	Hydrological Region	R		6			
2	(SOIL) type (1-5)	S		5			
3	Development Size	A		0.05	ha		
4	Method of Greenfield Analysis			If development area is 200+ ha a full FEH analysis is recommended to obtain a more accurate estimate of greenfield runoff characteristics			
No.	ASV2	Abbreviation	Calculations	Value			
5	Area	A		0.05	ha		
6	Annual Rainfall	SAAR		629	mm		
7	Soil runoff coefficient	SPR		0.53			
8	Development mean annual peak flow rate	QBAR	276.44	0.30	l/s		
9	Mean annual peak flow per unit area	QBAR/A	5.53	5.53	l/s/ha		
10	Minimum limit of discharge	Qthrottle	Minimum sizes of an orifice may limit the minimum hydraulic control flow rate. This allows the derivation of an equivalent value of QBAR/A	23.1	l/s		
10.1	100 year flow rate per unit area	Qthrottle/A		424.04	l/s/ha		
10.2	Equivalent mean annual peak flow per unit area	Qthrottle/3.5A		121.15	l/s/ha		
11	1yr, 30 yr and 100yr peak discharge rate of runoff per unit area			Use the larger of the 2 values of item 9 and 10.2 for calculating 11.1 to 11.3			
11.1		Q1yr		102.98	l/s/ha	5.61	l/s
		Q2yr		106.62	l/s/ha	5.81	l/s
		Q5yr		155.08	l/s/ha	8.45	l/s
		Q10yr		196.27	l/s/ha	10.69	l/s
11.2		Q30yr		264.12	l/s/ha	14.39	l/s
11.3		Q100yr		386.48	l/s/ha	21.05	l/s

BROWNFIELD ESTIMATION OF PEAK FLOW RATE OF RUNOFF

No.	ASV1	Abbreviation	Calculations	Value		
1	Hydrological Region	R		6		
2	(SOIL) type (1-5)	S		5		
3	Development Size	A		0.01 ha		
4	Method of Greenfield Analysis			If development area is 200+ ha a full FEH analysis is recommended to obtain a more accurate estimate of greenfield runoff characteristics		
No.	ASV2	Abbreviation	Calculations	Value		
5	Area	A		0.01 ha		
6	Annual Rainfall	SAAR		629 mm		
7	Soil runoff coefficient	SPR		0.53		
8	Development mean annual peak flow rate	QBAR	276.44	0.08 l/s		
9	Mean annual peak flow per unit area	QBAR/A	5.53	5.53 l/s/ha		
10	Minimum limit of discharge	Qthrottle	Minimum sizes of an orifice may limit the minimum hydraulic control flow rate. This allows the derivation of an equivalent value of QBAR/A	7.3 l/s		
10.1	100 year flow rate per unit area	Qthrottle/A		521.43 l/s/ha		
10.2	Equivalent mean annual peak flow per unit area	Qthrottle/3.5A		148.98 l/s/ha		
11	1yr, 30 yr and 100yr peak discharge rate of runoff per unit area			Use the larger of the 2 values of item 9 and 10.2 for calculating 11.1 to 11.3		
11.1		Q1yr		126.63 l/s/ha	1.77	l/s
		Q2yr		131.10 l/s/ha	1.84	l/s
		Q5yr		190.69 l/s/ha	2.67	l/s
		Q10yr		241.35 l/s/ha	3.38	l/s
11.2		Q30yr		324.78 l/s/ha	4.55	l/s
11.3		Q100yr		475.24 l/s/ha	6.65	l/s

	Abbreviation	Calculations	Value	
Impermeable area	R A		544.78	m^2

TOTAL VOLUME OF WATER LEAVING THE DEVELOPMENT SITE

Allowable Discharge	AD		***1.97E-04***	m^3/s
Discharge Coefficient	C		***1.0***	Pumped
Discharge Coefficient	C		***0.5***	Gravity Outlet (e.g. orifice)
Discharge Coefficient	C		***0.7***	Vortex Flow Control

A	B	C	D	E	F	G	H	I	J
Storm Duration D (Hours)	Rainfall Depth (mm)	Revised Depth (mm)	Rainfall Rate i (mm/hr)	Rainfall Rate I (mm/hr)	Inflow rate - 2.78 HS A i - (l/s)	Inflow volume - rate x 3.6D - (m^3)	Outflow volume - C x AD x 3.6D - (m^3)	Storage required V - in - out - (m^3)	Time to empty - 0.277V/A DC - (Hours)
0.17	10	10.00	60.00	60.00	9.09	5.45	0.06	5.39	1.07
0.50	30	30.00	60.00	60.00	9.09	16.36	0.18	16.18	3.20
1	40.51	40.51	40.51	40.51	6.14	22.09	0.36	21.73	4.30
4	57.37	57.37	14.34	14.34	2.17	31.28	1.42	29.86	5.91
6	63	63.00	10.50	10.50	1.59	34.35	***2.13***	32.22	6.37
12	72.21	72.21	6.02	6.02	0.91	39.37	4.26	35.11	6.95
18	78.36	78.36	4.35	4.35	0.66	42.72	6.39	36.33	7.19

1 in 100 year, 6 hour event	CV		***2.13***	m^3

	Abbreviation	Calculations	Value	
Impermeable area	R A		544.78	m^2

TOTAL VOLUME OF WATER LEAVING THE DEVELOPMENT SITE

Allowable Discharge	AD		***5.61E-03***	m^3/s
Discharge Coefficient	C		***1.0***	Pumped
Discharge Coefficient	C		***0.5***	Gravity Outlet (e.g. orifice)
Discharge Coefficient	C		***0.7***	Vortex Flow Control

A	B	C	D	E	F	G	H	I	J
Storm Duration D (Hours)	Rainfall Depth (mm)	Revised Depth (mm)	Rainfall Rate i (mm/hr)	Rainfall Rate I (mm/hr)	Inflow rate - 2.78 HS A i - (l/s)	Inflow volume - rate x 3.6D - (m^3)	Outflow volume - C x AD x 3.6D - (m^3)	Storage required V - in - out - (m^3)	Time to empty - 0.277V/A DC - (Hours)
0.17	10	10.00	60.00	60.00	9.09	5.45	1.68	3.77	0.75
0.50	30	30.00	60.00	60.00	9.09	16.36	5.05	11.31	2.24
1	40.51	40.51	40.51	40.51	6.14	22.09	10.10	11.99	2.37
4	57.37	57.37	14.34	14.34	2.17	31.28	40.39	-9.11	-1.80
6	63	63.00	10.50	10.50	1.59	34.35	***60.59***	-26.24	-5.19
12	72.21	72.21	6.02	6.02	0.91	39.37	121.18	-81.81	-16.19
18	78.36	78.36	4.35	4.35	0.66	42.72	181.76	-139.04	-27.51

1 in 100 year, 6 hour event	CV		***60.59***	m^3

	Abbreviation	Calculations	Value	
Impermeable area	R A		544.78	m^2

TOTAL VOLUME OF WATER LEAVING THE DEVELOPMENT SITE

Allowable Discharge	AD	***1.77E-03***	m^3/s
Discharge Coefficient	C	***1.0***	Pumped
Discharge Coefficient	C	***0.5***	Gravity Outlet (e.g. orifice)
Discharge Coefficient	C	***0.7***	Vortex Flow Control

A	B	C	D	E	F	G	H	I	J
Storm Duration D (Hours)	Rainfall Depth (mm)	Revised Depth (mm)	Rainfall Rate i (mm/hr)	Rainfall Rate I (mm/hr)	Inflow rate - 2.78 HS A i - (l/s)	Inflow volume - rate x 3.6D - (m^3)	Outflow volume - C x AD x 3.6D - (m^3)	Storage required V - in - out - (m^3)	Time to empty - 0.277V/A DC - (Hours)
0.17	10	10.00	60.00	60.00	9.09	5.45	0.53	4.92	0.97
0.50	30	30.00	60.00	60.00	9.09	16.36	1.60	14.76	2.92
1	40.51	40.51	40.51	40.51	6.14	22.09	3.19	18.90	3.74
4	57.37	57.37	14.34	14.34	2.17	31.28	12.76	18.51	3.66
6	63	63.00	10.50	10.50	1.59	34.35	***19.15***	15.20	3.01
12	72.21	72.21	6.02	6.02	0.91	39.37	38.29	1.08	0.21
18	78.36	78.36	4.35	4.35	0.66	42.72	57.44	-14.72	-2.91

1 in 100 year, 6 hour event	CV	***19.15***	m^3

	Abbreviation	Calculations	Value	
Impermeable area	R A		544.78	m^2

TOTAL VOLUME OF WATER LEAVING THE DEVELOPMENT SITE

Allowable Discharge	AD		***1.97E-04***	m^3/s
Discharge Coefficient	C		***1.0***	Pumped
Discharge Coefficient	C		***0.5***	Gravity Outlet (e.g. orifice)
Discharge Coefficient	C		***0.7***	Vortex Flow Control

A	B	C	D	E	F	G	H	I	J
Storm Duration D (Hours)	Rainfall Depth (mm)	Revised Depth + 30% Climate Change (mm)	Rainfall Rate i (mm/hr)	Rainfall Rate i + 30% Climate Change (mm/hr)	Inflow rate - 2.78 HS A i - (l/s)	Inflow volume - rate x 3.6D - (m^3)	Outflow volume - C x AD x 3.6D - (m^3)	Storage required V - in - out - (m^3)	Time to empty - 0.277V/A DC - (Hours)
0.17	10	13.00	78.00	101.40	15.36	9.21	0.06	9.15	1.81
0.50	30	39.00	78.00	101.40	15.36	27.64	0.18	27.46	5.43
1	40.51	52.66	52.66	68.46	10.37	37.33	0.36	36.97	7.32
4	57.37	74.58	18.65	24.24	3.67	52.86	1.42	51.44	10.18
6	63	81.90	13.65	17.75	2.69	58.05	***2.13***	55.92	11.06
12	72.21	93.87	7.82	10.17	1.54	66.54	4.26	62.27	12.32
18	78.36	101.87	5.66	7.36	1.11	72.20	6.39	65.81	13.02

1 in 100 year, 6 hour event	CV		***2.13***	m^3

	Abbreviation	Calculations	Value	
Impermeable area	R A		544.78	m^2

TOTAL VOLUME OF WATER LEAVING THE DEVELOPMENT SITE

Allowable Discharge	AD		***5.61E-03***	m^3/s
Discharge Coefficient	C		***1.0***	Pumped
Discharge Coefficient	C		***0.5***	Gravity Outlet (e.g. orifice)
Discharge Coefficient	C		***0.7***	Vortex Flow Control

A	B	C	D	E	F	G	H	I	J
Storm Duration D (Hours)	Rainfall Depth (mm)	Revised Depth + 30% Climate Change (mm)	Rainfall Rate i (mm/hr)	Rainfall Rate i + 30% Climate Change (mm/hr)	Inflow rate - 2.78 HS A i - (l/s)	Inflow volume - rate x 3.6D - (m^3)	Outflow volume - C x AD x 3.6D - (m^3)	Storage required V - in - out - (m^3)	Time to empty - 0.277V/A DC - (Hours)
0.17	10	13.00	78.00	101.40	15.36	9.21	1.68	7.53	1.49
0.50	30	39.00	78.00	101.40	15.36	27.64	5.05	22.59	4.47
1	40.51	52.66	52.66	68.46	10.37	37.33	10.10	27.23	5.39
4	57.37	74.58	18.65	24.24	3.67	52.86	40.39	12.47	2.47
6	63	81.90	13.65	17.75	2.69	58.05	***60.59***	-2.54	-0.50
12	72.21	93.87	7.82	10.17	1.54	66.54	121.18	-54.64	-10.81
18	78.36	101.87	5.66	7.36	1.11	72.20	181.76	-109.56	-21.68

1 in 100 year, 6 hour event	CV	***60.59***	m^3

	Abbreviation	Calculations	Value	
Impermeable area	R A		544.78	m^2

TOTAL VOLUME OF WATER LEAVING THE DEVELOPMENT SITE

Allowable Discharge	AD		***1.77E-03***	m^3/s
Discharge Coefficient	C		***1.0***	Pumped
Discharge Coefficient	C		***0.5***	Gravity Outlet (e.g. orifice)
Discharge Coefficient	C		***0.7***	Vortex Flow Control

A	B	C	D	E	F	G	H	I	J
Storm Duration D (Hours)	Rainfall Depth (mm)	Revised Depth + 30% Climate Change (mm)	Rainfall Rate i (mm/hr)	Rainfall Rate i + 30% Climate Change (mm/hr)	Inflow rate - 2.78 HS A i - (l/s)	Inflow volume - rate x 3.6D - (m^3)	Outflow volume - C x AD x 3.6D - (m^3)	Storage required V - in - out - (m^3)	Time to empty - 0.277V/A DC - (Hours)
0.17	10	13.00	78.00	101.40	15.36	9.21	0.53	8.68	1.72
0.50	30	39.00	78.00	101.40	15.36	27.64	1.60	26.05	5.15
1	40.51	52.66	52.66	68.46	10.37	37.33	3.19	34.14	6.75
4	57.37	74.58	18.65	24.24	3.67	52.86	12.76	40.10	7.93
6	63	81.90	13.65	17.75	2.69	58.05	***19.15***	38.90	7.70
12	72.21	93.87	7.82	10.17	1.54	66.54	38.29	28.24	5.59
18	78.36	101.87	5.66	7.36	1.11	72.20	57.44	14.76	2.92

1 in 100 year, 6 hour event	CV		***19.15***	m^3

	Abbreviation	Calculations	Value	
Impermeable area	R A		544.78	m^2

ATTENUATION STORAGE VOLUME

Allowable Discharge	AD		***1.77E-03***	m^3/s
Discharge Coefficient	C		***1.0***	Pumped
Discharge Coefficient	C		***0.5***	Gravity Outlet (e.g. orifice)
Discharge Coefficient	C		***0.7***	Vortex Flow Control

A	B	C	D	E	F	G	H	I	J
Storm Duration D (Hours)	Rainfall Depth (mm)	Revised Depth + 30% Climate Change (mm)	Rainfall Rate i (mm/hr)	Rainfall Rate i + 30% Climate Change (mm/hr)	Inflow rate - 2.78 HS A i - (l/s)	Inflow volume - rate x 3.6D - (m^3)	Outflow volume - C x AD x 3.6D - (m^3)	Storage required V - in - out - (m^3)	Time to empty - 0.277V/A DC - (Hours)
0.17	10	13.00	78.00	101.40	15.36	9.21	0.53	8.68	1.72
0.50	30	39.00	78.00	101.40	15.36	27.64	1.60	26.05	5.15
1	40.51	52.66	52.66	68.46	10.37	37.33	3.19	34.14	6.75
4	57.37	74.58	18.65	24.24	3.67	52.86	12.76	40.10	7.93
6	63	81.90	13.65	17.75	2.69	58.05	19.15	***38.90***	7.70
12	72.21	93.87	7.82	10.17	1.54	66.54	38.29	28.24	5.59
18	78.36	101.87	5.66	7.36	1.11	72.20	57.44	14.76	2.92

1 in 100 year, 6 hour event	CV		***38.90***	m^3

Appendix C Green Roof Flow Capacity Calculations

Flow Capacity of Intensive Green Roof Substrate - Conservatively based on Maximum Dimension of Main Roof Area; Sandy GRAVEL Composition and Flat Roof with Pitch of 1:80

No.		Abbreviation	Calculations	Value	
1	cross-sectional flow area	A		8.42	m^2
2	coefficent of permeability of filter media	k	CIRIA Report C573	3.00E-02	m/s
3	hydraulic gradient	i	1 in 80	1.25E-02	
4	Flow capacity of filter media	Q	A.k.i	3.16E-03	m^3/s
				3.16	l/s
		Qmax		N/A	l/s

Appendix D MicroDrainage Calculation

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	100	PIMP (%)	100
M5-60 (mm)	20.600	Add Flow / Climate Change (%)	30
Ratio R	0.438	Minimum Backdrop Height (m)	0.200
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	1.500
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	1.200
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Time Area Diagram for Storm

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.004	4-8	0.002

Total Area Contributing (ha) = 0.006

Total Pipe Volume (m³) = 0.300

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type
1.000	17.000	0.113	150.4	0.006	5.00	0.0	0.600	o	150	Pipe/Conduit

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	50.00	5.35	46.800	0.006	0.0	0.0	0.2	0.82	14.4	1.1