Energy use in listed buildings and conservation areas in London

Report to Historic England by the Building Stock Lab

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Research Report

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Historic England asked UCL to provide data on listed buildings and conservation areas in London and their use of energy, and to make analyses. The work was done using the Building Stock Laboratory's 3DStock model of London (Steadman et al 2020: DOI: 10.5334/bc.52) The data for the version used here relate mostly to 2017, with some additional data on EPCs and DECs for March 2023. The model covers all buildings, domestic and non-domestic, out to the M25 motorway. A full description of the model and the sources of data on which it is based is given in the accompanying User Guide.

Basic statistics on listed buildings and conservation areas

Historic England provided a database of 7939 listings in London with Unique Property Reference Numbers (UPRNs). Of these 7,827were successfully matched to the 3DStock model. They comprise 9,421 domestic UPRNs and 2,308 non-domestic UPRNs.

These UPRNs are distributed across 18,365 Self-Contained Units (SCUs). The concept of the Self-Contained Unit is explained in detail in the User Guide. Essentially its purpose is to represent the sometimes-complex relationships between premises, buildings, and energy meters. For example, a multi-tenant office building contains many premises (the office suites), each of which would typically have its own electricity meter; but there could be a shared central heating or air conditioning system serving the whole building, with its own meters. A large school or hospital, by contrast, constituting one premises, could comprise many buildings on a single site. Here the meters for the whole premises might be in one building, with pipes and wires running across the site to other buildings. The SCU is defined in such a way as never to split any premises. This means that the total floor area, and the total quantities of electricity and gas going into the SCU are known; so that energy intensities can be calculated precisely. Most houses are single SCUs. Blocks of flats are also single SCUs containing many premises (the flats).

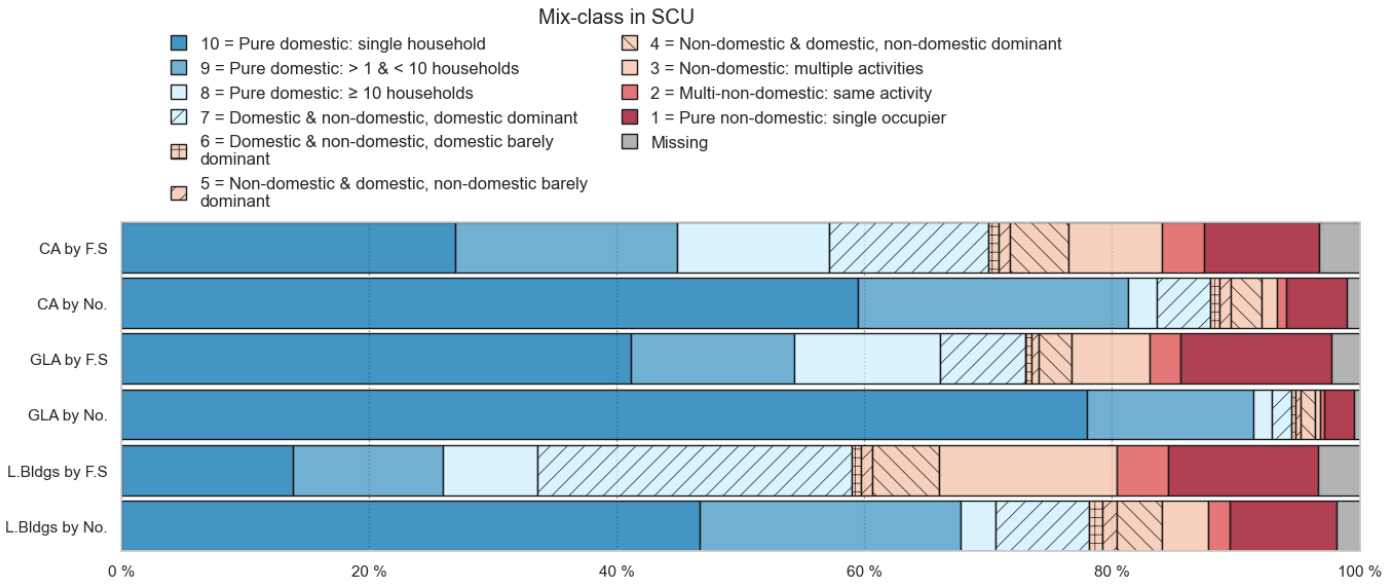
Historic England also provided the boundaries of conservation areas in London. There are 1,056 conservation areas containing around 300,000 SCUs, out of a total of some 2 million SCUs in the whole of London. The SCUs in conservation areas contain 710,000 domestic premises, 326,000 of which have Energy Performance Certificates (EPCs); and 400,000 non-domestic premises, 17,000 of which have EPCs.

Many listed buildings are in conservation areas. Taking just domestic UPRNs, Table 1 shows that just 910 of these are in listed buildings that *are not* in conservation areas; and 8,511 are in listed buildings that *are* in conservation areas; while 704,940 are in buildings in conservation areas that are not listed. For comparison, the number of domestic UPRNs in London that are neither in listed buildings nor conservation areas is 2,803,955.

UPRN location	No. dwellings		Total floor area (m^2)		Median floor area (m^2)
UPRN in CA only	704,940	20.04%	27,362,163	21.73%	68
UPRN in LB and CA	8,511	0.24%	606,087	0.48%	143
UPRN in LB only	910	0.03%	41,381	0.03%	98
UPRN not in LB or CA	2,803,955	79.70%	97,897,717	77.75%	71

Table 1 – Domestic UPRNs by planning protection type

A series of characteristics of SCUs in listed buildings and conservation areas are tabulated in the following charts. Each chart has six bars. The two bars at the top relate to conservation areas (CA). The two bars at the bottom relate to listed buildings (L Bdgs). The two bars at the centre give statistics for the remainder of the London stock for comparison (GLA). In each pair, the upper bar gives total floor areas on all floor levels and the lower bar gives numbers of SCUs.

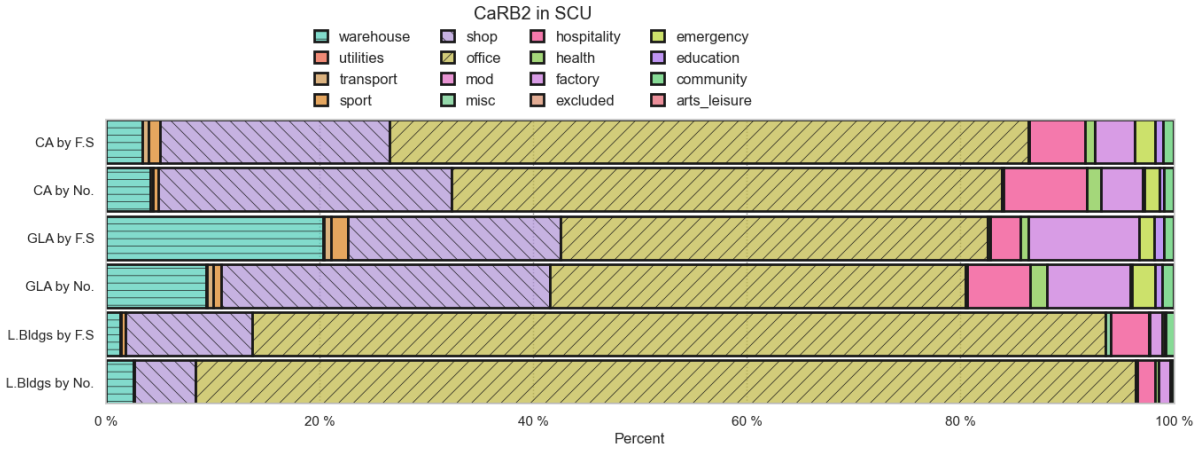


The mixing of activities (Figure 1)

Figure 1 relates to the mixing of domestic and non-domestic activities within SCUs. The London stock as a whole is very mixed in terms of uses, and listed buildings are particularly mixed. Precise definitions of the classification are given in the User Guide. Essentially this is a spectrum from domestic in blue, through various mixtures, to non-domestic in red. The darkest blue stands for single houses; the next lightest blue for domestic with from 2 to 10 households, i.e. small blocks of flats or houses converted to flats; the next lightest blue for domestic with more than 10 households, i.e large purpose-built blocks of flats. Working from the other end: the darkest red stands for non-domestic with a single occupant, such as an office building for a single organisation; the next lightest red for multiple non-domestic premises of the same activity, such as a multi-tenant office building; and the next lightest for multiple non-domestic premises housing different activities, for example offices over shops. In between are different proportions of domestic/ non-domestic mixing.

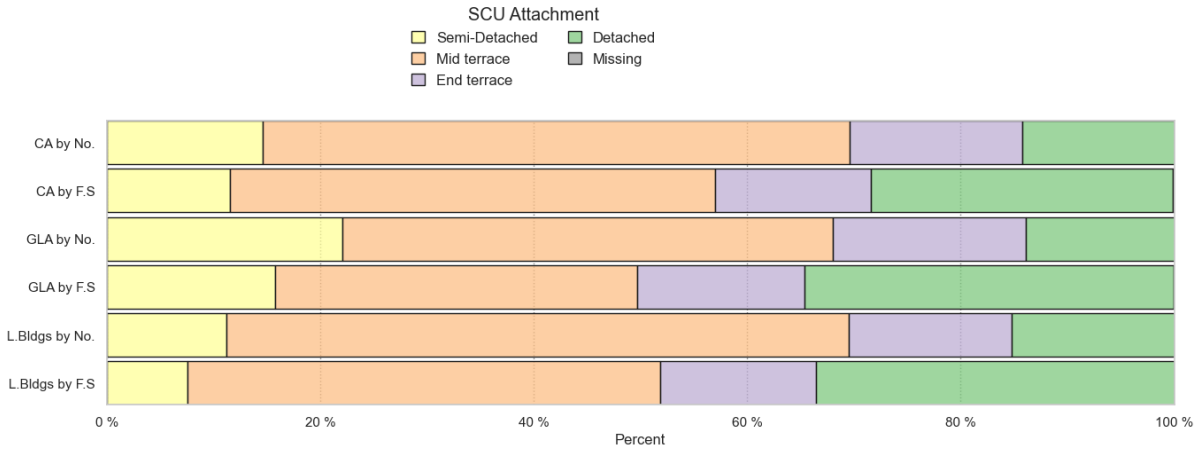
The statistics presented in Figure 1show that the pattern of mixing in conservation areas is broadly similar to that in the rest of London, the main difference being that there is a larger proportion of single houses in the general stock, as might be expected. One finding that stands out for listed buildings is the relatively large floor area represented by Class 7 (diagonal blue shading) which is defined as mixtures of domestic and non-domestic in which domestic dominates, as measured by floor area.

§This phenomenon was investigated in more detail by looking at an arbitrary sample of cases on Google Maps and StreetView. Many of these are pubs with the landlord's flat or other flats above, as in The Shakespeare on Goswell Road which forms part of a large post-War block of flats. There are also examples of shops, cafes, or restaurants on the ground floor with flats above, as in Arcade House on the Finchley Road. We found an odd case: Frogpool Manor Farm in Chiselhurst, which is comprised of a large farmhouse, a farm shop, and a restaurant. Lawyers' chambers, Inns of Court, and headquarters of the London Guilds also fall in this class, as do some colleges with flats. All these examples illustrate the necessity for, and usefulness, of the Self-Contained Unit.



Non-domestic activities (Figure 2)

Figure 2 relates solely to non-domestic activities and shows numbers and floor areas in the same layout as the previous table. The classification of activities is made according to the CaRB system developed at UCL. This is derived and adapted from classifications used by the Valuation Office Agency (VOA) for commercial rating, and the Ordnance Survey for AddressBase maps. A full explanation is given in the User Guide. A very large number of low-level codes, listed in an appendix, are grouped into 17 higher-level classes which are the basis of the analyses in Figure 2. The predominant non-domestic activities in conservation areas and London as a whole, by count and by area, are offices (dark yellow with hatch), followed by shops (purple with hatch). This dominance of offices is even more marked in listed buildings, presumably because of the presence of large numbers of old (and some newer) listed offices in the City and central London.

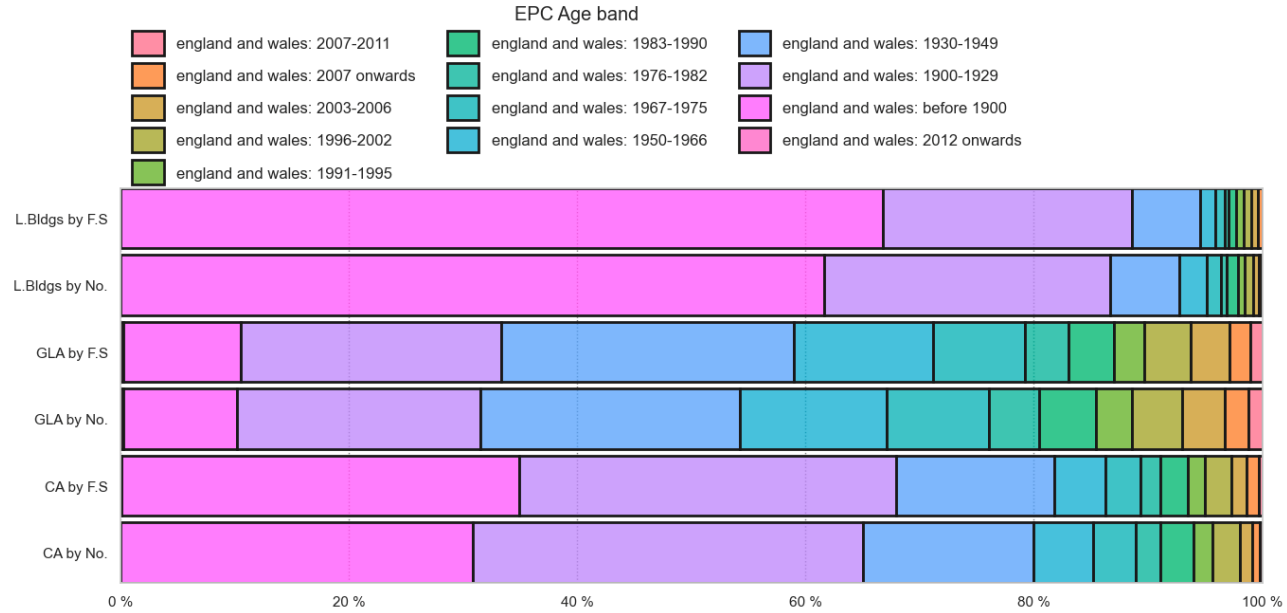


Attachment of buildings (Figure 3)

Figure 3 gives data on the attachment of SCUs one to another. This is the basis of the familiar classification of houses into detached, semi-detached, end-terrace, and mid-terrace. The same categories have also been applied here to non-domestic and mixed SCUs, by analysis of the contiguities of building footprints. The classification covers cases where buildings are touching, along significant lengths of party walls, at the corners of streets as well as along streets. There are higher proportions of mid-terrace SCUs in the listed buildings and conservation areas, and smaller proportions of semi-detached, than in the London stock as a whole. This is because of the preponderance of terraces in the older central parts of the capital, and of semi-detached houses built in the twentieth century in the outer suburbs.

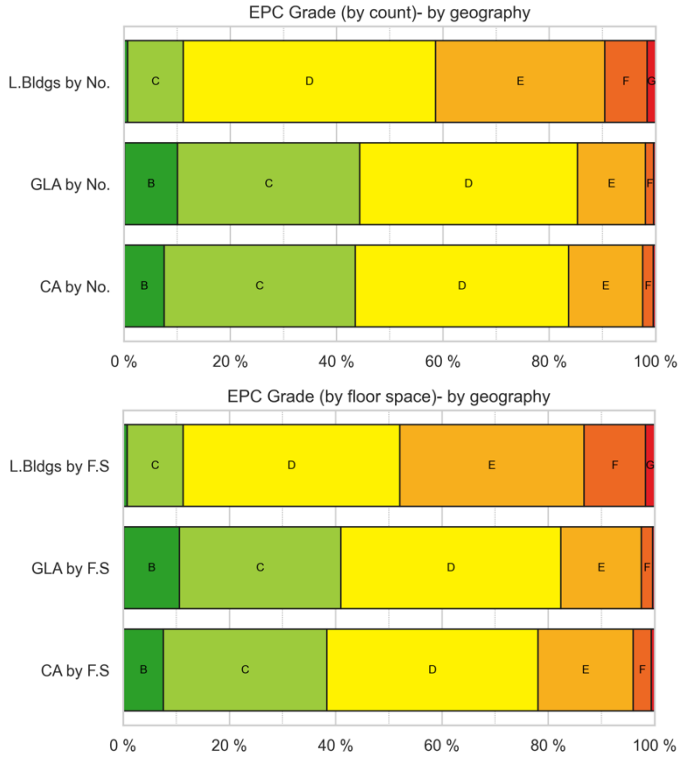
Materials data in Energy Performance Certificates

The 3DStock model as mentioned uses data from 2017, but domestic energy use has been measured, at the UPRN level, i.e. for individual houses and flats, using 2023 EPC data. This will have resulted in a certain number of mismatches between data derived from the EPCs and other data from the model. EPCs give some information on the materials of walls and roofs, but these have not been analysed here, since the details contained within Historic England listing documents are liable to be much more accurate.



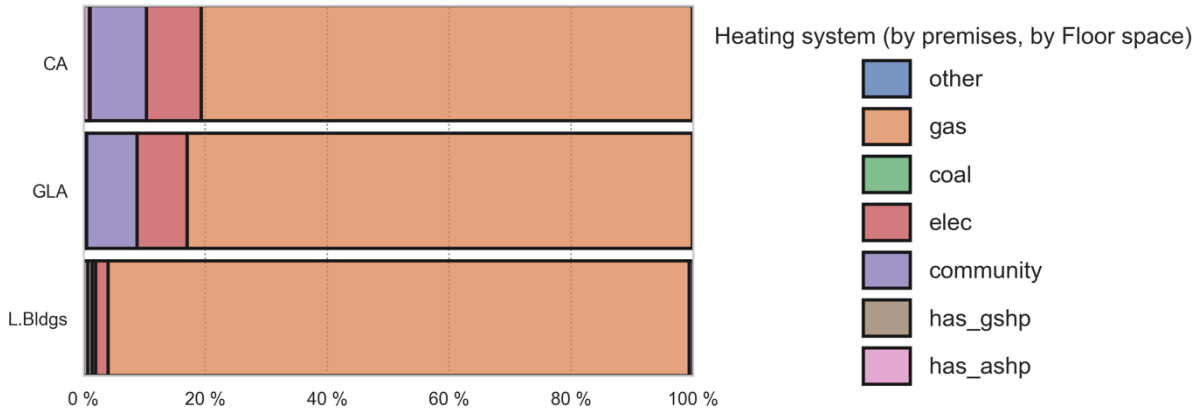
Ages of houses and block of flats (Figure 4, n = 2.1m)

EPCs give estimates of the ages of houses and blocks of flats. These are analysed in Figure 4 for those dwellings that have certificates. Ages are grouped into 13 bands as indicated. In some cases, the surveyors give actual years of construction: these have been assigned to the appropriate band. The results show, unsurprisingly, that listed buildings and building in conservation areas are generally older than the remainder of the London stock, and that large numbers fall in the pre-1900 (bright pink) and 1900-1929 (purple) age bands.



Performance Certificate grades (Figure 5a and 5b)

Figure 5 shows the distribution of domestic Energy Performance Certificate grades by count and by floor area for dwellings in conservation areas, listed buildings, and the remainder of the London stock, using the standard colour codes. There are proportionately more dwellings without EPCs in listed buildings (51% compared to 37% GLA average); but for those that do have certificates, there is a higher fraction with D and E grades (yellow and orange) than in the rest of London, and a lower fraction of B grades (green). The grade distribution in conservation areas is broadly as the rest of London if viewed by count, viewing by floor area shows that the EPC grades in them are slightly lower this is linked to the larger average floor areas of these properties (as Table 1).



Heating systems (Figure 6)

Domestic EPCs give data on the main forms of heating in dwellings, as illustrated in Figure 6, which gives statistics by floor areas. These are completely dominated by gas heating (orange), as would be expected. In the statistics for the rest of the London stock there are significant fractions for community heating i.e. district heating and heat networks (purple) and electrical resistance heating. The figures for ground source and air source heat pumps are low throughout. But one encouraging finding here is that the penetration of heat pumps is higher (1.5%) in listed buildings and in conservation areas (by floor area) than elsewhere (0.5%).

Display Energy Certificates

Estimates of energy use in non-domestic Energy Performance Certificates are modelled, and analysis by UCL has shown that these bear no statistical relationship to actual energy use. We do not therefore present any analyses here. Display Energy Certificate (DEC) grades are however based on actual metered gas and electricity use and give useful information. There are relatively small numbers (~3k) of premises/ buildings with DECs in London. The activities in these buildings are very varied, so it is not easy to find homogeneous sample for which comparisons would be meaningful. There are however quite large numbers of buildings with DECs that are entirely devoted to offices. Analyses show a negligible difference between offices in conservation areas and the rest of London (108 and 104 kWh/m^2); but a very much lower figure of just 65 kWh/m^2 in eight listed office buildings. These are large public offices and law courts, some by prominent architects including William Kent, G E Street, and Denys Lasdun.

Domestic energy use intensity

Gas and electricity meter data for individual dwellings are confidential and cannot be published. However, the former Department for Business, Energy and Industrial Strategy made domestic energy use data for 2017 available, aggregated to the level of postcodes. These have been used to estimate mean domestic energy intensities by postcode in conservation areas and in the rest of London. Analysis has been confined to postcodes that fall fully inside conservation areas, of which there are 15,609; and within these to 3487 postcodes where the number of gas meters equals the number of UPRNs. The results show that the intensity of domestic electricity use is the same between conservation areas and elsewhere (40 and 41 kWh/m^2), but that gas use is slightly lower in conservation areas (150 and 156 kWh/m^2).

Solar energy

DECs and EPCs give information about buildings where solar PV or solar thermal collectors have been fitted to date. This shows that installations of some kind of solar generation in conservation areas and on listed buildings, although small in number (660 and 47 respectively), are being made at a higher rate than in the rest of the London stock. These figures represent 0.2% of SCUs in conservation areas, and 0.25% of listed buildings, compared with 0.16% for London as a whole.

As an extension to the London 3DStock model, the Building Stock Laboratory has developed the London Solar Opportunity Map. This uses laser measurements made from overflying aircraft to model the geometry of all roofs in 3D, as well as the topography of the land surface. Calculations have been made of the amounts of direct and indirect solar radiation reaching all roofs annually, taking into account their slopes and orientations, as well as any obstruction by neighbouring buildings and trees. (Calculations have also been made for areas of open land, but those are not used here.) The Map is publicly available, with a user guide, at https://maps.london.gov.uk/lsom/.

These figures for incident radiation can be converted into estimates of the amounts of electricity available from photovoltaic installations, given values for the efficiency of the panels. The average roof area of buildings in conservation areas is 58 m^2, and of listed buildings 93 m^2, compared with 49.5 m^2 for the rest of London. This means that the figures for the amounts of electricity that can be produced annually per roof, assuming an average panel efficiency, are 6120 kWh (conservation areas), 9730 kWh (listed buildings), and 5340 kWh (London). Calculations for the whole of the London area show that, in theory, the total PV potential for all roofs in the capital is some 16.5 gigawatts. Of this, conservation areas could contribute 1.9 gigawatts and listed buildings 0.2 gigawatts.

Appendix A – EPC Heat source

Heat source	Count of EPCs	Total EPC floor area	Georgraphy
other	847	38665	CA
gas	320499	30321899	CA
coal	23	2362	CA
elec	53347	3206507	CA
community	52106	3362062	CA
has_gshp	277	62565	CA
has_ashp	3009	366837	CA
community	170934	10581468	GLA
elec	188231	10542422	GLA
coal	102	9404	GLA
gas	1375300	116999834	GLA
other	3773	142500	GLA
has_ashp	6359	605407	GLA
has_gshp	564	74902	GLA
has_ashp	20	7611	L.Bldgs
community	50	5332	L.Bldgs
coal	1	66	L.Bldgs
gas	4523	799426	L.Bldgs
other	15	4331	L.Bldgs
has_gshp	6	5299	L.Bldgs
elec	137	15885	L.Bldgs

Appendix B – Offices with DECs

UPRN: 121000680
Roehampton University
Downshire House
Roehampton Lane
London
SW15 4HT

UPRN: 200000069493
Trinity House Lighthouse Service
Trinity Square
London
EC3N 4DH

UPRN: 5069347
Royal College of Physicians
11 St Andrew's Place
London
NW1 4LE

UPRN: 100023336965

Scotland Office
Dover House
Whitehall
London
SW1A 2AU

UPRN: 128006629
Royal Borough of Kingston Learning Disability Services
Sessions House
17 Ewell Road
Surbiton
KT6 6AF

UPRN: 100023533405
City Of London Magistrates Court
1 Queen Victoria Street
London
EC4N 4XY

UPRN: 100023473482
Graff Diamonds Ltd
28 Albemarle Street
London
W1S 4JA

UPRN: 100023430224
Royal Courts of Justice
Strand
London
WC2A 2LL