build energy

compliance
testing
consulting

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

Our Ref: BE0969

DATE: 10 May 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

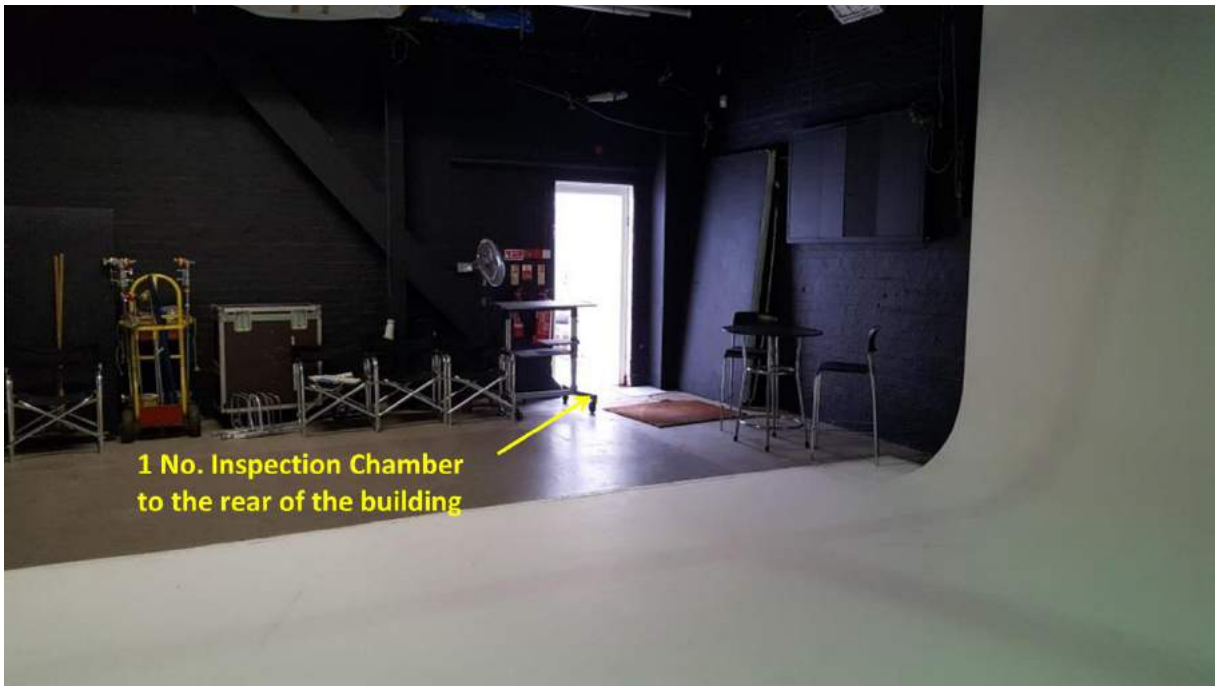
The footpath; vehicle access and pedestrian access that bound the site to the west fall towards Hampshire Street - which in turn falls towards Torriano Avenue further to the south (Photograph 4).

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 were noted close to both these locations (Photographs 7-9), indicating these inspection chambers are part of a combined sewer system, taking both surface water and foul water.

Photograph 5



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 discharging to the sewer (Photograph 15).

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'[1].

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'[2].

The nearest available borehole log on the BGS Geoindex website is 85m west of the site. TQ28SE1049[3] - 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

[1] http://www.landis.org.uk/soilscapes/
[2] http://www.bgs.ac.uk/lexicon/lexicon.cfm?pub=LC
[3] http://scans.bgs.ac.uk/sobi_scans/boreholes/592630/images/12216756.html

at the time of digging in April 1970'[4].

Groundwater beneath the site location is not associated with a source protection zone[5].

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[6].

[4] http://scans.bgs.ac.uk/sobi_scans/boreholes/592630/images/12216756.html
[5] 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
[6] 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[7].

A review of the Environment Agency (EA) Flood Map for Planning (from Rivers and the Sea)[8] 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[9] 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[10].

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[11]. Where a low risk is indicated, the surface water depth is below 300mm and 300mm to 900mm respectively[12] and the surface water velocity is over

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

0.25 m/s[13].

3.3 Flooding from Groundwater

Figure 4e Rev 1 of the London Borough of Camden (LBC) Strategic Flood Risk Assessment (SFRA)[14] 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[15] 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[16].

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[17]) and the FRA indicates that there is a low risk of flooding from all sources.

[13] https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=529715&northing=184956&address=5020916
[14] URS, London Borough of Camden Strategic Flood Risk Assessment, Revision 2, July 2014.
[15] URS, London Borough of Camden Strategic Flood Risk Assessment, Revision 2, July 2014.
[16] https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=529715&northing=184956&address=5020916
[17] 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[18].

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).

[18] CIRIA C697, The SuDS Manual, 2007

Table 5.9 of CIRIA C697[19] 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).

[19] 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)[20]; 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'[21].

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[22] 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).

[20] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[21] Thames Water Addendum to Sewers for Adoption 7th Edition Nov 2012
[22] 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[23].

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[24].

5.4.1 Intensive Green Roof

Please see Section 12.7 of CIRIA C753, The SuDS Manual, 2015[25] for Biodiversity Design Requirements for Green Roofs.

[23] CIRIA C753, The SuDS Manual, 2015
[24] CIRIA C753, The SuDS Manual, 2015
[25] 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

Rate and volume of runoff calculations are included in Appendix A. Please see Appendix B for Green Roof and Linear Drainage Substrate Flow Capacity Calculations.

The calculated greenfield and brownfield runoff rates are 0.20 l/s and 0.26 l/s respectively.

The calculated attenuation storage volume for the post development impermeable area - based on the 100 year critical event with 30% uplift for extreme rainfall intensities and 2 l/s (to reduce the risk of blockage) - is 17.05m^3 with a time to empty of 3.37hrs.

The discharge rate for the intensive green roof and terrace catchments has been set as low as possible while also ensuring that there is not a risk to the development (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 460m^2 green roof will comprise of a 300mm substrate (general planting) with an underlying 60mm drainage mat filled with Bauder Mineral Drain[26] or similar. The substrate will be recycled crushed brick, expanded clay shale and composted pine bark or similar[27]. Based on maximum roof cross sectional area dimensions of 16.75x0.30m; a Sandy

[26] http://www.bauder.co.uk/green-roofs/accessible-green-roofs-gardens/soft-and-hard-landscaping/full-garden-planting-scheme
[27] http://www.bauder.co.uk/assets/b/a/bauder-intensive-substrate.pdf

GRAVEL composition[28]; and a flat roof with a pitch of 1:80[29], the flow capacity of this filter media is estimated to be 1.88 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 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[30].

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.

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

Rainwater from the fourth storey terrace (around 85m^2) will discharge to 8 x 50mm diameter roof drain outlets with guards on the basis that each of the 4 flats terraces require two roof drain outlets in case of blockage (maximum flow rate of 7.20 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 that can drain 50-90m^2 of terrace area at a rate of 0.90 l/s[31]. Please note that at the time of writing, FIXFAST are unable to provide a flow rate for FarBo® FO-FLO 50mm outlets with FO-BG Bacony Leafguards so 0.90 l/s is based on FarBo® FO-FLO 50mm outlets with FO-UG Universal Leafguards.

[28] CIRIA C753, The SuDS Manual, 2015
[29] FarBo® drainage outlets - technical data sheet
[30] FIXFAST, Flat Roof Drainage Systems, Product Overview
[31] FIXFAST, Flat Roof Drainage Systems, Product Overview

Rainwater from the ground floor terrace (around 55m^2) will discharge to 4 x 50mm diameter roof drain outlets with guards on the basis each terrace requires two roof drain outlets in case of blockage (maximum flow rate of 3.60 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 that can drain 50-90m^2 of terrace area at a rate of 0.90 l/s[32]. Please note that at the time of writing, FIXFAST are unable to provide a flow rate for FarBo® FO-FLO 50mm outlets with FO-BG Bacony Leafguards so 0.90 l/s is based on FarBo® FO-FLO 50mm outlets with FO-UG Universal Leafguards.

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 Extensive Green Roofs.

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

Figures

SITE LOCATION PLAN

SCALE 1:1000

N

NOTES

SITE BOUNDARY

drawing status: P L A N N I N G

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

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P : Suite 14, Arquen House, 4-6 Spicer St, St Albans, AL3 4PQ.

E : letterbox@sada-architecture.com

W : www.sada-architecture.com

T : 01727 860810

project: **17-010** - 2 Hampshire Street, Camden

drawing: SITE LOCATION PLAN

date:	drawn by: LM	check: CC
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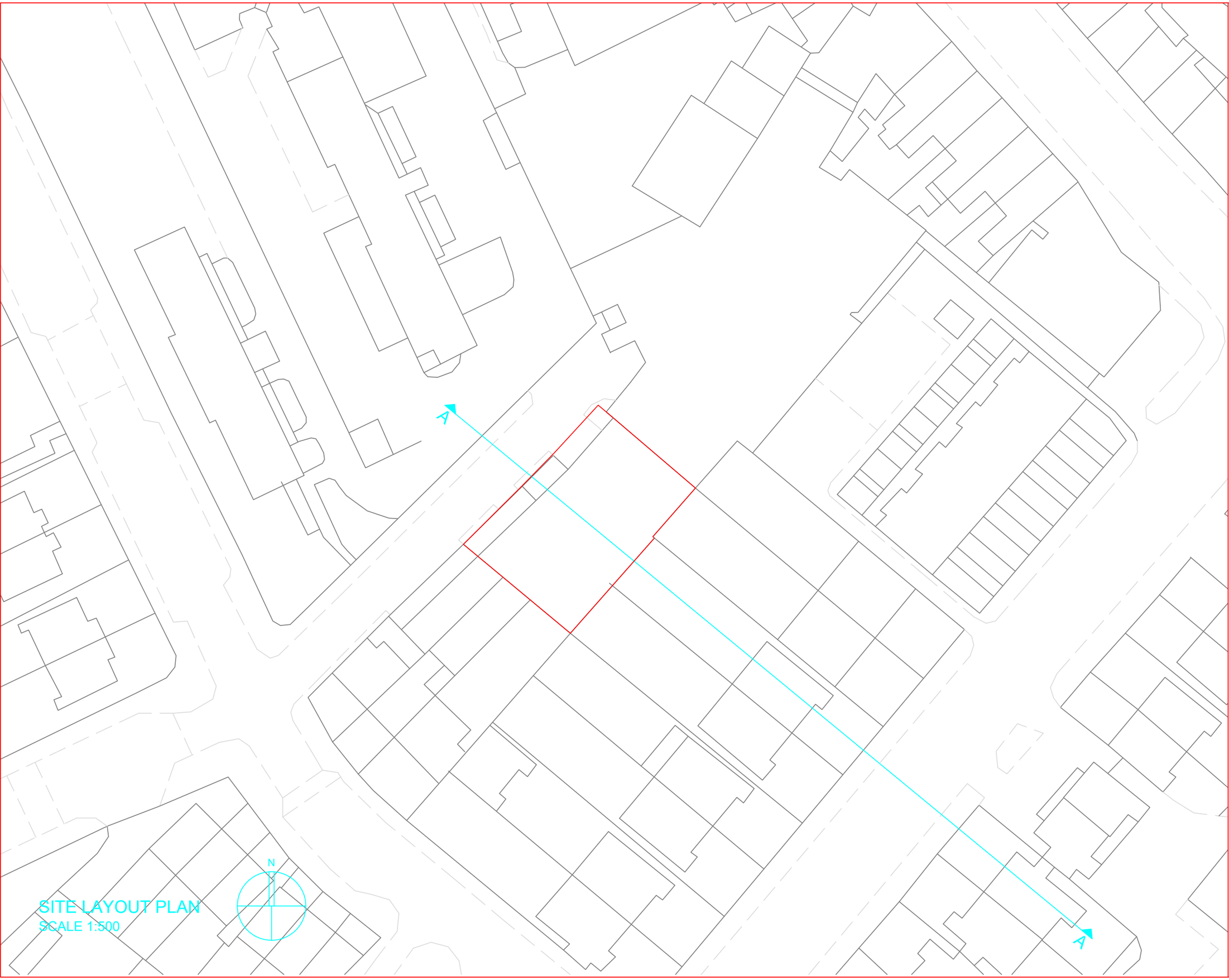

SITE LAYOUT PLAN

SCALE 1:500

NOTES

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W : www.sada-architecture.com

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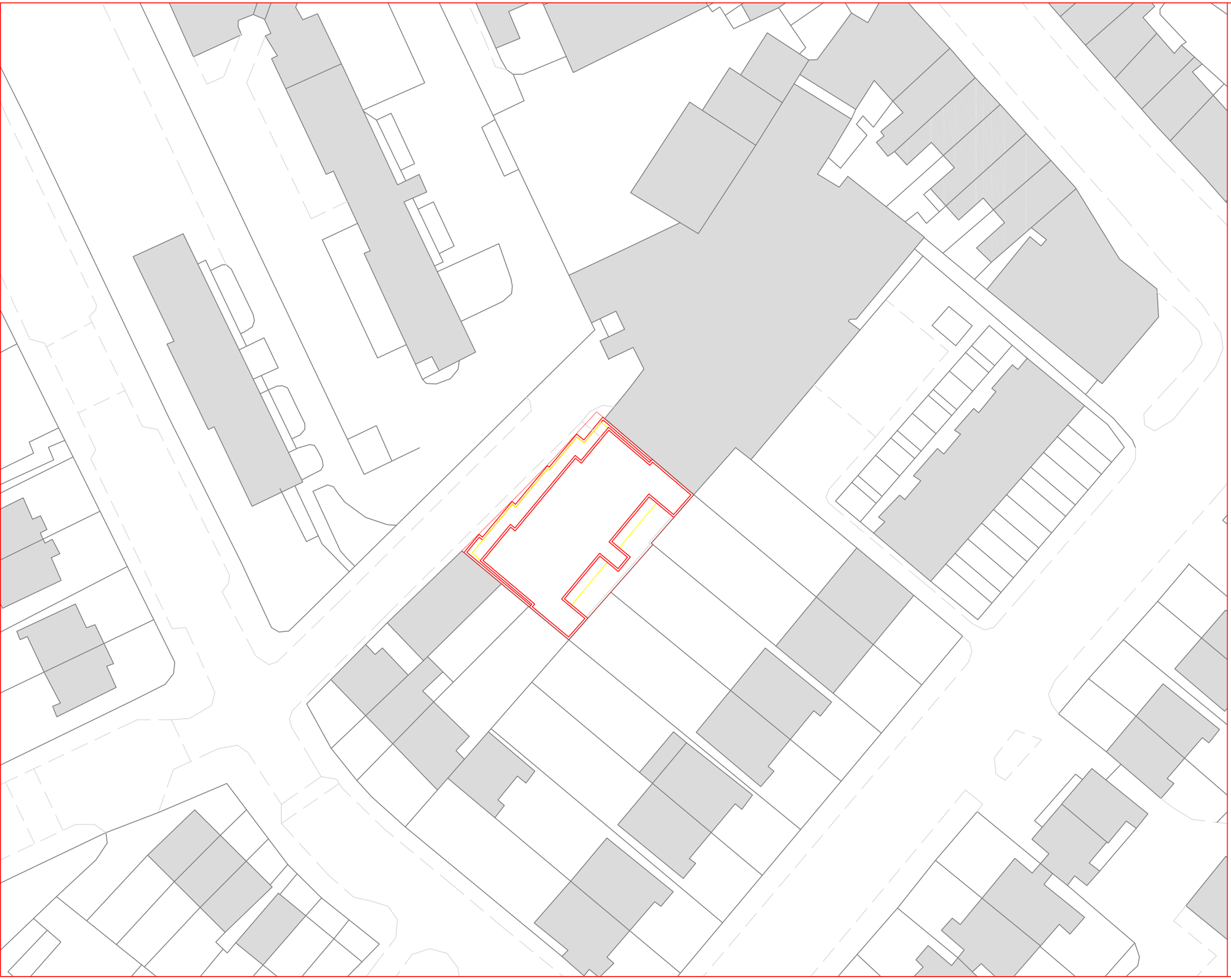

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NOTES

SITE BOUNDARY

CYCLE
STORE
(26 Spaces)

PLANT

BIN STORE

COMMERCIAL UNIT 1
GIA 109 sqm

COMMERCIAL UNIT 2
GIA 84 sqm

COMMERCIAL UNIT 3
GIA 141 sqm

GROUND FLOOR PLAN
SCALE 1:100

0 1 2 3 4 5M
1:100

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drawing status:	P L A N N I N G

revision:	description:	date:
P.01	Issued for PLANNING	27.01.17

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P : Suite 14, Arquen House, 4-6 Spicer St, St Albans, AL3 4PQ.

E : letterbox@sada-architecture.com

W : www.sada-architecture.com

T : 01727 860810

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drawing:	PROPOSED GROUND FLOOR PLAN		
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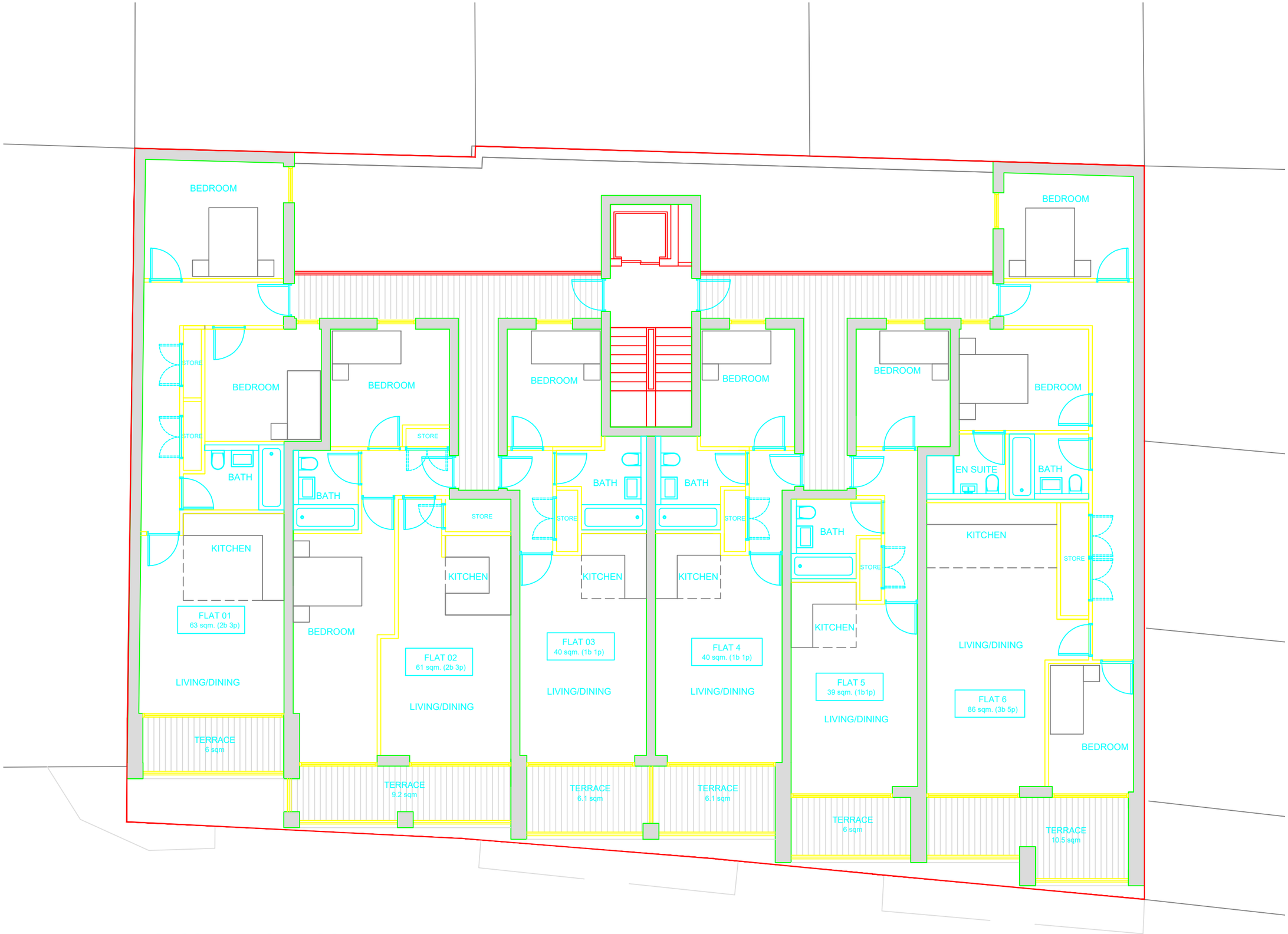

PROPOSED FIRST FLOOR PLAN

SCALE 1:100

0 1 2 3 4 5M

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SITE BOUNDARY

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SADAarchitecture

P : 1st Floor, 26C George Street, St. Albans, AL3 4ES

E : letterbox@sada-architecture.com

W : www.sada-architecture.com

T : 01727 860810

project: **17-010** - 1 Hampshire Street, London NW5 2TE

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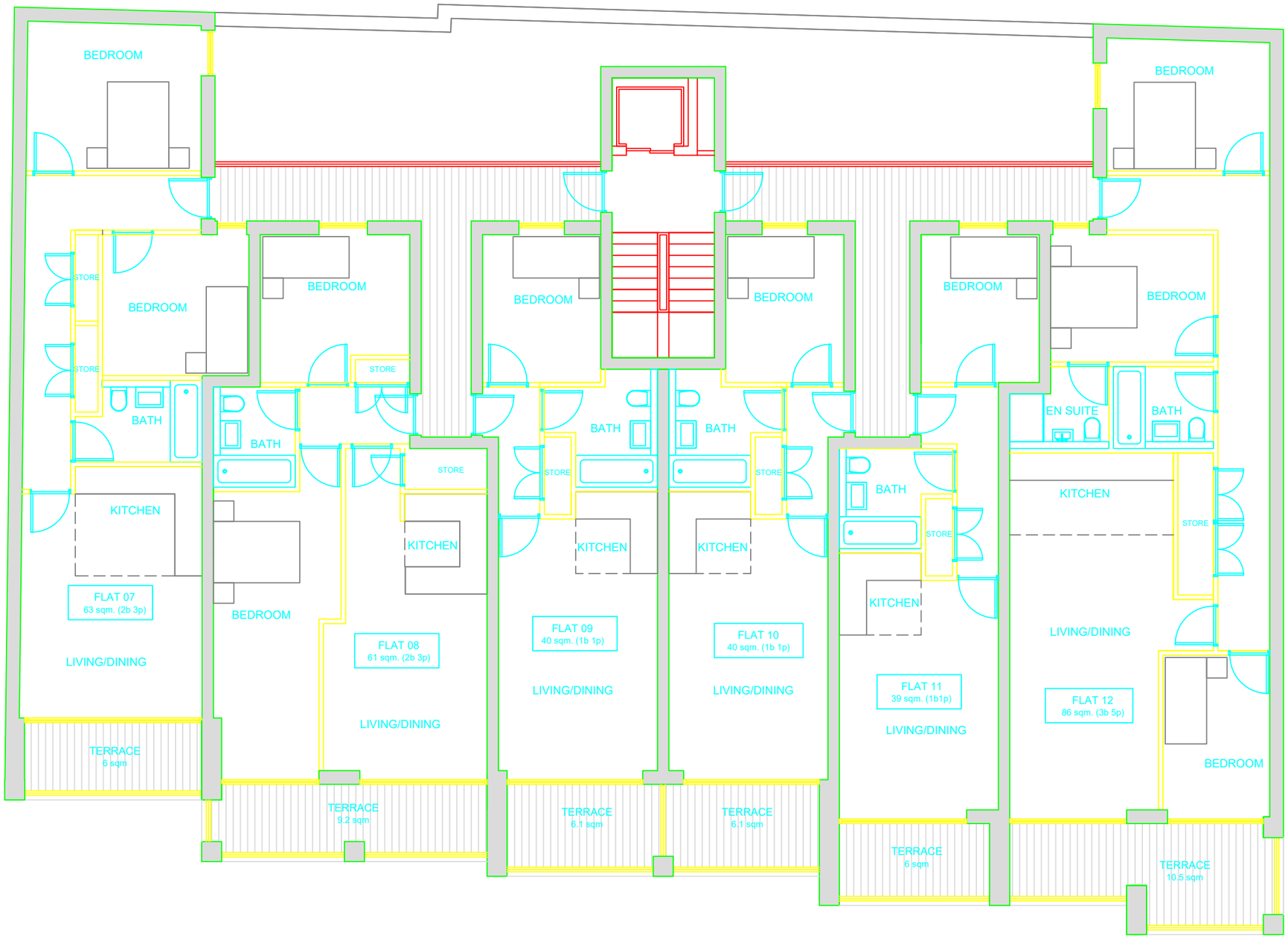

SECOND FLOOR PLAN

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1:100

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drawing status:	P L A N N I N G

revision:	description:	date:
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P : Suite 14, Arquen House, 4-6 Spicer St, St Albans, AL3 4PQ.

E : letterbox@sada-architecture.com

W : www.sada-architecture.com

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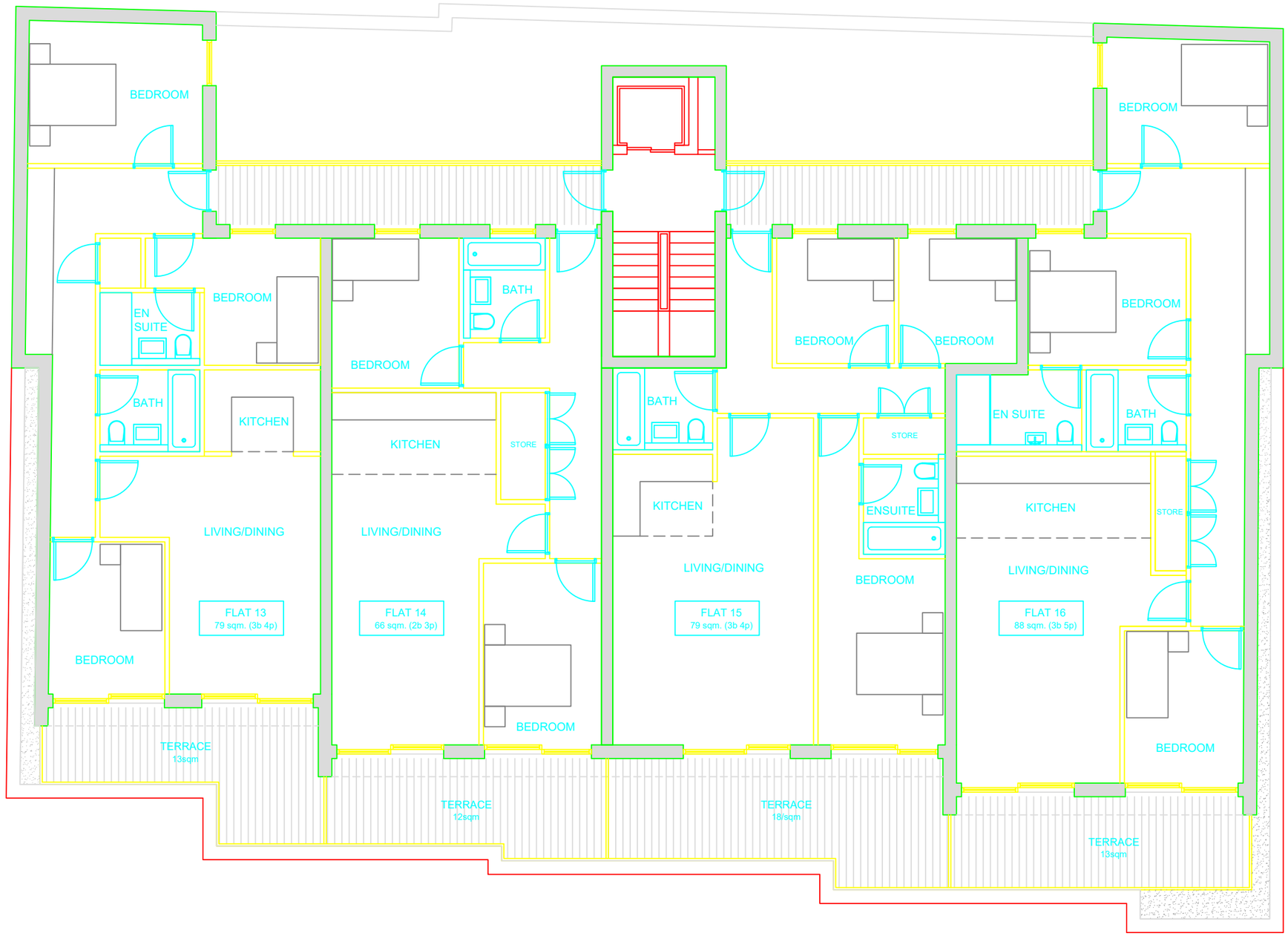

THIRD FLOOR PLAN

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T : 01727 860810

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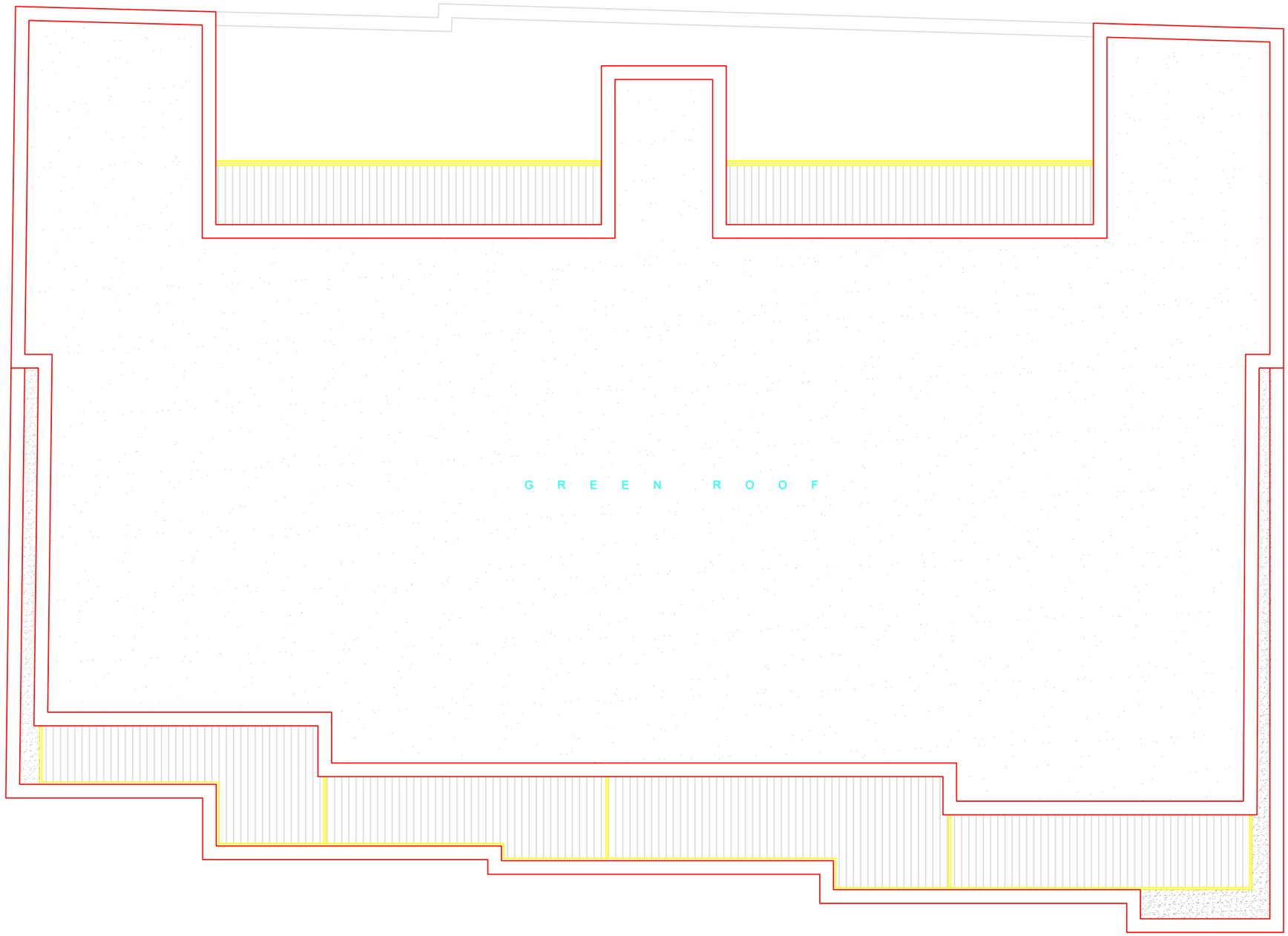

ROOF PLAN
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date: 18.04.17 | drawn by: LM | check: CC
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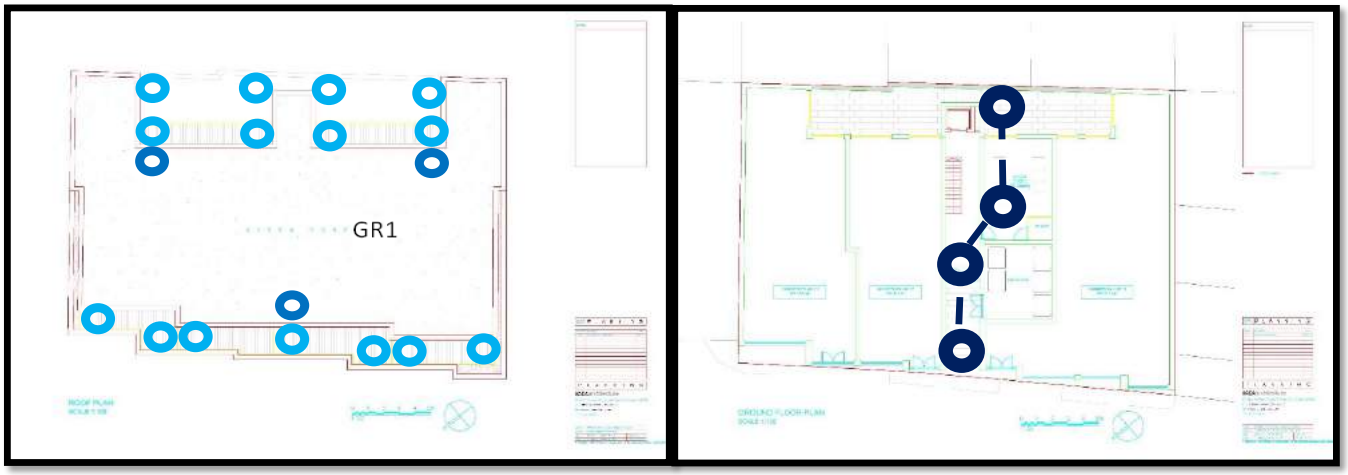

Figure 9 Proposed Sustainable Drainage Plan

Key

- Approximate Location of Proposed 50mm Terrace Drain With FarBo® FO-BG Balcony Leafguards or Similar
- Approximate Location of Proposed 62mm Roof Drain With FarBo® FO-UG Universal Leafguards or Similar
- GR1 — Green roof comprising of 300mm substrate (general planting) with underlying 60mm drainage mat filled with Bauder Mineral Drain or similar
- Approximate route of proposed 150mm diameter surface water sewer pipe with minimum 1 in 150 fall towards Hampshire Street
- 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 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 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		4.70	l/s/ha	0.26 l/s
		Q2yr		4.87	l/s/ha	0.27 l/s
		Q5yr		7.08	l/s/ha	0.39 l/s
		Q10yr		8.96	l/s/ha	0.49 l/s
11.2		Q30yr		12.05	l/s/ha	0.66 l/s
11.3		Q100yr		17.64	l/s/ha	0.96 l/s

DETAILED ASSESSMENT OF INTERCEPTION STORAGE VOLUME

	Abbreviation	Calculations	Value	
Total site area	TS A		544.78	m^2
Total site area converted to hardstanding	HS A		544.78	m^2
Total volume from 5mm rainfall		5mm x 100% x H/S A	***2.72***	m^3

DETAILED ASSESSMENT OF 100 YEAR ATTENUATION STORAGE VOLUME

Allowable Discharge	AD	***2.00E-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	60.00	78.00	9.09	5.45	0.84	4.61	0.91
0.50	30	39.00	60.00	78.00	9.09	16.36	2.52	13.84	2.74
1	40.51	52.66	40.51	52.66	6.14	22.09	5.04	***17.05***	3.37
4	57.37	74.58	14.34	18.65	2.17	31.28	20.16	11.12	2.20
6	63	81.90	10.50	13.65	1.59	34.35	30.24	4.11	0.81
12	72.21	93.87	6.02	7.82	0.91	39.37	60.48	-21.11	-4.18
18	78.36	101.87	4.35	5.66	0.66	42.72	90.72	-48.00	-9.50

1 in 100 year, 6 hour event	CV	***17.05***	m^3

Appendix B 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		5.03	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	1.88E-03	m^3/s
				1.88	l/s
		Qmax		N/A	l/s