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Defining, Measuring and Implementing Density Standards in London

LONDON PLAN DENSITY RESEARCH PROJECT 1

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Executive Summary

Defining density

- This project explores the various definitions of density and the different methods by which it can be measured. It considers which approaches best provide an understanding of two key issues: urban form and the number of people in an area.

- The main reasons for using and measuring density include helping to ensure that (i) housing is available for the population; (ii) what is built is suitable both of itself and in relation to the surrounding areas; (iii) households can access services, infrastructure and employment, and (iv) available services and infrastructure are effectively used and planned for the future.

- The London Plan has always taken as read that the main objective is to densify in order to provide housing for the growing population within the London boundary. Because of rapid growth that is expected to continue to be the most important objective.

- The measures used in planning documents across the spectrum of land use planning systems vary somewhat but in the residential context come down three main categories:
    - Numbers - including numbers of dwellings, numbers of rooms (habitable rooms, bedrooms, bed spaces), square metres or equivalent;
    - Built form - which at its simplest tends to be based on plot ratios and other physical relationships between land and building; but also includes type of area (as in the London Plan's central, urban and suburban); tallness of buildings and other standards;
    - Person based measures such as persons per hectare.

- Numbers are generally used to achieve the homes required; built form to specify design and the local environment; and persons to clarify requirements for existing and planned service and infrastructure provision.

- An additional complication is that measures may use either net and gross densities – and identify these in different ways.

- Planning densities - i.e. ones related to buildings rather than people - cannot directly impact on people-based service and infrastructure requirements. These depend on the use made of the buildings provided.

- Most of the available data in London relate to numbers - notably the number of units and the number of bedrooms. Aspects of built form and environment are measured in a more qualitative fashion. Material on accessibility and connectivity is available and used through the summary PTAL measure.

Density in London Planning

- In the context of density, Mayoral London Plans since 2000 have included substantial innovations *both* in relation to:
  - the direction of policy, with a compact city policy being pursued to help achieve both environmental sustainability and economic growth; *and*
  - in the adoption of a density matrix as an operational tool, linking city-wide strategies to (mostly) borough level implementation.

- The density matrix is an attempt to summarise different aspects of planning notably built form and accessibility into a simple 9 cell descriptor which is used to provide guidance on the range of suitable residential densities.

- This guidance appears to be more honoured in the breach than the observance - with the majority of new developments over the last decade above the suggested range (mostly well above) and a significant minority below.

Quantitative Evidence on Density Changes and Residential Outcomes

- The empirical analyses presented in the paper address two issues in relation to the Plan's use of density standards:
  - the operational significance of the Plan's density matrix for residential development densities in London; and.
  - clarifying the factors that help drive the realised pattern of outcomes and how these might be used (rather than the matrix itself) to help determine suitable residential densities on 'new' development sites identified in the SHLAA.

- In terms of operational significance, while densities of new development in London have risen greatly over the period that the London Plan has been in place, this seems to owe much more to shifts in market pressure and factors occasioned by national policies, than to the Plan itself. In particular, the distribution of achieved densities suggests the upper limit is often treated as a norm, while there is also significant development at densities below the lower limit.

- Moreover, whatever the source of this increase in densities, the numbers of dwellings provided has not increased significantly and as a result less land has been used. Thus the core objective of achieving more housing has not been met, although potentially there is now scope for much more residential and other construction on the land that has been identified as available.

- With respect to the factors driving existing densities the analysis suggests that a quite simple regression model that includes a wider range of indicators of centrality/suburbanity than underpin the density matrix; prevailing/inherited variations in local population densities; and accessibility not just to the network but to a range of other opportunities could provide a much more realistic basis for attributing likely development densities of plots in particular LSOAs (including ones with few precedents) than the matrix norms previously used for the SHLAA.

Qualitative Evidence on how Densities are Defined and Used

- We also interviewed London practitioners about how they determined suitable densities; examined the plans in place in other UK cities; and undertook an international survey of experts.

- In the London context it was clear that qualitative judgements were seen as just as important as quantitative measures of density in determining individual decisions.

- The overall picture presented in other cities and countries was that
  - densities were seen as important but for very different reasons in different contexts;
  - the measures used were usually fairly simple and there was no attempt to try to bring them together as in the London Plan matrix;
  - qualitative assessments particularly of built form in comparison to existing development were the norm; however,
  - there was increasing evidence that particular areas were being identified as suitable for higher density forms of development in city plans.

- In terms of implementation experts noted considerable opposition to densification in a number of countries as well as considerable differences between stated principles and actual practice. They also commented on enforcement problems where city-wide or national policies were out of line with local experience and attitudes to change.

Conclusions and Recommendations

- On *forecasting***:** since there is little evidence that the matrix is being followed. It or its equivalent cannot readily act as a basis for estimating capacity in order to meet the projected housing need.

- Using regression estimates produces a somewhat different map to that based on the matrix, reflecting a wider set of (valued) aspects of accessibility, with a pattern reflecting actual behavioural tendencies rather than planning norms, and (most importantly) covering a very much wider range of relevant contexts.

- On *prescription and advice to local authorities*: given the need both for additional housing and to reduce dependence on the private car there remains a clear cut case for the Plan to encourage higher density levels than might otherwise be accepted by local planners, by setting minimum density standards (in room-related terms) for different kinds of area.

- On the other hand, we see no case for continuing to set a maximum level, since the appropriate criteria for limiting density are judgemental ones.

- Decisions about density are a matter of negotiation between developers and politicians at the local level within constraints set by wider central government policies on land release. Past experience suggests that there is no way in which the GLA can enforce what is essentially advice. The locus of responsibility above the minimum should therefore clearly lie at the local level.

- On *monitoring:* We are concerned about the use of numbers of dwellings as a performance measure in planning for new construction. It would be highly

desirable to monitor a range of variables - dwellings; habitable rooms/bedrooms; sq. meterage; and indeed expected first tenure as this also impacts on likely space and service usage.

- On r*eporting and analysis:* at the present time data are collected but there is almost no analysis of what is actually happening. The objective of annual monitoring should be to learn from what is going on.

- Local authorities (and the Mayor in relation to call-ins) should therefore submit evidence on what they have done and why they had made the decisions - in other words report on their own activity in relation to Plan implementation

Overall

- No single measure of density can provide the information to support the range of objectives that are identified.

- It is important that responsibility should lie where the relevant decisions are made. When the decision making power lies with local authorities they should also take responsibility for those decisions.

- There is a clear case for setting minimum density standards and publishing these in statistical and mapped form (in place of the density matrix) for the information of boroughs and prospective developers. But it should be up to boroughs to determine any local maxima and the most suitable built form.

Section 1. The Research: definitions and measurement of density

1.1 Objectives of the research

Within the overall objectives of the five projects, the first project is expected to explore the different definitions of density and the different methods for measuring density. It is asked to consider which approach or approaches best provide an understanding of two key issues related to higher density development: urban form and number of people in an area. In addition the project is asked develop a definition for different categories of density which can be applied irrespective of the site context to help provide clarity to a significantly wide ranging debate.

The findings from the report are expected to provide recommendations on how a new Mayor could take account of these in the full review of the London Plan. The project will also provide a recommended approach for estimating density for understanding housing capacity at a strategic level.

Within this overall objective the brief requires the research to address the following questions:

- What are the different definitions/measures of density, and what are their advantages and disadvantages? The study should explore:
    - different spatial level measurements e.g. building footprint, site area, surrounding areas of different size (e.g. neighbourhood area) etc.,
    - how to measure density in mixed use developments,
    - how to measure the impact of the development on the surrounding area,
    - how density measures can relate to the social and physical infrastructure requirement of the development;
    - The effectiveness of the application of different definitions/measures of density in other cities

- What density measure is appropriate to indicate the intensity of the development e.g. the building's form, scale and bulk?

- How can density be defined in categories which relate to different levels of relative density, such as low, medium, high within the London context?
    - Which density measurement should be used for this definition?
    - What range of densities should each category apply to?

Because the objective of the research is to go back to basics and ask how measures of density can be defined, measured and operationalised in different contexts it is necessary not just to accept the brief as written but to take a positive but both broader and more critical approach to some of these questions.

1.2 Background: how density is measured in the London Plan

As Policy 3.4 of the London Plan makes clear, it is accepted that density is the outcome of the interplay of a range of policy, financial and other considerations. Nevertheless, in practical terms it remains a key measurement used to describe and

plan development, particularly residential development. The London Plan SRQ matrix (its Table 3.2) is predicated on the relationship between public transport accessibility and development. Historically this has been considered fundamental in ensuring that development in London is sustainable in the broadest sense, and the matrix expresses this as ranges for appropriate residential density in different urban settings. The density ranges in the matrix help implement London Plan Policy 3.4 which aims to ensure that development optimises (or as in the original Plan 'maximises') housing output for different types of locations in London. Density in the matrix is measured by the number of habitable rooms per hectare, and the number of residential units per hectare within the development site.

The brief notes that there are various other ways to describe and measure density. For example the density of a wider area than the development site can be measured to take into account the density of the existing surrounding buildings; or the density measurement can take account of all the land uses in a mixed use site or area; or it can measure the number of people in an area rather than its land use. Other density measurements, such as plot ratio, can be used better to describe the intensity of the site being developed than units/ha or habitable rooms/ha, although plot ratio on its own provides a poor description of the built form.

1.3 Approach

The approach taken in the research involved:

- Reviewing the professional / academic / trade literature on concepts, measures and outcomes;
- Clarifying the way in which the current matrix approach operates to support local planners and to project capacity;
- Reviewing such existing statistical work as is available for areas in London on the relation between density standards, actual realised densities and net changes in population densities across areas
- Undertaking some analysis, with our LSOA level database of room, residents, etc., change between the 2001 and 2011 Censuses[1], and linking these to LDD information on construction.
- Undertaking an e-mail based questionnaire with international experts;
- Discussion with local planners about use and interpretation;
- Examining certain other cities' plans;
- Drawing out conclusions and preliminary recommendations on how to move forward both on projecting capacity and on advice within the London Plan.

1.4 Density Principles: Objectives, definitions and measurement

Why measure density?

Density is one way of thinking around the physical/neighbourhood structure and population needs of a particular site, the immediate locality and different more general scales such as an administrative area, a country or even the world. In the main above the immediate locality level definitions and measures of density tend to be in relation to population or some segment of population - e.g. the density of ethnic minorities or young people.

[1] As used in Gordon (2014)

The reasons for measuring physical/building based densities and population based densities while related are rather different. The first has to be about built form on and off site while the second is about those living in the area or likely to do so. Thus building based density relates to the supply of buildings in relation to land while population density involves demand as well as supply and may therefore generate quite different outcomes than those expected or planned for. It can also be measured at site neighbourhood and area level - but is often most appropriately used in the context of wider areas. It is also easier to compare across areas and indeed countries.

Three main planning objectives in providing a density measure are (i) to project potential capacity and to clarify where that capacity can best be provided, (ii) to advise local authorities about the broader context in which their own decisions should be made and (iii) to help meet regional requirements notably with respect to housing.

The main immediate reasons for using and measuring density relate to (i) ensuring housing is available for the population (which to be satisfied involves both demand and supply); (ii) ensuring that what is built within the site is suitable both of itself and in relation to the surrounding areas; (iii) providing the capacity to enable households to access services, infrastructure and employment and (iv) enabling planners better to use available services and infrastructure and to plan for future requirements. It is therefore both a contribution to determining current capacity as well as to predicting requirements and by implication to assessing the most cost-effective /net value of building in different locations.

In the context of the London Plan and land use planning more generally the starting point is actually what physical entity is planned in relation to what is already in place in terms of buildings, infrastructure, accessibility etc. Population density is normally derived or implicit rather than directly measured and relates more to services and the types of housing that might be provided.

The immediate use for a density measure when specifying standards and granting planning permission is to ensure that the permission meets defined objectives and contributes effectively to capacity - based on an understanding of the area and wider requirements. Each site is marginal to the overall density of the wider area. It can in principle directly take account of likely developments nearby but there may be very little information on which to base such an assessment.

Objectives

It is important to recognise that density measures have two main rationales: they are an element in determining the capacity available within a defined area; and they are an element in determining what and where the required housing, commerce and industry should be provided. In the context of the London Plan most of the emphasis is on residential density, although where there is mixed use these different elements have to be brought together into a single set of decisions. Equally at the GLA level the first is about meeting their requirement to provide adequate land for projected housing need; the second is within their advisory role to local authorities and helps to support other aspects of the Plan, notably with respect to public transport and sustainability.

The London Plan has always taken as read that the main objective is to densify in order better to fit the growing population within the London boundary. Because of rapid population growth that is expected to continue to be the most important

objective. Ensuring the number of appropriate dwellings has dominated both with respect to forecasting available capacity and in advice to local authorities.

The objective does need testing both on the grounds of whether it is appropriate to solve the problem where it lies (a question outside this project) but also with respect to the questions of whether increasing density increases output and whether density directly relates to built form (notably tall buildings) in a clearly understood fashion as seems to have been assumed. In addition it is obvious that simply providing a number of units cannot achieve the objective of housing the range of projected household types - so even at its simplest density cannot stand alone.

The second objective is that of appropriate built form. This is a more qualitative matter and relates not just to cost and demand but also to place making and sustainability. Design is an area where one would expect local planners to use past experience and theory to determine suitable built form for the building/site and the area. It is not obviously something that plays significantly at regional level - unless built form and density are closely related to one another - another reason for assessing that relationship.

The third main objective, that of identifying unused capacity and planning for new infrastructure particularly with respect to transport, is clearly directly an issue for the GLA as well as for local planners. This basically relates to population density (and the type of population envisaged). The core relationship is thus how what is built turns into numbers of users of the infrastructure. That is where demand comes in and points to the use of past experience of outcome densities to predict future possibilities, rather than simply assuming conformity with a desired norm. Specifically it makes sense to look for predictable relations between actual outcomes and the kinds of accessibility, public transport connectivity and area character indicators that figure in general planning principles and the specific logic of London Plans.

Different models of land use planning

Land use planning systems tend to be along a spectrum from tightly determined zonal systems to individual site planning permissions related to but not bound by experience and rules. In principle zonal systems should produce consistency and certainty while permission systems should reflect the specifics of the development and its environment more closely and thus are less readily predictable. In practice this is not a straightforward distinction. While in zonal systems densities (or ranges of densities) are specified for each zone, changes in density to reflect particular objectives and the specifics of the investment do occur and are a matter of negotiation. Such negotiations occur when the developer can see opportunities and/or when planners have other objectives - such as achieving affordable housing through density bonuses (Monk et al, 2013).

In planning permission systems density is not usually determined ab initio for each development. Densities may be specified in general policy and in local plans. But each development is treated separately and is a matter of individual decision. This raises issues about how secure the general approach is (e.g. in terms of what the matrix says), with this uncertainty reflected in land values. It also raises major issues about how to ensure that the density levels of the neighbourhood are appropriate. Within these concerns is the fact that developers will be reflecting demand, while planners are looking to optimise some concept of the common good.

Comparative evidence suggests that the differences between the apparently very different approaches are often not as great as might be expected. Rather changes in economic and other conditions and therefore opportunities after plans are set in

place, together with changing priorities, lead to varying levels of discretion and negotiation (Monk et al, 2013).

Both systems generally use density measures as one of their metrics. Outcomes will be dependent not just on the extent to which outcomes are consistent with the measure chosen but also on the form of that measure. In other words what will be put forward in order to meet the plan and/or to get permission to develop will be framed by the measure chosen in the documentation.

Measures

The main measures to be found in planning documents across the spectrum of land use planning systems from zoning to individual planning permission systems vary somewhat but in the residential context come down to three main categories:

- Numbers - including numbers of dwellings, numbers of rooms (habitable rooms, bedrooms, bedspaces), square metres or equivalent;
- Built form - which at its simplest tends to be around plot ratios and other physical relationships between land and building; but also includes type of area (as in the London Plan's central, urban and suburban); tallness of buildings and other standards;
- Person based measures such as persons per hectare or other area measures sometimes identifying specific types of person such as children.

These three categories relate to the different objectives specified above. Numbers are generally used to achieve the homes required; built form to specify design and the local environment; and persons to clarify requirements for existing and planned service and infrastructure provision.

Looking in more detail, we refer back to an earlier report for the GLA on density that noted: *'Residential density policy is about everything and nothing. On the one hand it informs everything to do with housing design and management. On the other hand, the actual density calculation of an acceptable development (in terms of units or habitable rooms per hectare) is a product of all of the relevant design and management factors; if they are all met, the resultant density figure is what it is and is arguably irrelevant.'*[2] Thus how we measure density is, in no small part, related to why we are seeking to measure it.

We have taken selected examples and adapted the table from Boyko and Cooper (2011) to show how the different measures of density relate to different reasons for measuring. We have retained those we consider the most relevant, useful or practicable. We have also re-ordered them in terms of function and scale. Although each measure is not necessarily applicable to only one scale, overall we also move from the smallest to largest scale; from a building, to block, to neighbourhood to city.

Density type	Metric	Notes
1. Where the primary purpose is to establish the quantum of living space to be delivered. This can also include units per hectare but is not included in the original table.		
Habitable rooms per hectare	The number of rooms in a dwelling	Useful (along with dwellings per hectare) for providing a broad indication of the intensity/form of development on a site or in an area; it is not

[2] housing density study Maccreanor Lavington Architects Emily Greeves Architects Graham Harrington Planning Advice Final Document: 30th August 2012

Density type	Metric	Notes
	that are used for dwelling purposes (except for kitchens, bathrooms and WCs) divided by total land area	effective in predicting or controlling the form of development on a site
Parcel or site density (or plot ratio, when used with floor area)	Dwelling Units (DU), residential population (RP) or floor area divided by total site/parcel area DU and RP are typically calculated as a per hectare measure	Often used by developers; the most un-ambiguous gross measure; easy to calculate with GIS; can be difficult to calculate from physical observations because parcel or site boundaries are not always visible; floor area is useful when the same parcel consists of land for residential and non-residential purposes (i.e., mixed-use) or in areas of high density and large buildings; adopted as a standard indicator for land use zoning and development control regulation; used in design briefing and development budgeting
Where the purpose is to establish a fit between number of residents and services.		
Occupancy density	Total number of occupants in an individual dwelling divided by the total floor area	Used in building services to determine services required for that space

2. Where design based measured are required to assist in indicating what proportion of a site or block will be built on and how much will remain open. Useful when making decisions on open space and trading this off with heights.

Floor area ratio	Built floor area on all floors divided by the parcel area	Often based on usable floor area rather than footprint area; includes wall thickness; varies by municipality; as plot ratio, it is extensively adopted as a standard indicator for land-use zoning regulation, development control and urban masterplans; used in design briefing and development budgeting
Building site coverage or coverage ratio	Area of ground floor footprint of building	Indicates the amount of open space left on a site

Density type	Metric	Notes
	divided by the parcel area	

3. Where the intention is to look more broadly than a single development, site or block in order to capture a sense of the overall context.

Net neighbourhood residential dwelling/population density	DU or RP divided by total land area devoted to residential facilities	Neighbourhood should be a census tract or city-delineated area, typically 40–200 ha; relatively simple using GIS; care must be taken to assign land to residential uses rather than other uses (e.g., recreation) – include dwelling sites and gardens, private gardens, play spaces, landscaped areas adjacent to and related to residential use, driveways/private access drives, ancillary structures (e.g., garages), resident parking; exclude the following, unless beneath a dwelling: commercial/industrial areas, shops, commercial garages, public parks, playgrounds, undeveloped vacant land, vacant unsuitable land, schools, houses of worship, public streets, public parking spaces

4. Where there is a reason to know the overall density, possibly for comparative purposes between a neighbourhood or borough and the rest of the city.

City density	DU or RP divided by the entire developed area of the city	Includes the entire city, but on the urban edge, it only includes developed land; a gross density measure; appropriate when planning for a major mixed-use development
Net residential density at city or metropolitan level	DU or RP divided by residential land at a city or metropolitan level	Possible using large GIS databases; presence of housing in mixed-use areas makes it complicated, but not impossible to calculate

Source: Boyko and Cooper 2011 with adaptation by report authors.

The roles of these measures in forecasting are also rather different to the same measures' roles in advising on or determining individual decisions. So for instance a measure of connectivity and access to public transport may be used to forecast relative demand for different areas and therefore likely acceptable densities in terms of demand. In the context of advice however it is more about whether capacity needs to be expanded in the context of increasing density.

Most importantly measures generate incentives and disincentives. For example, numbers of units on their own look as though they deal with objective one BUT it provides an incentive to produce small units within the limits set by market demand. So unless in addition some measure of rooms is included it can result in a mismatch between the types of household to be accommodated and the types of dwelling that will meet the density requirement. Equally, rooms can be too small to meet

requirements as in the case of bedrooms or indeed dwellings without adequate storage space - leading to the need to specify space standards. Thus, ideally, one might wish to include all of the different measures relating to numbers rather than concentrate on one.

The issue is most relevant with respect to the inter-relationship between physical numbers and people. Ultimately the objective is to satisfy demand and ensure those living in an area are properly served by their home, environment, infrastructure and services at the same time as ensuring social objectives are achieved and positive and negative externalities (notably with respect to sustainability) addressed. Planners are concerned with buildings, their relationship with one another and built form as well as connectivity and accessibility. They do not directly allocate people. Thus they often assume a fixed relationship between the built form/physical numbers and the number of people. However the actual relationship depends on how the development is occupied - a matter of demand more than supply. Over and under-occupation in planning terms can completely change outcomes - as can changes in occupation levels in the surrounding area which arise from changing demand. One implication is that outcomes should be monitored and taken into account in forecasting and future decisions; a second is that what happens in the surrounding area - which is usually much bigger - is generally more important than any specific site decision.

What data are available?

At the current time most of the data available for London relate to numbers - notably the number of units and the number of bedrooms. There are no data collected on space and although data on habitable rooms appears to be collected it is not in a useable form.

Aspects of built form and environment are measured in a more qualitative fashion and are cruder than some of the other data.

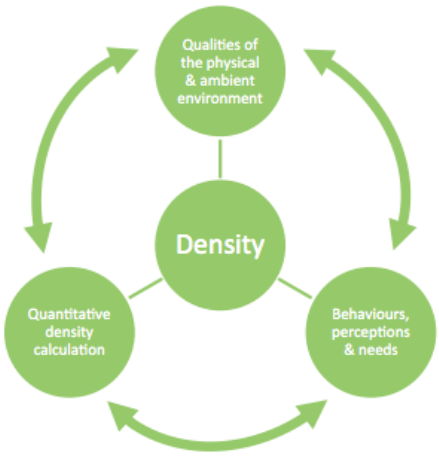
Material on accessibility and connectivity is available and used through the summary PTAL measure. Because these data are well analysed they probably have more influence than other equally important variables where quantification is more difficult.

It is important to note that while, in principle, once the measure to be used is identified results should be easy to interpret, in practice there are different approaches to measurement particularly because of assumptions about the relevant scale to which the measurement applies. Most importantly, in some contexts planners use what is called net density which includes only the most immediate area; in other contexts they use gross measures of density which includes the land used for services and other uses in the defined area - so what is actually measured is not as consistent and accurate as is usually assumed.

1.5 Density in the literature and in practice

In seeking to conceptualise density, Boyko and Cooper (2011) argue that technical or quantitative calculations alone are insufficient. They conceptualise density as being a composite of three elements (Figure 1.1); quantitative density calculations, qualities of the physical and ambient environment and behaviours perceptions and needs (p52). These three elements are addressed here.

Figure 1.1: 'The Conceptualisation of density'.



Source, Boyko and Cooper 2011: 52

Quantitative density calculations

There are numerous publications that discuss ways of measuring density (e.g. Cheng 2010; we reproduce Table One from Boyko and Cooper (2011) below as one example). The three most common elements in measuring density are Floor Area Ratio ((FAR) or plot ratio[3], dwellings (or habitable- or bed-rooms) within a given area and population within a given area. There are differing institutional and economic drivers favouring any one of these but "although each measurement provides good information about a place, alone, they do not paint a complete picture of the density of a neighborhood (sic)" (Densityatlas:nd) http://densityatlas.org/measuring/metrics.shtml

In addition to applying any combination of FAR, dwellings/rooms and population another consideration is the physical extent of the area over which these are to be measured; this is captured in simple terms by the distinction between net or gross areas. A general distinction is that, "net residential density measures the area of a housing site up to the surrounding roads include facilities for the immediate benefit of the housing, such as small areas of open space, community centres, a few shops and so on. Gross residential density measures a residential area and includes - in addition to housing - parks, schools, the road and transport network and other mixed uses. It does not normally include large commercial or industrial areas" (Towers 2002:148). An example of the differing results that net and gross measures produce is provided by Rudlin and Falk (2000) (Table 1.1). Here we can see that the distinction yields very different figures; on this example to a magnitude of approximately 44% for each element, but this would vary depending on the detail of how the net and gross areas were defined.

[3] For brevity we do not detail FAR and the related matter of coverage here. But to give one simple example, a building could cover all of its allotted land at a height of one storey giving a coverage of 100% and a FAR of 1. If the same building was cut into quarters and each part placed on top of the other you would have the same amount building. Therefore the FAR would still be 1. But the building would now be four stories high and the coverage would be 25% (of the total land available to the building)

Table 1.1:
Net and gross density calculations

	per hectare
Net Density	
Dwellings	62
Bedspaces	247
Population	148
Gross density	
Dwellings	27
Bedspaces	108
Population	65

Source, based on Rudlin and Falk (2000:219 Table one)

A common option for a net measure is whether or not to include some of adjoining roads in the 'site' area[4]. Other variations include that net measures can be of the internal or external dimensions of a building. Gross densities have even greater need for definition as they can cover much greater territory. To summarise, which elements we measure and combine, and the choice of net or gross measures produce considerably different results. It seems likely that deciding how to measure density will partly rest on why we are measuring it.

Qualities of the physical and ambient environment

We can characterise this as the design element that quantitative measures of density do not dictate. As we have already noted very different urban forms can produce the same density. We use design in a broad sense, meaning not just the massing of the building but the character of the wider urban form e.g. the fit with existing buildings. This is partly captured in the existing density matrix in the London Plan by the three settings - central, urban and suburban - which serve as a basic design element. Numerous other documents add to this in London including; other London Plan Policies, GLA Housing Supplementary Planning Guidance, borough's Local Plans and design guides. All of these, Boyko and Cooper (2011:52) suggest, might give positive consideration to other forms of density - of parks and trees, or negatively, of takeaways and betting shops for example. These elements are sometimes addressed through planning but are rarely, if ever, expressed in terms of density.

Behaviours, perceptions and needs

The final category is partly concerned with the potential gap between what planning policy seeks to achieve and how people respond. First, behaviours, Dempsey et al (2012:92) distinguish between:

- environmental determinism - that behaviour can be determined through the environment
- "environmental possibilism – the idea that it is entirely possible for people to live happily in an environment…as long as they are not problem people [and]
- environmental probabilism - the idea that the physical environment can be designed so that 'some choices are more likely than others'"

Density policies can assume all three. The PTAL element of the density matrix reflects assumptions about behaviours. We can build at higher densities near to public transport because people living nearer to public transport are more likely to

[4] "The London Plan defines density in terms of net residential site area" (Draft Interim Housing Supplementary Planning Guidance 2015: 1.3.60).

use it. The point here is that the relationship between the built form and individual behaviour is complex and, therefore, not easily predicted. As we noted in section two, the oft quoted correlation that Newman and Kenworthy (1989) demonstrated between density and car use has been misinterpreted as showing density causing behaviour change (less car use), whereas other factors come into play, including the relative cost of driving, across the international comparisons. Dempsey at al (2012) cite numerous articles that, in addition to the example of transport mentioned, focus on the complex relationship between density and behaviour.

Second, perceptions, Churchman (1999) notes the difference between formally measured density and the perception of density, sometimes referred to as social density. Judgements of overcrowding can have many causes, among others these can include; culturally bounded notions of density, design that makes density appear more or less intense and household circumstances such as overcrowding. Related to this, Breheny (1997) notes there is no fixed or universal point at which density is unacceptable. While design can mitigate perception to a degree, the point is that there is a personal element to how density is perceived.

Third, needs (which we see as interacting with behaviours): While it is possible to specify a quantum of services required, and even to provide it, Bretherton and Pleace (2008) emphasise the influence of individual characteristics in making use of these. While more services may be present in a higher density neighbourhood for some, decreased sense of personal safety may prevent access (Talen 2001). The place specific nature of social outcomes including, again, the importance of design and neighbourhood character is also the focus of Raman (2010) who looks at Oxford and London. Moreover, others question whether the services provided always meet the needs of the full range of residents, “recent research conducted in London shows that in reality, the adequate range of services and facilities required to support the needs of communities (including older people and young children) ‘is rarely established’ and instead favours a transient population for whom the compact city is a temporary choice and lifestyle” (Dempsey et al 2012:97 on Foord 2010). This is expanded on by Holman et al (2015) who identify a ‘discourse of pragmatism’ or trade-offs when developing at higher density, including between individual and collective goals.

Such examples of uncertainty lead Dempsey et al (2012) to suggest that “within the UK context, the lack of consensus between theory, policy and practice arguably points to a requirement for residential densities to be examined on a case-by-case basis according to the policy in place at the time as well as the particulars of the place itself (p96).

The rest of the report looks first at how and why density has been used as a tool in London planning; next at some quantitative evidence on how densities have evolved particularly since the first London Plan; then at qualitative evidence from London, the UK and abroad on how densities are used and the practicalities of implementation; and finally at some possible recommendations.

Section 2. Density as an issue and a tool in London planning

2.1 Some history and earlier literature

The spatial strategies prepared for London since a strong Mayoral system was adopted in 2000, and embodied in successive versions of The London Plan, give a distinctive role to density, both as something to be positively pursued for the city as a whole, and as an operational tool to guide planning practice and development control at the local, borough level. In combining these two elements, the Plans differ both from common practice elsewhere, and from previous phases in London's own history of planning and urban policy. To understand the significance of the current approach, and identify some key issues about how it works, it is useful to look back at the changing significance of densities across those phases: in urban strategies; practical interventions; the evolving structure/performance of the city/region; public debate about the direction of these; and the relation between them. Most of this is very familiar ground, but significant implications may still be drawn for current practice, and directions in which this might be reshaped, or at least enhanced. Some of the approaches and issues to be discussed are at least nominally 'national', but London and its extended region is commonly the key example underlying these.

Round One

To start off in national terms, we might say that the *first century* or so of English urban planning/policy took off (in the later 19th century) from a series of concerns with social/environmental pathologies of the dense urbanisation that accompanied and enabled an economically productive form of industrial development. Some of these problems (of disease, social disorder, inadequate housing etc.) were understood to be bound up with high levels of social inequality and poor administration. But for the urban reform/planning movements, aspects of density were a central concern, requiring action – in London as in the factory cities to the north - both to mitigate its worst effects (in unplanned slums lacking basic infrastructure), and simply to lower densities in core areas (by clearance/dispersal, regulation of housing occupancy etc.).

Formally this reached its apotheosis in Abercrombie and the post-war decentralisation strategies for the London metropolitan region. But it also had an important individualistic/private sector counterpart in suburbanisation/exurbanisation, which worked (with the aid of new transport modes), again most notably in this region, to secure lower density forms of living as rising incomes enabled this. And, whereas the formal strategy combined decentralisation with containment of London's physical extension by a (strongly enforced) Green Belt, informal dispersal through the market was to extend the functional regional further out, beyond the Belt (Hall, 1973). Commitment to this population decentralisation strategy, on the part of both national government and the GLC came to an end in the mid-1970s, in the context of both rising doubts as to the efficacy of spatial (rather than socio-economic) approaches to dealing with the problems of 'inner city' communities, and worries - misplaced or at least exaggerated, and verging on panic - as to the likelihood of this strategy engendering a damaging downward spiral in population and employment levels within core cities (notably London, see Donnison and Eversley, 1973).

This brought a new national urban policy focused on reversing 'inner city decline', and for London an end to managed decentralisation (via the New/Expanded Towns

programme and office dispersal). It did not, however, affect the (much more significant) unmanaged private outflow of people and channelling of business expansion to areas in South East England, mostly beyond the Green Belt, where the desired space was more readily available (Buck et al.,1986).

Looking back on that first (classic) phase of metropolitan planning, while de-densification was obviously a key aspect both of public policy and market behaviour; strategy was not couched in those terms (aiming more specifically at reductions in 'congestion', overcrowding' etc.); and density measures were not used to monitor its impacts. At the level of town planning practice, however, as noted nostalgically by Michael Breheny (1992): 'an understanding of densities formed a core part of planner's education' and pre-occupied the designers of new towns'. And, planning practice required careful local surveys/mapping of the densities of the range of local land uses, and their inter-relation, contributing to a diagnosis of problems and prescriptions for balanced and appropriate development of the settlement pattern and urban form, down to neighbourhood level (Keeble, 1952).

Round Two

The phase which followed – from the early 1970s through to the late 1990s – very substantially downplayed both aspects of 'density' , with a retreat *both* from the strong aspirations of strategic metropolitan planning (including the decentralisation agenda) *and*, before that, from detailed, map-based development plans (in favour initially of more argued structure plans). Hence Breheny's (1992) observation about expertise with densities having become 'a lost art, except with a few local planners' (p.372-3). In the metropolitan region it was a period of quite dramatic change – including a turnaround in growth trends for population, jobs and incomes – but one without any effective replacement of the 1969 Greater London Development Plan (before or after GLC abolition). London boroughs were more likely to have density standards in their plans, mostly in terms of habitable rooms, but as elsewhere these only set upper limits (Breheny et al., 1997).

Round Three

The context of Breheny's comment about lost skills was the dawning of a third phase, with a (quite unexpected) return of issues of density to a central role in the planning agenda, cast now in a positive light. This really stemmed from the touting of compact 'sustainable cities' as an effective spatial-management response to the energy/emissions-saving goals endorsed at the 1992 Rio Earth Summit. This led to an initial central government 'guidance' (PPG13 in 1994) urging planning authorities to seek higher densities in residential developments - both to limit emissions and deflect rising housing demand away from greenfield sites, where resistance was strong. This initiative yielded only a very limited initial response (Breheny et al., 1997). But through the 1990s the environmental argument was joined by a much wider set of socio-economic objectives identified as being advanced by urban compaction and agglomeration – and a new confidence that competitive forces had brought a new era of urban resurgence, in contrast to the pessimistic assessments of the 1970s.

The initial connection between compaction and 'urban sustainability' focused very heavily on transport. Specifically it was argued that there was a reduced '*need* for travel' in more densely populated metropolitan regions, which also made energy efficient forms of public transport more economically viable (Newman and Kenworthy, 1989). Critics pointed out, however, that: *demand* for travel was rather elastic (being stimulated by more accessible opportunities); that impressions of very strong density effects were exaggerated by confusion with those stemming from socio-economic

differences; and that the potential for land-use planning substantially to alter metropolitan densities in the UK was much more restricted than for more direct fiscal action on motoring costs via fuel taxes (Breheny et al., 1997). These issues are pursued further in our other report in this set (number 5). But the significant point here is that, whether compaction or decentralisation are the strategic aims, the continuing power of market forces has to be recognised and brought into policy analyses.

At a national level, the broadening of the case for a 'compact city' strategy from transport/energy considerations[5] - with more qualitative arguments about the greater vitality of life/culture in denser cities, and/or of social mixing/interaction in compact communities rather than sprawling, class-segregated city-regions – was pursued by the (Richard Rogers-chaired) Urban Task Force[6]. Their recommendations (GBUTF, 1999) fed directly into a revised Planning Policy Guidance on housing (PPG3, 2000), which formally introduced the 40% limit on greenfield development. In the London context, the potential for combining residential densification with an enhanced environment and travel mode-mix was pursued from a more micro-perspective in work on 'sustainable residential quality' commissioned by LPAC from Llewelyn Davies and Partners. Its focus was on intensified use of small sites within residential communities with a design-led approach to assessing the sustainable capacity of a sample of locations, from which the aggregate potential of such sites could be grossed up. This analysis led to a primary emphasis on 'ped-sheds', walkably close to established centres, rather than 'backlands' for a combination of reasons including both demand factors (and the commercial attractiveness of higher density developments), and ease of achieving acceptable design-solutions without major land assembly problems (LD, 1997).

In substantive terms, it indicated a way of adding between 77,000 and 106,000 to London housing capacity, without recourse to high-rise development or exploitation of very large sites. And methodologically it demonstrated a way of integrating the strategic and design approaches to density-planning – with a bridge between these to be provided by a density matrix:

> 'indicating a range of different densities appropriate to sites in different locations, each with different mixes of houses and flats, and with different requirements for off-street car parking… cross-referenced to the design exercises .. show(ing) the forms of development possible on different types of site and each density range. … (as) a conceptual and indicative tool … not .. a prescriptive specification … (S)ite specific design and quality considerations should be the predominant concerns not a predetermined view about density' (paras 8.2.5 – 8.2).

As well as the rise of sustainability concerns, the other new factor in shaping the density agenda for the third round of strategic planning for London was simply the challenge of meeting the aggregate housing supply challenge. Progressive increases in the scale of projected population growth projections have made this a much more demanding task than seemed the case at the time of the LPAC research. By the 2002 draft of the first London Plan it had clearly become the focal consideration in terms of density policy, giving as a primary objective – 'to accommodate London's growth within its boundaries without encroaching on open

[5] These had already led to

[6] A further strand for the argument emerged soon after from spatial economists pointing to important productivity gains from agglomeration of activities in large and dense city-regions (Fujita, Krugman and Venables, 1999; Duranton and Puga, 2004). The salience of this relationship for setting of residential density standards in London is discussed in our other report in this set (no. 5).

spaces' – which was not going to be easy to accomplish. And, just a few years later, when the UTF produced its follow-up report (reinforcing the 'compact city' message), one member, with a perspective close to that of the LD team, was arguing that at best two thirds of the Plan's 2016 target for new dwellings in London was achievable, and that only by shoe-horning dwellings into inappropriate sites offering very poor residential quality (Hall, 2006).

2.2 Density Policy in Mayoral London Plans from 2004 and the role of the Matrix

The terms in which density policy entered the Plan's objectives differed significantly between the first (2004) Mayoral Plan and the Replacement Plan (of 2011): in the former the aim was straightforwardly to 'increase' densities, in the second it was to 'optimise' them – reflecting critical responses to an apparently unbalanced approach. In practice it is not clear that the difference is so great; in both cases the numerical targets (little changed) included maxima as well as minima, and similar textual qualifications were included about the need to consider qualitative issues in different local situations. Objectively the housing pressures underlying the push for density had increased (and have continued to do so), and the signal conveyed by the Plan remained one of a general need to intensify.

The Density/Sustainable Residential Quality Matrix
The centrepiece of the Plan's treatment of a density is a matrix, relating the acceptable range of densities for new development to a two-dimensional categorisation of locations, involving *accessibility* (3 broad bands of PTAL levels) on the one hand and *area character* (central, urban or suburban – differentiated in terms of existing densities, as well as the status of nearby town centres) on the other[7]. These two dimensions are naturally somewhat correlated, with very few development sites in central areas having poor public transport accessibility, and even fewer in suburban areas having very good accessibility. But various other combinations are quite common.

We might note also that the salience of each dimension is a matter of both the potential attractiveness to occupants of denser types of housing (those more concerned with accessibility than space), a private market demand factor, and the likely acceptability of such development (in terms of channelling travel demands into less energy intensive modes, and of fit to the established urban character), a social externality/policy concern.

For each of the 9 types of location so distinguished, upper and lower density limits seem to have been prescribed initially in terms of numbers of habitable rooms per hectare[8]. This traditional measure[9], provides a simple indicator of both the likely area/volume of accommodation and potential numbers of occupants. It is not,

[7] This account relates to the 2009 Plan. In its (2004) predecessor a very similar kind of approach was employed, though it distinguished only 6 of the possible 9 area types , and added a third dimension in terms of car parking provision, which was both project-specific and subject to separate policy-guidance in the transport section of the Plan.
[8] This sequence, starting from habitable rooms per hectare and then approximating this in terms of a dwelling per hectare, is not made explicit in the Plan, but seems obvious from arithmetic of the matrix.
[9] Originally recommended, alongside persons per acre, for use in the local planning surveys required under the 1947 Act (Keeble, 1952).

however, routinely returned by either developers or London planning authorities. Hence the ranges are also presented in terms of units (dwellings) per acre, for three alternative assumptions about relevant ratios of habitable rooms per unit – though the expected source of such estimates is unclear.

Because each assumption is also presented as a range, and extreme values for the range are used to carry out the conversions, the unit density ranges corresponding to a particular habitable rooms density standard, and any one of the three (high, middle, low) assumptions about rooms/unit are a bit wider in proportionate terms than the habitable rooms ranges.

More significantly, however, if – in the absence of any readily available information about numbers of rooms per unit – this factor is ignored and the relevant range is assumed to be from the lowest of the three minimum unit density estimates for this location; to the highest of the corresponding maximum density estimates (i.e. making the most permissive possible assumptions) the proportionate range in unit dwelling terms turns out to be much greater – typically 40-45 percentage points higher. (The logic and implications of this procedure are spelled out for a couple of cases in Appendix A2). In the absence of any returns of habitable rooms constructed, this is the (rather generous) basis on which conformity of outcomes to the prescribed density range has been calculated for the monitoring statistics.

If information on habitable rooms cannot be made obligatory, a reasonable alternative would be to prescribe density standards (and calculate statistics) on a bedroom basis. Since these data are already available on the London Development Database (LDD), we have used these experimentally in the next section to provide an alternative rooms-based density measure.

A simple take-away point at this stage is that the (neat-looking) density matrix is rather opaque in relation to its operational implications, and to how practitioners are actually likely to use it.

Exhibit 2.1: The 2011 Plan's Density Matrix

Table 3.2 Sustainable residential quality (SRQ) density matrix (habitable rooms and dwellings per hectare)

Setting	Public Transport Accessibility Level (PTAL)		
Indicative Average Dwelling Size	0 to 1	2 to 3	4 to 6
Suburban	**150-200 hr/ha**	**150-250 hr/ha**	**200-350 hr/ha**
3.8-4.6 hr/unit	35-55 u/ha	35-65 u/ha	45-90 u/ha
3.1-3.7 hr/unit	40-65 u/ha	40-80 u/ha	55-115 u/ha
2.7-3.0 hr/unit	50-75 u/ha	50-95 u/ha	70-130 u/ha
Urban	**150-250 hr/ha**	**200-450 hr/ha**	**200-700 hr/ha**
3.8-4.6 hr/unit	35-65 u/ha	45-120 u/ha	45-185 u/ha
3.1-3.7 hr/unit	40-80 u/ha	55-145 u/ha	55-225 u/ha
2.7-3.0 hr/unit	50-95 u/ha	70-170 u/ha	70-260 u/ha
Central	**150-300 hr/ha**	**300-650 hr/ha**	**650-1100 hr/ha**
3.8-4.6 hr/unit	35-80 u/ha	65-170 u/ha	140-290 u/ha
3.1-3.7 hr/unit	40-100 u/ha	80-210 u/ha	175-355 u/ha
2.7-3.0 hr/unit	50-110 u/hr	100-240 u/ha	215-405 u/ha

Source: GLA (2011)

A critical appraisal of the density matrix

Although other work and substantial debate have intervened, the connection between the Plan's density/SRQ matrix and the LD (1997) report remain significant. The logical link (via LD's early version of the matrix) was a persuasive demonstration by the report's case studies that *with appropriate site/neighbourhood design*, rather higher densities, in ranges comparable with those in the Plan matrix, could be accommodated 'sustainably' (in QoL as well as transport terms) without recourse to high rise, in the relevant areas. There is no implication that schemes which fit within the specified ranges would actually pass the quality test by virtue of doing so– nor could there be. A simple density value cannot cover the range of dimensions of design, neighbourhood fit, target occupants etc. which have a bearing on the acceptability and impact of particular schemes.

It seems to us that densities specified as upper and lower limits actually carry rather different significance and intent. At the bottom end, the point seems to be one of conveying (to borough planning authorities and the developers who negotiate with them) an expectation that rather higher densities should be achieved – at neighbourhood and/or site level – than has been the local norm, on the basis that there are wider benefits to be taken into account (in meeting housing needs and carbon reduction goals). At the top end, however, the main criterion seems to be the more subjective one of what is likely to be qualitatively acceptable to residents inside and outside the new development, now and in the future. If we are broadly right in this perception, it underlines the point that a single kind of measure cannot really do the same job – at the top end, for example it seems likely that plot ratio or height have more significance than mean density. But it also raises questions as to whether strategic, London-wide, guidance should play the same role at the top as at the bottom end of the scale. The case in terms of externalities for not leaving decisions to be resolved interactively by developers, qualified professionals and democratic

representatives, at a local level seems very much stronger in relation to setting minima than it is to suggesting maxima in a density matrix. Even so, the Plan might (continue to) play an important role in specifying desirable criteria to be used in defence of the public interest and qualitative objectives for London's direction of development.

At a rather more specific level, we have noted two main kinds of criticism of the way in which density policies have operated in practice, both well summarised by Bowie (2010) in relation to the original 2004 Plan where a stated goal was *maximising* use of space, though still relevant despite a semantic shift to optimising in the 2011 *Replacement Plan*. These relate to negative impacts of an effective prioritisation of raising density over, on the one hand the issues of housing mix (particularly of greater access to family-sized dwellings) and on the other that of crude disjunctions between tall buildings and the local context. Both of these reflect the inadequacy of any one-dimensional measure as a guide to appropriate local development patterns – but it is doubtful if the specifics of the density matrix have much to do with this.

What is clear is that the lower ends of the range in the matrix do not imply that small flatted dwellings (still less high-rise) must be built, while at the top end most of the cases that are criticised involve densities that clearly exceed the upper limit set out in the Plan. The issue seems rather to be the (mostly) implicit message of the Plan that densification is a good and necessary thing, particularly in the context of numerical housing targets that are recognisably very demanding (at the least). A secondary consideration is the framing of those targets simply in terms of numbers of dwellings – without reference to the number of people to be accommodated. In our judgement, however, reframing the matrix in terms of a single guide number – appropriately conceived of as a minimum – would contribute to a more balanced approach, by making it clear that judgements about what was appropriate to the local situation (above that limit) were really the responsibility of professional/political actors to determine, on a qualitative basis in relation to local/sub-regional planning strategies/criteria, rather than on any simple numerical basis.

Monitoring

Since the first Plan, reporting of the relationship between the patterns of approved residential developments and the relevant local limits in the (current version of the) density matrix have been a formal requirement for the Plan's *Annual Monitoring Report* (AMR). Though the key performance indicator has shifted (between the two Plans) from 'increasing' to 'optimising' density, the operational target has remained that 95% of approved units should lie within the specified range. Perhaps oddly this reporting requirement rests solely with the GLA - using an integrated version in the London Development Database of data supplied by boroughs – rather than with those responsible for the relevant decisions (i.e. City/boroughs or, in called-in cases the Mayor), who could explain departures from target, as well as how they had applied the matrix criteria to particular cases.

The AMRs have regularly reported the proportions of approved units on schemes lying above, below or within the specified range (so far as that can be discerned from the LDD) across London as a whole, with an occasional sub-regional reference. Under the first Plan (when increasing density was an objective), borough-level time series on average densities of completions in terms of dwellings p.ha. were also included and briefly commented upon.

Exhibit 2.2 : Density Key Performance Indicator: report table from Annual Monitoring Report 11 (2015)

TABLE 2.3 RESIDENTIAL APPROVALS COMPARED TO THE DENSITY MATRIX – ALL SCHEMES

FINANCIAL YEAR	% OF UNITS APPROVALS		
	WITHIN RANGE	ABOVE RANGE	BELOW RANGE
2006/07	36%	60%	4%
2007/08	40%	55%	5%
2008/09	41%	53%	7%
2009/10	39%	56%	6%
2010/11	37%	58%	5%
2011/12	40%	55%	5%
2012/13	58%	37%	5%
2013/14	43%	50%	7%

TABLE 2.4 RESIDENTIAL APPROVALS COMPARED TO THE DENSITY MATRIX – SCHEMES OF 15 UNITS OR MORE

FINANCIAL YEAR	% OF UNITS APPROVALS SCHEMES 15+		
	WITHIN RANGE	ABOVE RANGE	BELOW RANGE
2006/07	30%	69%	1%
2007/08	36%	63%	2%
2008/09	36%	62%	2%
2009/10	35%	63%	2%
2010/11	31%	68%	1%
2011/12	37%	60%	3%
2012/13	59%	39%	2%
2013/14	40%	56%	4%

Source: London Development Database

In terms of how the policy works, as distinct from development trends, conformity with the density matrix has always been the relevant sort of evidence, and here the pattern has been a remarkably consistent one of *non-conformity*. Typically just 40% of units are recorded as being on schemes within the density range, with the majority (in every year except in 2012/3) being above the upper limit and around 5% below. The upward bias is notably stronger among bigger schemes (see Exhibit 2.2, above).

This longstanding pattern of overshooting upper limits specified in the Plan has never attracted serious discussion/analysis in the AMR. What has been noted are the (modest) proportions of units recorded as falling below the lower limit (noted in AM11 as averaging 10% in Outer London, but still representing 5% within more central areas[10]). Actually there is some reason to think the significance of this category has been understated, because of a lack of information as to which dwelling-based density was actually appropriate to specific cases. Taking (recorded) bedroom density as a guide to how the habitable rooms standard might reasonably have been translated, actually suggests that around 15% of units might really have been below the intended limit (see next section). This might have a bearing on whether the extraordinary level of non-conformity with the density matrix mainly reflects its operational irrelevance to how decisions about residential development applications are made (whether in the boroughs or on call-in) or a general understanding (effectively reinforced by the way this section of the AMR is written up) that the relevant Plan policy is simply one of raising accepted density standards.

[10] Though, as we discuss in the next section, this may significantly under-estimate the extent of development below the range in *habitable room* terms.

2.3 Summary

Mayoral London Plans since 2000 have been innovative in several respects, including the processes of development, updating and revision which have been successfully followed through over 15 years (in striking contrast to the 21 year history of GLC planning).

In relation to density specifically there have been substantial innovations *both* in relation to:

- the direction of policy, with a compact city policy being pursued as a contribution to environmental sustainability and as a means to accommodating economic growth objectives; *and*
- in the adoption of a density matrix as an operational tool, linking city-wide strategies to (mostly) borough level implementation, and promotion of a more intensive use of land across the city aimed at securing sustainable residential quality at the local scale.

There are problems at both levels in pursuing this duality especially in the context of stronger growth pressures than could have been anticipated before 2000. At the policy level, these involve issues about the appropriateness of setting (and accepting) housing targets for London on the basis simply of recent population growth trends (however those are accommodated), which are entirely outside the scope of this report. In terms of the operational use of density standards, they involve questions about the possibility of using a range of values on a single indicator both to encourage positive approaches to intensification/transport sustainability and to set a guide around the likely acceptability of changes in urban form in terms of environmental quality. As importantly there is a question about the value of standards which seem to be honoured mostly in the breach, and which are not effectively monitored. These are issues that (now) need to be looked at a bit more closely in relation to the available empirical evidence on residential density change - both overall and more specifically on new developments approved and implemented in the past decade or so.

Section 3. Policy, Density Standards and Achieved Residential Densities in London

3.1 An Approach to Analysing the Evidence on Density Change and Residential Development

Thinking about how density standards can most appropriately be set by London planners' needs to have regard not just to their clarity, consistency with Plan objectives and appropriateness to particular settings within the city. It should also consider how these formal norms may influence actual behaviour – on the part of borough planners, developers and other actors within the regional housing market – in contexts where other policies may also exert a significant influence.

We have tried to address this behavioural issue in two ways. One is to review the experience and perceptions of practitioners, as we do in section 4 below. The other, which is pursued in this section is to look at evidence on realised density levels - particularly on completed residential development sites - exploring how these vary over time and location, and how far these variations correlate with density standards and/or other salient factors,

The simple perspective underlying our examination of evidence on varying/shifting outcomes involves three (interacting) sets of influences on actual residential densities across the city:

- Pure market-based interactions shaped by the supply and demand for locational characteristics, notably for accessibilities and for occupiable space, in the face of constraints on the availability of both and relative priorities as between these varying between different population groups;
- Inherited area characteristics of various kinds (both soft and hard), some natural and others shaped by previous rounds of market activity and settlement; and
- Institutional 'interventions' by public agencies or larger private organisations responding to market failures of various kinds (e.g. non-marketed spillover effects within population concentrations) and/or inertia in overcoming the legacy of past occupancy patterns.

Getting such interventions right is dependent (among other things) in being able to disentangle how (and how far) these directly impact on the outcomes of interest, and what indirect effects may be produced as market actors adjust (in their own interests) to the interventions.

Our substantive discussion of what can be learned from available data on changing patterns of residential density in London starts from a broad, top-down view of population change, spatial concentration and building occupancy from Census and other national sources (section 3.2). It then focusses specifically on new residential developments and their density, in terms of dwellings per hectare of land, using DCLG statistics (for the years/areas where these are available) to put London changes in a wider context (3.3), before considering the more detailed site level data available from the London Development Database (3.4).

3.2 Population Growth in London since 2000 and the Overall Densification of the City

If we start with the most comprehensive view, relating total resident population to the land area in use for domestic houses/gardens, it is pretty clear that residential densities across London as a whole (and in almost all boroughs) have increased markedly through the period since the GLA was established – and by significantly more than in the decade before, when the upturn in London population started.

Overall, the city's population has been growing at over 1% p.a. since 2000, while the area dedicated to domestic housing/gardens has changed minimally. Actual estimates of this area are only available (from the Generalised Land Use Database) for 2001 and 2005 but these clearly illustrate the point. Between those two years London's total population grew by (a relatively modest) 2.7%, but the area in these domestic uses increased by only 0.14% (from 51,891 to 51,962 hectares). The kind of increase in overall residential densities that this implies has not, however, been matched by that of numbers of rooms. Again we rely on estimates for a pair of years (though different ones), with data from the 2001 and 2011 Censuses. These suggest that the stock of rooms across London increased by some 7.7% across this decade (of which two thirds probably came from wholly new dwellings)[11], while the resident population grew by 12.5%. A quite substantial part of the densification of London's population over this decade was thus attributable to a denser/more crowded occupation of existing residential spaces. Cross-sectional analyses of small area (LSOA level) change across London (and the WSE) suggests that this particularly reflected the much higher densities at which *recent* migrants from poor countries occupied properties in their main destination areas within London (Gordon, 2014) .

This form of densification is outside the scope of our review of ways of setting density standards for new dwellings, but it points to a couple of significant facts, namely:

- such standards cannot actually determine how many people will come to occupy any set of dwellings; and
- there are substantial margins of adjustment in occupancy of the existing stock – though in previous decades these had more commonly involved a net *reduction* in densities of occupation.

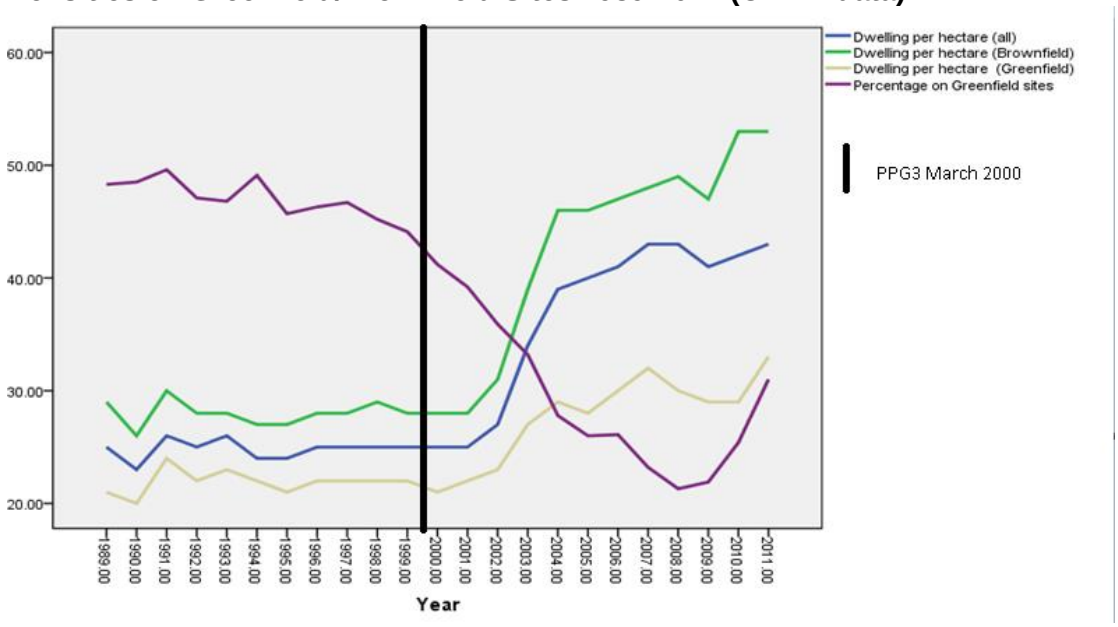
3.3 National Trends in Residential Development and the Brown/Greenfield Balance

Greenfield-brownfield development. Examination of trends in the density of London residential development, and of influences on these, has to start with a national

[11] The rest would have come from rooms added through extension/conversion of existing dwellings. There seem to be no direct estimates of the impact of either process on the stock of rooms. The 2010/11 English Housing Survey, however, suggests that more recently constructed London dwellings typically have fewer rooms, with those from after 1990 having an average of 3.26 habitable rooms, 21% below the overall London average (of 4.13). In total in indicates that these two decades worth of new dwellings accounted for 8.3% of the stock of such rooms in 2010/11. This is consistent with what might have been expected from the recorded number of new dwelling completions over these two decades (143 and 201 thousand respectively equivalent to 4.6% and 6.5% of the stock), given the lower number of rooms recorded for these dwellings. For the inter-Censal period then, it suggests that new dwellings are likely to have accounted for 5.1% out of the 7.7% estimated addition to the dwelling stock, with a possible 2.6% then being contributed by net additions to existing dwellings.

picture[12], both to identify more general influences affecting most urban areas, and because of a lack of regional disaggregation in published DCLG statistics (since 2011). Figure 3.1 presents the longest available time series for the density of new development, with a breakdown between green/brownfield sites (i.e. those which have/have not been previously developed). Overall, this points to pretty steady densities from 1989-2001, with a significant but stable differential between green/brown field contexts: for the previously developed land (which would include virtually all London housing sites) the prevailing density through this period hovered around 28 dwellings per hectare. There was a dramatic upturn in the next 3 years, however, with brownfield densities rising by 64% (double that on greenfield sites), followed by continued slower growth (except in one post-crisis year). The context for this (as the Figure suggests) was a sharp reduction between 1999 and 2004 in the share of building occurring on greenfield sites, which had been coming down more slowly since the beginning of the 1990s, but fell by a third during these 5 years – apparently as a direct reflection of the tightening up of quotas in greenfield usage, with the 2000 version of PPG3 (cf. Bramley et al., 2010, Evans and Unsworth, 2012)[13].

Figure 3.1: English Trends in Green Field Development and Residential Densities on Greenfield/Brownfield Sites 1989-2011 (ODPM data)



Source: DCLG Live Tables 211 and 231

Significantly, in relation to big cities such as London, the response to this curtailment of the flow of greenfield land into development was not to stimulate development of more brownfield land (the flow of which into actual development scarcely changed[14]),

[12] i.e., in this context, one for England as a whole.

[13] Publication of these data series was interrupted in 2012 and only resumed on a non-comparable basis in the last 2 years. It cannot therefore be ascertained whether the upturn in the percentage of greenfield developments reported for 2010 and 2011 has been sustained, under NPPF's more flexible planning guidance – or whether this was a shorter term consequence of much depressed levels of housing activity after the financial crisis.

[14] As between 1989-98 on the one hand and 2004-7 on the other (before the financial crisis curtailed all development). Between these 'before' and 'after' periods, a substantial falling off in re-use of vacant/industrial sites (the classic 'brownfields') was more or less balanced by increased recycling of residential land (DCLG Live Table P226). Comparing these two periods, overall housing output across England was sustained (in terms of dwelling numbers,

but rather to increase sharply the intensity with which brownfield land was developed. It seems therefore that a major tightening of the land supply mainly affecting development outside the cities (during the years running up to the first Mayoral Plan) made higher density development of urban sites substantially more profitable and altered the intensity with which current sites were developed. This did not, however, generally increase the speed with which sites were actually developed, probably because in the long term the less elastic supply of land in the wider housing market was likely to lead to still higher rewards for intensified development in future years – and least in city-regions with a strong growth dynamic. In such circumstances, the (obvious) potential for densification to yield substantially more housing from the finite stock of developable land might only be realised in the very long run.

London in relation to its hinterland and to other cities. A second set of DCLG tables offer a different cut at the data – with a geographic breakdown by local authority (not green/brownfield) but just for four, quadrennial periods – though again with data series curtailed at 2011[15] (and without regional sub-totals). On the basic issue of changes in the densities of new residential development, Table 3.1 provides a summary comparison of trends in London, relative to the national average and those in a set of other core cities, plus the Wider South East's larger towns and the rest of this hinterland region.

Table 3.1: Changes in the Density of New Developments 1996-2011: comparing area types and periods

Areas	**Average Dwellings per hectare**	**Proportionate Change in these densities**			
	1996-1999	**2000-2003 over 1996-9**	**2004-2008 over 2000-3**	**2009-2011 over 2004-8**	**2009-2011 over 1996-9**
English Districts	25 (25)	+9% (+12%)	+40% (+46%)	+0% (+2%)	+52% (+68%)
London Boroughs/City	57	+36%	+34%	+33%	+144%
7 other large urban LADs	34	+30%	+74%	-3%	+118%
7 leading urban LADs in ROSE	34	+31%	+53%	+4%	+107%
Rest of ROSE	23	+13%	+44%	+2%	+67%
Rest of England	25	+9%	+40%	+0%	+52%

Source: OS data reported in DCLG Live Table P232
Notes: 1: dwelling densities recorded here use a method of calculation quite distinct from that used for the London Development Database;
2 : figures (except for the bracketed ones for England as a whole), are based on unweighted averages of density estimates recorded for local authorities (since DCLG no longer recognise 'regional' units).
3: the 'other large English cities' are Birmingham, Bradford, Bristol, Liverpool, Manchester, and Sheffield; the 'leading urban LADS in ROSE' are Brighton, Luton, Medway, Milton Keynes, Oxford, Portsmouth, Reading and Southampton.

The significance for this report of the four periods that DCLG distinguishes is that these correspond effectively to:

- the run-up to GLA creation and the revised national planning guidance;

though not rooms) solely through much more intensive development of urban sites (at densities more than double those which had been typical of greenfield sites).
[15] Some data are now available for the single year 2013/4, but not on the same basis.

- the years of Plan development in the GLA and of a strong shift elsewhere away from greenfield development;
- the first years of implementation of the London Plan; and
- the aftermath of the 2007-8 financial crisis, with its severe effects on economic activity and development (in most areas except central London).

The broad picture which the Table presents, for the period since 2000 is one of substantial increases in residential density across the country as a whole but with far greater increases in the cities and larger urban areas, consistent with the development there being primarily on brownfield sites (where intensification has been much more marked, as noted above).

This difference is basically a feature of the 2000-3 period, and by the following four years densification seemed to be progressing strongly right across the country. In fact, the figures clearly imply a further acceleration in the other leading cities (outside the South East) - but notably *not* in London, where there is no sign of an immediate intensification of development in the wake of the Plan's publication. In the last period covered by the DCLG data there is, however, a clear difference between London and the rest, with the financial crisis inducing a particularly sharp cutback in construction of *flats* (maybe because these are more dependent for demand on first-time buyers, who were harder-hit), which was experienced in a much milder form in London. It is possible that the Plan was having some deferred effect on density norms (since completions lag significantly behind planning approvals). But more obvious explanations for a singular continuation in London's steadily increasing densities of new development relate to the ways in which the capital's economy in general, was substantially insulated from what was happening elsewhere in the country (Gordon, 2016).

The combined effects of the greenfield-brownfield shift and induced increases in development densities within these categories for London's role in additions to the dwelling stock are shown in Table 3.2 (below). In the first part of this Table, covering a further 4 year (post-recession) period, it can be seen that London has actually secured a substantially higher average rate of completions since 2004 than in the 8 years before (up by a third), whereas that in the rest of the Wider South East is little changed, and that over the rest of England the dwelling completion rate fell (by a sixth). Over the sub-periods since the late 1990s then, London's share of housing completions within the Wider South East and across England as a whole both increased (Table 3.2a). In relation to the WSE in particular, the biggest shift was at the start of the 2000s (when the brownfield quota first took effect), but has continued since then – so that, for the first time in decades London's per capita completions rate almost matches that in the rest of the WSE.

However, over the more restricted period (up to 2011) for which there are published density figures, the rate of increase in completions within London has fallen a very long way behind that in densities of new development (Table 3.2.b). Indeed, the implied flow of residential land into development in London appears to have fallen by some 42% (or around 4.5% p.a.) between the late 1990s and the post-crisis years. This is only a bit less than in the rest of the country, where greenfield had contributed a large proportion of the land supply and where policy was intended to reduce its use. Including the 2008-11 sub-period, where the largest reduction in the (implied) London flow occurred, might be misleading (because the strong/uneven impacts of the crisis). Restricting comparison to changes between 1996-9 and 2004-8, however, our estimates suggests a net 11% reduction in the amount of land built out in London, as compared, (on DCLG figures) to an increase of 7% in England as a whole. At the same time the use of greenfield fell by 47%.

Table 3.2a Housing Completions: London, versus rest of Greater South East and England, 1996-2015

Annual Completion Rates and Shares

Period	Average Housing Completions p.a. (000s)			London Completions as Share of	
	London	Rest of GSE	Rest of England	Greater South East	England
1: 1996-9	13.6	44.3	86.6	23.5%	9.4%
2: 2000-3	15.9	39.6	80.7	28.6%	11.6%
3: 2004-7	22.1	49.2	93.3	31.0%	13.4%
4: 2008-11	19.1	38.9	63.9	32.9%	15.7%
5: 2012-15	18.2	34.5	62.3	34.5%	15.8%

Source: DCLG LiveTable 253

Table 3.2b Comparing Changes in Completions, Densities and the Implied Flow of Land into Residential Construction

Period	% changes in dwelling completions		
	London	Rest of GSE	Rest of England
Period 1:2	16.7%	-10.4%	-0.7%
Period 2:3	39.0%	24.1%	15.6%
Period 3:4	-13.4%	-20.9%	-31.5%
Period 4:5	-4.8%	-11.4%	-2.5%
Period 1:4	40.5%	-12.1%	-26.3%
% change in densities (LAD averages)			
Period 1:4	144%	72%	55%
% implied change in residential land supply			
Period 1:4	-42%	-49%	-52%

Sources: completions (as above); densities (as in Table 3.1); land supply flow, own calculations from completions and densities.

Notes: changes in completions are based on recorded totals for regions, while for density changes (which are not published for these aggregates) estimates are based on unweighted averages of LAD data; the estimates of implied land supply change ARE computed from comparison of these two change estimates (density being the ratio of dwelling completions to site area); the bases of these are not strictly comparable, but they provide at least a reasonable estimate of the direction and scale of change. For England as a whole the implied reduction is 45%, as compared with 50% when the appropriate (weighted average) measures of new dwelling densities are used.

This is at least consistent with the interpretation that, over a period when a shift in *national* planning policy was the dominant influence:

- supply restrictions elsewhere made denser development within London (in particular) substantially more attractive; and
- contributed to an important increase in housing completions. They also
- encouraged a rather slower development of available London land, especially as compared to brownfield sites elsewhere.

This does not imply that ad hoc intensification, infill or redevelopment of residential land at higher densities need have negative effects on the speed with which land comes forward. Nor does it imply that encouraging/permitting higher density

development within large schemes on London land supply does not help bring more housing forward. But how far it does so should not be taken for granted – and deserves closer investigation.

3.4 Patterns of Variation in Residential Development Densities within London

A much more detailed view of the range of densities at which residential development has been occurring across London is provided by the GLA's London Development Database. This relates to schemes / sites for which planning permission has been awarded, maintaining and updated record of location, hectarage plus the approved number, size-mix (in terms of bedroom numbers) and market type of dwellings, with a continuing update on number/mix of dwellings on completed sub-sites. Since only full (residential) site areas are recorded, densities attributed to completions on these sub-sites (in terms of dwellings p.ha, or as we prefer bedrooms p.ha.) are those necessarily those of the full-site[16]. Evidence on heights, of the tallest building in the development is also available (and is deployed in the 3 Dragons project in this series) but we have not explored this aspect of 'density'. And, as noted in the previous section, there are no available records of overall the overall number of habitable rooms in dwellings. The data series we have examined relates specifically to the period from 2008 (post-dating that referred to by Bowie, 2010) – thus relating mostly to the period of the Replacement Plan, though permissions for many completions on larger sites will have been given earlier.

We have used this evidence in order to address two sets of questions. First, we seek to understand (in more detail than the Annual Monitoring Reports attempt) how densities across various kinds of residential development relate to the relevant local standards under the Plan's density matrix. In particular we are interested in whether most of the developments recorded as falling outside the prescribed range only do so by a modest (negotiated) margin, with just a small number of major exceptions (to which special factors might apply), or whether there is a continuum between these extremes. And, secondly, for an average case, we are interested in understanding the spatial pattern of variation in densities, and its relation to the local planning norm embodied in the matrix and/or other locational attributes that might impact on market/commercial evaluations or the views of local decision-makers. One idea is that this might cast light on what difference the prescriptions of the matrix actually make, while another is that identification of a clear, robust pattern in actually realised densities might provide another basis for SHLAA judgements about credible development densities for potential sites for which there are not yet planning applications.

Bedroom Densities and Standards

For the first of these analyses, we started by computing bedroom densities attributable to each of the completed sub-sites (as the only available approximation to a habitable room's measure). To set benchmarks to compare these with, we first identified the area type (within the 3 x 3 framework of the Plan's 'matrix') on the basis of the GIS-assigned PTAL and 'character' values for the site on LDD and then took the mean of the upper and lower limits in habitable rooms p.ha. terms as the appropriate *norm*. This was then converted into a bedroom density equivalent, using the average proportion (0.60) of bedrooms/habitable rooms for post 1990s dwellings in London, from the 2010/11 *English Housing Survey* – yielding a standardised

[16] i.e. the area covered by the most recent planning application.

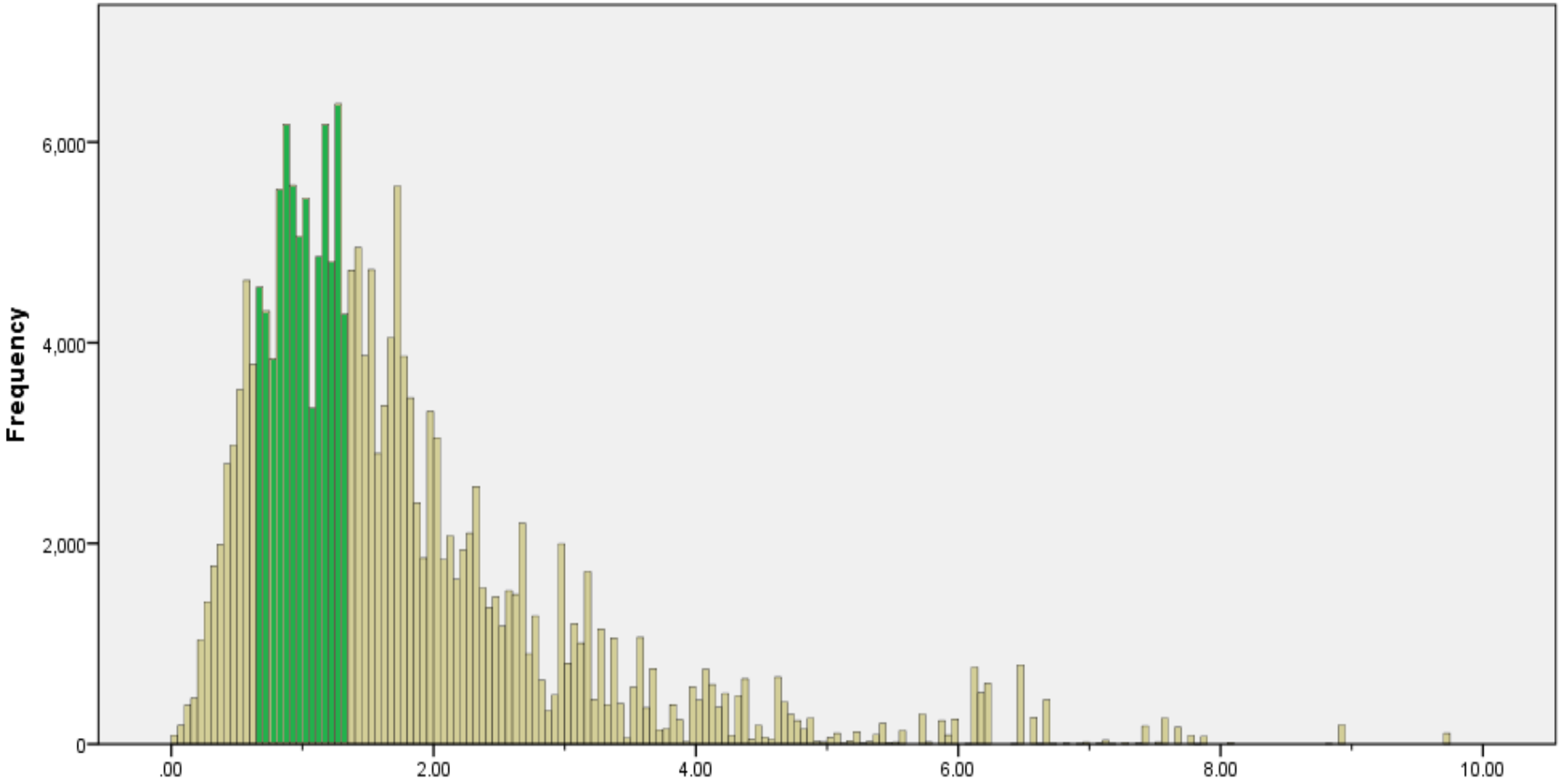
bedroom ratio for each case (equal; to 1.0 when the actual bedroom density equalled this local norm). Finally, to provide a generalised indicator of the degree of conformity of actual developments to a habitable rooms-based form of density standards, notional upper and lower limits for each area-type were set, 33% above and below the norm (corresponding to the average spread of upper/lower limits for the habitable rooms ratio). This is clearly not intended as a literal translation of the limits which the Plan expects to be normally applied, but a tidied up version – removing the ambiguities about how multiple dwelling-based criteria are supposed to be applied (when room numbers are not known), and producing an approximation which can be simply graphed and discussed.

Figure 3.2 (below) is a histogram showing the frequency distribution (In bedroom terms) of the standardised bedroom ratio (SBR) for completed sub-sites, highlighting those that fall within our approximated version of the (habitable room) density limits. It can be seen firstly that the distribution is positively skewed, - actually corresponding rather closely to a log-normal distribution, which is what is expected where a number of independent influences get multiplied together to produce the outcome (rather than simply being added up). That pattern is very evident for the distribution of simple residential densities across London as a whole, but the graph shows that it still applies when the different area norms (of the density matrix) are controlled for. The spread is obviously *very* much greater than the sort of bands envisaged in the matrix, with some instances of bedroom densities 10 times the local norm – but it is clearly not these exceptions which are responsible for great spread of outcomes, they are just the end markers for it.

On this basis, some 50% of building involves densities above the upper benchmark (slightly less than in the approvals-based AMR reports), while for about 15% they seem to be below (compared with just 6% in the AMR reports[17]). As the first statistic implies, average densities are close to the upper end of the range – but spread about as far above that as below; this is actually true in geometric terms (i.e. for log densities[18]), in terms of actual values the spread is rather greater on the up-side. So, 25% of all bedrooms seem to have been built on sites with densities double the upper benchmark. This represents a quite remarkable degree of non-conformity with the Plan's guidelines – whether because developers find it easy to negotiate concessions from borough planning authorities (or in called-in cases with the Mayor), or because the matrix is effectively disregarded is unclear. But it is vital to understand the reasons if this element of density planning is to play a more than symbolic role.

[17] This difference seems to reflect adoption of a lower limit in unit density terms *assuming* maximal numbers of habitable rooms per dwelling, which don't seem consistent with achieved bedroom numbers. This reflects a real problem with the construction of the density matrix.
[18] Where a doubling of the density level around the average is as likely as a halving of it.

Figure 3.2: Frequency Distribution of Standardised Bedroom Densities (relative to the norm of the Plan's Density matrix)



Source: our estimates based on 2008-15 completions data from the London Development Database.
Notes: 1. the observation units are sites; 'frequency numbers' relate to numbers of bedrooms among completed dwellings on these sites.;
2: the green area represents our translation to bedroom terms of the acceptable densities of habitable rooms specified for the relevant area in the 2011 Plan's density matrix; 3. The bedroom density ratio is standardised in relation to the mid-point of the specified range for the type of location.

Without begging that question, a simple statistical analysis was undertaken across all of the sites with recorded completions in order to see what types of site or project were associated with density ratios that were particularly high (or low) in relation to the supposed local norm (i.e. the mid-point between the upper and lower limits appropriate to the area, according to the Plan's density matrix). The comparison was made in terms of bedroom densities, by regressing[19] the standardised bedroom density ratio (SBDR, as shown in Figure 3.2) on a set of recorded characteristics of the project, including where it was located[20]. This analysis showed statistically very significant links between departures from the supposed local norm (i.e. the SBDR values) and four of these characteristics:
:

- borough of location (much higher than expected densities in the City, Barking, Greenwich, Newham and lowest in Bromley, Enfield, Kingston, and Lambeth)
- market/provider type (relative densities being highest in private sector/market projects and lowest in public sector/social housing)
- small size of site (densities being substantially higher than expected in sites of under 1 hectare)
- new development (SBDRs being higher for these than for conversions).

Patterns and sources of spatial variation in bedroom densities across London

To look more closely at the sources of this spatial variation, a second set of analyses of the LDD completions data was undertaken, looking at patterns of variation across areas, rather than individual sites. This was intended both:

- to find an efficient way of characterising the spatial pattern of densities in new developments across London, which might offer a better approach (than the 'matrix') for the SHLAA to attribute realistic development densities to those potential sites it identifies which are not yet subjects of planning applications; and, more ambitiously
- to cast light on how much of this pattern might reflect the influence of the density matrix, as distinct from other non-policy factors, on achieved densities in different areas.

For this purpose we again worked with the bedroom density measure (rather than dwellings), now aggregated up to the level of Lower Super Output Areas (LSOAs) - as a standard geography available on a (virtually[21]) consistent basis from the 2001 Census onward. In total there are some 4800 LSOA across London (with average populations of around 1500), of which 90% had some recorded development during 2008-14, for which we had complete data on 4130.

A series of exploratory regressions[22] of these densities were carried on a number of simple and relatively durable attributes of the LSOA, including PTALs and area 'character', but also a couple of other complementary indicators of accessibility (to opportunities, rather than simply to the transport network), some borough level

[19] The logic of regression analysis is explained in simple terms in Appendix A1
[20] The logged value of the ratio was actually used, cases were weighted by unit numbers, and years were pooled (in the absence of any evidence of a consistent time trend through these years, when densities seem to have gone up for two years, falling back and then started to recover).
[21] LSOA are much less vulnerable to change over time than other spatial units, but some occurs either because they have to nest into LADs whose boundaries may change, or when population local growth/decline takes them outside the designated size range for LSOA, requiring either a split or a merger.
[22] See footnote 19.

attributes, and the LSOA's population density in 2001. Those variables which were retained after this exploration were:

Density norm for SQR matrix category (logged)
PTAL – coded as a continuous variable on a scale from 0-8
Distance from CBD centre (kilometres)
Employment access (principal component of 6 indicators from the DfT JTS0501 set)
Suburban 'character' LSOA (as a proportion)
Central 'character' borough (as a proportion)
Outer London Borough (dummy variable, 1/0)
Domestic residential density, numbers of residents per hectare of domestic buildings/gardens, LSOE, 2001 (logged)

The main findings are presented as a sequence of regressions in Table 3.3 (below), starting with one relating average densities to those expected from a local norm based on the Plan's SRQ matrix and finishing with one including all the other listed variables, plus (as a control/robustness test) dummies for each London borough – but excluding the SRQ-based variable.

Key findings include:

- actual densities are quite strongly correlated with the matrix's density norm, with an elasticity suggesting a 73% responsiveness to that norm – though with a positive constant term indicating a general tendency toward higher values than the SRQ matrix proposes (column 1);
- this apparent responsiveness is seen to be very much lower, however, when account is taken (successively in columns 2-6) of other factors which are relevant to the strength of market demand, and/or the acceptability of higher densities in different areas – notably a wider range of indicators of centrality/suburbanity than underpin the density matrix, and prevailing/inherited variations in local population densities, which seem to exercise a very strong effect (columns 5-8);
- after controlling for these factors, the estimated responsiveness to matrix norms is just 16-17%, although it never loses its statistical significance (columns 5 and 6). Dropping this policy-related variable does not, however, greatly weaken the overall fit of the regression model (cf. columns 5-6 with 7-8);
- the full range of PTAL scores has an influence on realised densities (columns 3-8), not just the two specific steps distinguished in the matrix (Exhibit 2.1). The implication is network access has more of a direct relevance to the densities which occupants are prepared to accept in different locations, than the indirect one via the SRQ matrix's policy signal;
- other measures of accessibility (to opportunities not just to the network) are important in relation to acceptable densities, notably straight-line distance from the centre, but also a more general measure of accessibility to jobs[23];
- the suburbanity aspect of area character only seems to make a difference to realised densities within the outer boroughs. The centrality aspect appears to be relevant at borough rather than neighbourhood level – if at all, since its apparent effect (in columns 3 and 4) is greatly reduced when past population densities are taken into account (in model 6);

In summary this analysis has two implications for the concerns of this project:

[23] Other exploratory regressions nor reported here suggest that marginal variations in PTAL levels have more impact on densities in more peripheral areas where generalised accessibility is low.

1. a strong suggestion that the Plan's density norms may be more a (very simplified) approximation to outcomes generated exogenously by market/political interactions than a really important independent influence on achieved densities; and
2. an equally strong suggestion that the pattern of predicted values from a quite simple regression model (see Figure 3.3 , based on the model in column 7 of the table) could provide a much more realistic basis for attributing likely development densities of plots in particular LSOAs (including ones with few precedents) than the matrix norms previously used for the SHLAA.

In this context it is understood that the SHLAA has to produce output expressing capacity in terms of dwelling units (rather than a room-based measure), which is also straightforward with the regression method. This is illustrated in Appendix A3 which presents separate results for dwelling unit densities and the bedroom-dwelling unit ratio – as well as evidence of trade-offs between these.

Table 3.3: Regressions of Bedroom Densities for New Developments for London LSOAs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	1.458 (20.3)	3.415 (27.9)	3.733 (30.3)	4.184 (32.7)	3.415 (27.9)	3,379 (25.1)	4.161 (64.3)	4.085 (63.0)
Norm from matrix (logged)	0.730 (55.0)	0.518 (25.6)	0.223 (8.8)	0.206 (8.2)	0.168 (7.2)	0.157 (6.7)		
PTAL score		0.081 (13.6)	0.078 (13.4)	0.062 (10.6)	0.039 (7.1)	.038 (6.8)	0.061 (13.6)	0.061 (13.4)
Distance from centre (km)				-0.024 (10.4)	-0.011 (4.8)	-.009 (2.9)	-0.009 (4.2)	-0.008 (3.3)
Job accessibility				0.116 (3.6)	0.116 (3.9)	0.208 (5.1)	0.155 (5.2)	0.212 (6.9)
Central character (LB)			0.545 (18.5)	0.248 (6.3)	0.052 (1.4)	..	0.123 (3.4)	0.100 (2.6)
Suburban character (LSOA)*Outer borough (only)			-0.231 (10.1)	-0.143 (6.1)	-0.091 (4.2)	-0.086 (3.9)	-0.172 (9.2)	-0.161 (8.6)
Pop. Density in 2001(logged)					0.342 (26.1)	0.340 (24.6)	0.349 (26.4)	0.346 (26.1)
Borough Fixed Effects included?	N	N	N	N	N	Y	N	Y
R squared (proportion of variance accounted for)	0.431	0.455	0.507	0.528	0.595	0.602	0.589	0.594
N (number of observations	4129	4129	4129	4129	4129	4129	4129	4129

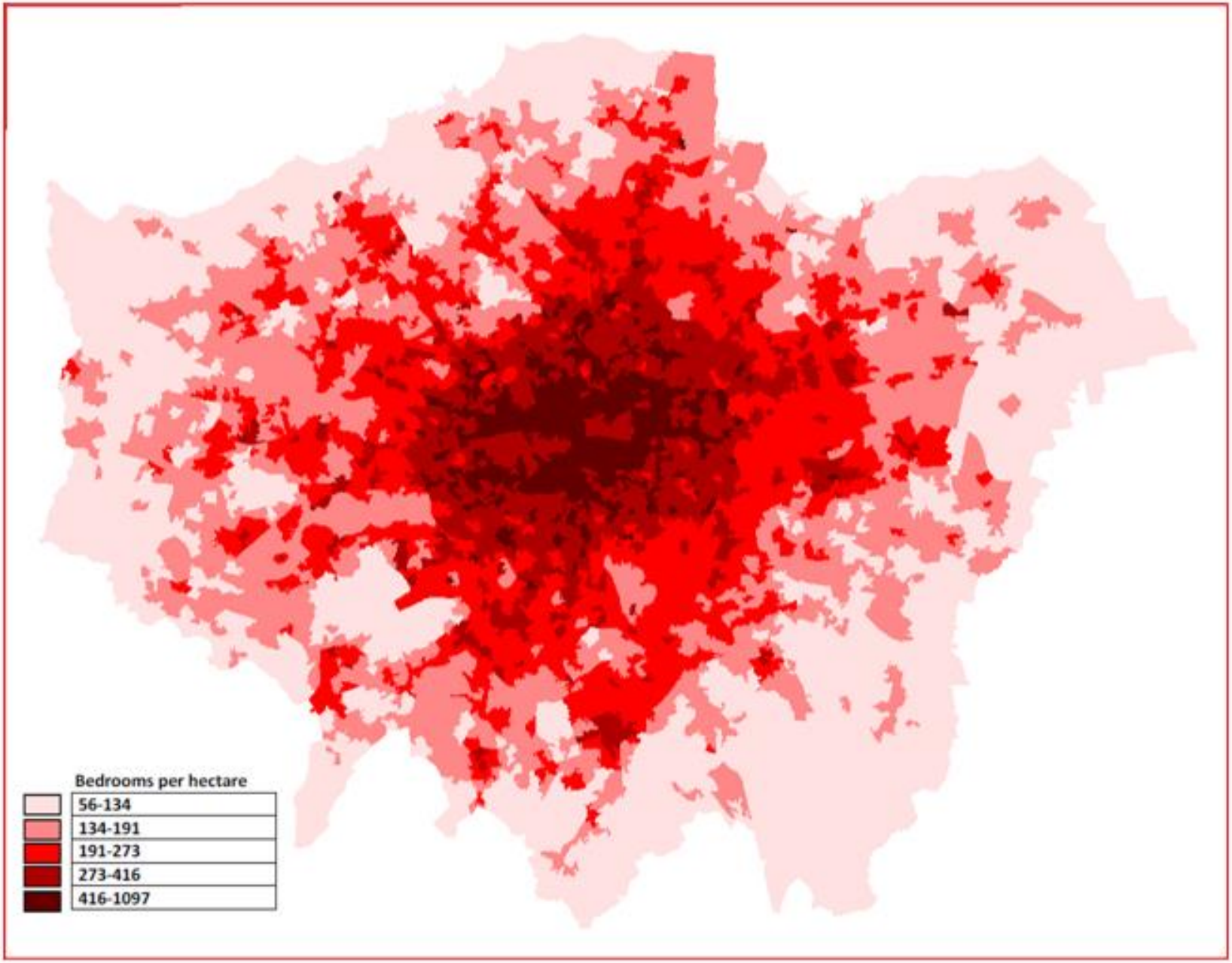
Source: data from GLA's Development DataBase – completed residential developments 2008-15.

Notes: 1. Bracketed values are t statistics; all reported relations are significant at the 0.1% significance level or better – except for the Central character regression in column 6 which is not significant even at

the 10% level[24].; 2. The dependent variable is logged , so coefficients on the matrix norm and on 2001 population densities are elasticities (i.e. proportionate effects); 3. The borough fixed effects controlled for in column 7 include *positive* effects (significant at 5 % or better) for Hammersmith, Lewisham, Richmond, Southwark, Tower Hamlets and Wandsworth.

[24] Significance at the 0.1% level signifies a very small likelihood (at most 1 chance in 1000) that the apparent relationship could have emerged simply by chance, whereas lack of significance at the 10% level suggests a substantial possibility (more than 1 in 10) that it could have arisen in this way. Conventionally the 1% and 5% levels tend to be expressed as indicating 'significant' and 'possibly significant' relations and the 0.1% level as 'highly significant'.

Figure 3.3: Pattern of Mean Bedroom Density Values at LSOA Level as Predicted from Regression with 2008-14 completions



3.5 Summary

The empirical analyses in this section have tried, within the limits of readily available data (from national and GLA sources), to address two sorts of question in relation to the Plan's use of density standards. These follow on from the previous section's discussions of principles and the evolving way in which density issues have been treated (substantively and technically) in earlier rounds of London planning.

One concern has been to look for evidence about the operational significance of the Plan's density matrix (as its most conspicuous policy guideline) particularly in relation to prevailing residential/development densities in London (as an instrument for accommodating more of the projected population growth). This has been relative to a kind of null hypothesis suggesting that the pattern of realised densities is essentially being determined by market forces, conditioned on the one hand by the broadest kind of national policy (a greenfield quota added to the existing Green Belt constraint in the Wider South East) and established norms about accommodating to local preferences. The other approach has been to try to develop some understanding of the realised pattern of outcomes (particularly in spatial terms), both to see how (and why) this corresponds with the area typology in the 'matrix' and to consider how this might be used (rather than the matrix itself) as a source of assumptions about the residential densities which 'new' development sites identified in the SHLAA might be expected to support.

The main results have lent support to the idea that the role of the Plan might be very modest relative to that of market forces plus national policy, both generally in promoting higher densities (even though densities have increased very considerably), and specifically in shaping the evident variation in densities of development in different areas and sites across the city. Reasons for this include indications of close links with national planning policy; a distribution of achieved densities which treats the upper limit as a norm (but also involves significant development at densities below the lower limit; and evidence that the matrix represents more of a crude approximation to a pattern of outcomes engendered by market-planner interaction at local level than a strong direct causal influence on the realised pattern of densities.

This review of empirical evidence lends support to some of the more conceptual observations in the previous section about the density matrix. Specifically, whatever the strategic case for encouraging boroughs to accept rather higher densities (signalled by minima), the notion of a maximum seems even more artificial in practice (or non-practice) than it did in principle. Equally, the idea that London can usefully be divided up into just 9 differentiated contexts for this purpose appears an unnecessary simplification.

Section 4. Qualitative Analysis on how Densities are Defined and Used

4.1 London Practitioners

In section two we noted, how the clarity of the density matrix on the printed page belies the opaque way in which it is used in practice It is therefore important to understand how the formal norms set out in the matrix may influence actual behaviour – on the part of borough planners and developers among others. To examine this we draw on interviews and conversations (the latter being more informal and generally briefer) with nine senior officers (six at a managerial level), four in outer and five in inner London and with a developer. Rather than offering a comprehensive overview that we might map onto our work in section three, we seek to shed some light on the 'black box' (Lord 2012) of planning practice. As noted, the appeal of density rests on multiple claims for what is can achieve. In addition to Dempsey et al (2012) who focus on social sustainability and density, Holman et al (2015) review more widely the claims for and against higher densities. They categorise the literature noting that one group of writers appear to pursue a 'discourse of conviction' that, at best, underplays the downsides of higher density. Referencing back to our 'long view' of density and planning in section two, while professional 'beliefs' have varied over time sometimes promoting lower, and sometimes higher densities the post Urban Task Force norm favours higher density. The high proportion of permissions that we report on might appear to lend support to London's planners often being on the side of the 'discourse of conviction'. However, this was not the case. As we will see, planners were acutely aware of the need to balance density as a quantitative measure against the quality of the built form and the social outcomes and also evidenced considerable reflection on the outcomes of earlier higher density schemes. In this context the density matrix was described by one (inner London) officer as 'a very helpful [but] crude tool' as density alone was misleading.

Turning first to the issue of 'quantity', to the range in the matrix, all of the Inner London planners reported that it was not unusual for applications to exceed the upper figures. Given the need to deliver more housing on a constrained land supply and/or a more permissive environment, developers may be seen as enjoying an 'open season' when seeking to exceed the Matrix figures. Two of our interviewees were of the view that planners were relatively powerless to resist and that developers could increasingly get what they wanted. This was because of a perceived permissive environment at the national level and also because developers were sometimes seen as adept at playing a borough off against Mayors with a more generally positive attitude to densification. This might however be to paint too simple and pessimistic a picture. Other interviewees saw the exceeding of the range in a more positive and proactive context.

In section two we noted that Llewelyn-Davies Planning (1997) had argued the importance of site-specific design and that quality should prevail over predetermined views about density (paras 8.2.5 – 8.2). This was reflected by most of the practitioners who reported the density matrix as being one consideration among many in pre-application discussions and in determining applications. Officers are, then, focused on the balance between 'quantitative calculations' and 'qualities of the physical environment'. Reflecting Boyko and Cooper's three-way conceptualisation of density, planners referenced both design (broadly, 'quality of the physical environment') and social outcomes (broadly 'behaviour, perception and need'). Density was described as 'just a figure'. Higher than matrix densities were seen as appropriate on a case-by-case basis and where design considerations could prevail. However, the overwhelming emphasis was on design. Apart from the existing built form other factors raised taken into consideration included; room size, overlooking, 'good design'

and ‘quality’. If the applicant deals with these and other design considerations in a satisfactory way the matrix figures might be exceeded. A representative of a mass house builder shared this experience. He described how, when the density matrix figures were regarded as too low, the matrix was taken as a starting point and design considerations would then be employed to facilitate exceeding the upper figure.

Many officers were confident in the robustness of a combination of their borough policies and their own experience to appropriately balance design and density. Experience and judgement were viewed as key in balancing density and design. However, this confidence is not universally shared. In the case of one borough, where the officer was very positive about the effectiveness of their design standards, the borough was categorised in an academic design journal as favouring development over design (for the purposes of anonymity we have not provided the reference). Design issues are, at least in part, matters of judgement, and this is an example based on one article where the research was carried out several years before the officer’s assessment. But the point remains that the confidence of officers that density is being appropriately achieved, in design terms, is not unanimously supported. Moreover, if we assume that officers will continue to learn and to develop further experience it seems likely that they will come, in the future, to identify weaknesses in current decisions. While design was clearly identified as a way of ‘mitigating’ exceeding the matrix figures, officers were less forthcoming on how social outcomes might be incorporated in this decision making process. The potential social benefits of higher density were referenced including bringing economic activity to an area, footfall to shops, vibrancy and the development of more mixed communities. However, it was not clear how exceeding the density matrix would interact with these claims for density. Overwhelmingly, the planners we spoke with emphasised the need for higher densities to provide more housing on a constrained supply of land. The ‘social’ focus was, therefore, primarily more housing. It was universally accepted that there was a constrained supply of land available to London (either inside or outside its jurisdiction). Given this constraint and in an extended period of pressing housing need, density was primarily referred to as a means to square the circle. An implicit beneficial connection was made between higher density and more housing.

Those interviewed were reflective on the experience of delivering higher density development. In some cases officers felt they/ their borough has got it wrong in the past but that this is no longer the case. For some the slowdown following the 2008 crash was seen as an important pause during which officers had time to reassess. The early 2000s were reported as a period, in particular, when proposed densities had been driven by speculative land deals and when market demand was driving density more than plans or policies. Several officers believed that now they had more robust local policies and/or that these were more consistently applied. This, they concluded, meant that the tools were available to resist more effectively ‘speculative density’ and to require applications ‘led by density’ to be moderated. This applied to both design and the social outcomes of higher density, although there was less confidence that unexpected social/behaviour outcomes were now effectively managed – even if they were better recognised. Officers discussed the, sometimes unpredictable, ways in which people ‘behaved’ in higher density development. Two notable examples were the over-occupying of flats and demand for car parking. In two cases officers noted how families with children had moved into two and sometimes one bedroom flats and that this had driven an unexpected demand for school places. This is a useful reminder of the distinction between unit and habitable room measures and how these are actually occupied. In the second example, in outer London, the issue of car parking was raised. Residents still sought to own and park cars even though occupying higher density development. Behaviour change did not simply follow form.

There are considerable differences between the boroughs of outer London. While we have reported on two outer London boroughs with some experience of densities at the higher end of the matrix range, in others there was little such experience. For one officer applicants

seeking to exceed the matrix range were rare. The focus was on where the matrix range within a setting was seen as appropriate because of the existing built form (in a suburban borough but near to a high street). This was not a case where the lowest overall figures in the matrix were too high, but where there was a perceived discrepancy between the 'settings' criteria in the density matrix and a particular proposal. However, the wide differences are reflected in section three where outer London boroughs are represented as having both higher (Barking, Newham) and lower (Kingston, Bromley) 'standardised bedroom density ratios relative to the local norm'.

To summarise, officers were clear that applicants has sought to push the upper end of the density matrix. As officers only saw the density 'numbers' as one element they, in general, described how this could be acceptable especially through mitigation by design. That this is so returns us to a general point, that the balance between the quantities and qualitative elements of density are a matter of judgement rather than of fact. We have used Boyko and Cooper's conceptualisation of density to emphasise that the quantitative element of density (however applied), is only part of considering density. This is already recognised through planning where numerous policies in GLA and borough plans sit alongside the density matrix. We see this play out in practice where officers referenced both design (qualities of the built environment) and social issues (behaviours, perceptions and needs). The second seemed the more difficult to address.

4.2 Approaches in other British cities

A review of the planning documentation in some other major British cities suggested that no city used any formal approach such as the density matrix used in London. Most made qualitative statements about what might be expected. Manchester has perhaps the most detailed guidance - summarised in Appendix A4. Densities are related to design, neighbourhood and transport. Apartments are seen as appropriate for central city development but the full range of housing types and sizes are to be encouraged. Density of population is seen as important for generating vibrant neighbourhoods and supporting services. In particular the documents stress the need for balance and for new building to fit into the surrounding area.

Glasgow's guidance stresses the importance of transport. It suggests higher densities in the city centre; in inner urban areas (ranging from 30 - 100 units per hectare unless transport is particularly good when densities could be higher); and in high accessibility outer areas. However it also specifies how lower density areas might range from 20 to 75 per hectare and should include a variety of housing types.

Leeds sets out minimum net densities for four character areas (city centre and fringe; other urban areas; fringe urban areas; and smaller settlements) in which densities are expected to range from 30 to 65 dwellings per hectare.

To summarise: there appears to be relatively little emphasis specifically on density rather than type of dwelling and ensuring built form fits into the local environment. Where there is more detailed advice it tends to be around the relationship between population and density and available public transportation. It is worth noting that Leeds (which is an area with relatively low existing densities) sets minima, while Glasgow, with somewhat higher existing densities, sets acceptable ranges as in London. There are no examples similar to the London density matrix.

4.3 The Use of Densities in Planning in Other Countries

We were asked to clarify whether other countries and cities saw density as an important part of their land use regulatory process and if so what it was used for, how it was measured and what issues arose with respect to density policy. The emphasis was on European experience as well as countries with a historical link to the UK.

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In looking at cross-country experience an important issue is the distinction between zonal and permission based systems. In zonal systems acceptable dwelling types and densities are usually specified in some detail, normally based on plot ratio, set back and sometimes number of floors. There is less likely to be well-defined categories in more permission based systems. However in either approach there is likely to be some general principles and evidence of success or failure. In this context it should be noted that the UK has until now been at one extreme of the spectrum from permission based to zonal systems - but that all systems are in practice something of a mix (Monk et al, 2011). Equally the three main commonwealth countries we examined (Australia, Canada and New Zealand) had all moved to zonal systems, although the way that this was implemented differed considerably and included considerable areas of negotiation through e.g. special zones with greater flexibility and density premia to achieve community objectives (Austin et al, 2014). Hong Kong has a far more centralised approach because of land nationalisation and the use of auctions to allocate land and achieve affordable housing.

Toronto is a good example of a zoned city that is positively addressing density issues. Toronto has an official City Plan which runs through to 2031 and is currently being revised. The most conspicuous—and, arguably, most consequential—element of the Plan has been the focused creation of high-rise development areas, with five areas of the city zoned for big increases in density. In particular, increased density throughout downtown Toronto is strongly encouraged, with developers facing fewer legal and bureaucratic roadblocks to high-rise development in the urban core. Together with a robust real estate market, a cultural shift towards urban living, low interest rates, and decreased development charges, the Plan is said to have helped facilitate Toronto's ongoing downtown construction surge. (http://torontoist.com/2015/11/what-you-need-to-know-about-torontos-official-plan/).

Within the City Plan a set of zones are specified and allocated across the city. These provide detailed requirements if a development is to be automatically accepted. In addition densities especially in high rise areas may be exceeded if community benefits are provided.

However the extent of detail found in cities like Toronto is the exception rather than the rule. Most countries and cites specify relatively general polices within which local authorities may make their own decisions taking account of a wide range of factors which generally emphasis built form and consistency with the neighbourhood - often with exception areas to enable greater development in central and regeneration areas.

Survey results

To exemplify the range of approaches we sent an e-mail survey to experts in some twelve mainly European countries that covered the spectrum from zonal based through to systems fairly similar to the UK planning permission system. The e-mail asked five quite general questions to allow respondents to reflect on their own experience. Details of the questions and the countries/cities covered are given in Appendix A5.

The experts in all the eleven countries for which we received responses all regarded density as an important concept within their land use planning systems. Many of the countries had

zoning and/or master planning where density is regarded as an important metric. However all saw this as only a part of the story.

A country's general approach to densities was usually specified in a national framework which clarified objectives and sometimes the mechanisms by which these objectives could be achieved. In most cases the objectives were very general. There were exceptions to a national approach, notably the Netherlands and New Zealand, where there was greater emphasis on local determination.

There were many examples of cities with strategic plans which include far more detail on densities and related issues. Examples included: Amsterdam (based on height rather than density); Auckland (with an increasing emphasis on constraining the metropolitan borders); Milan; Paris and Stockholm.

There were two main approaches to measuring density often used in tandem. In countries with strong zonal systems the starting point was normally a traditional building regulation approach including plot ratios, unit/floorspace ratios, set-backs and numbers of floors. In countries where there was a stronger emphasis on objectives such as the use of public transport other local services or more generally compact cities, population per hectare also tended to be used.

With respect to built form most countries emphasised ensuring harmony with the surrounding neighbourhood except where a positive decision had been made to change the nature of the area - e.g. by concentrating development in central and regeneration zones. In general the emphasis was on local authority responsibility for built form - the exceptions being mainly specific zones identified within a city-wide plan. In these areas there was usually an assumption that tall buildings would be a core part of the mix but this was rarely part of the formal plan.

There were no examples of detailed quantification of the specified planning approach - thus the London density matrix appears to be unique. Equally there was little evidence of regular outcome monitoring.

There were very different ***objectives*** when specifying densities:

A number of countries were operating mainly on traditional lines in that densities were held down by regulation. This applied in both France and Germany. However in both there was also a growing emphasis on concentrating development in particular areas with the objective of increasing population densities and going against this well established approach. Densities in Paris were treated differently to the rest of the country.

In a number of countries this concentration approach was being applied more generally. In Ireland, Italy, especially in Milan, and Norway the policy emphasis was on increasing population densities and limiting developed areas to gain the potential benefits of compact cities. In New Zealand, particularly in Auckland, the introduction of a metropolitan urban limit while a long way from the centre was aiming to reduce urban sprawl. Auckland also applies minimum density requirements in the city.

A number had also identified density zones where they were introducing higher density approaches specific to these areas and considerably higher than in the surrounding areas (i.e. outwith the general zoning system). Countries with this type of approach included Hong Kong where land is all state owned but auctioned out for best use; Australia and New Zealand which both have zoning systems; and Ireland with a planning system fairly close to the UK's. These are countries that have recognised the need for higher densities in order to enable higher development levels, normally within central urban areas and extensions.

A rather different approach was found in Hong Kong, Sweden and the Netherlands where the emphasis had moved more on limiting densities in central areas while trying to increase them in outer areas. In part this reflected the lack of available brownfield land in central areas.

More generally the emphasis was on using infrastructure, notably public transport, more effectively and concentrating new development around transport nodes. This was mentioned particularly in France, Hong Kong, Italy, especially Milan, the Netherlands, New Zealand and Sweden.

In relation to built form the objectives were generally around ensuring development was in line with neighbourhood densities, except where positive decisions had been made to increase densities in particular locations. This type of approach applied in Germany, France - notably Paris - and a number of other countries.

The only city example where density as such was not mentioned was Amsterdam. Instead their approach concentrated on height - and generally related the height of new structures to existing buildings. In most other countries no direct mention was made of height, although in some cases it was implicit that high rise development would be acceptable in specified areas.

In terms of *measures* it was the norm to base densities on population per hectare. In some countries where there was particular concern to increase housing output, as in London, housing units and /or habitable rooms were used as the most direct measure.

With respect to built form the norm was to use a version of plot ratios including for instance site coverage. Amsterdam uses height controls rather than density control but all the other examples were based on density.

In Australia there was no attempt to include services in their objectives /measures but in all other examples there was emphasis on linking density to service provision.

A final point which was made in Portugal, Ireland, France and Italy was that enforcement was often difficult and partial and that there was significant opposition to densification.

Summary

Thus the overall picture is that densities are important but for very different reasons in different contexts.

In general the measures used were fairly simple, based on plot ratios, dwellings or population and there was no attempt to try to bring them together as in the London Plan matrix.

There was evidence of city plans identifying particular areas for different higher density forms of development in city plans.

Finally there is considerable opposition to densification in a number of countries as well as considerable differences between principles and practice. There were often enforcement problems where city-wide or national policies were out of line with local experience and attitudes to change

Section 5. Conclusions and Recommendations

5.1 Conclusions

The material set out in the report identifies a number of distinct objectives that definitions and measures are expected to address. It is not really possible for all the objectives to be addressed by any one measure - and indeed some of the measures do not address any objective directly.

New building is only one element in an area and in terms of planning permission buildings may be phased as well as mixed use being part of that process - so what can be achieved by a given planning permission is quite limited.

Density measurement - whatever measure is used - is not as straightforward as might be assumed. Practitioners measure in many different ways and can generate very different results. In particular net and gross density measures can suggest quite different density outcomes.

Numbers of units may seem an easy measure. However as it does not control for size or the number of habitable rooms it is limited in its use as a means of meeting housing requirements. Moreover it, together with the rules around S106, tend to incentivise smaller units and flats as compared to houses, especially in central areas where land values are high. Additional constraints therefore have to be imposed if housing objectives are to be achieved.

Importantly what are often called planning densities - i.e. ones related to buildings rather than people - cannot directly impact on people-based service and infrastructure requirements - as these depend on the use made of the buildings provided. In this context, it is demand, as reflected in occupancy rates relating to the number and size of rooms together with tenure are likely to be important in determining the relationship.

The density matrix is an attempt to summarise different aspects of planning, notably built form and accessibility, into a simple 9 cell descriptor. It was appropriate at the time it was first introduced- which was in a lower density/lower rise era but hides as much as it helps in the current environment.

Importantly the density matrix does little more than provide guidance which appears to be more honoured in the breach than the observance - with the majority of new developments over the last decade above the suggested range (mostly well above) and a significant minority below. Of course the matrix is only one element to be assessed in the context of the whole range of policies in the Plan. However one of these policies, to promote substantially higher residential densities, appears to have predominated, making the upper limits in the matrix of limited relevance.

A rather different issue but one of considerable importance is that there are many different ways of interpreting how to determine density - so a great deal of uncertainty about what is actually built even before the question of occupancy arises.

Finally, while densities of new development on London have risen greatly over the period that the London Plan has been in place, this seems to owe much more to shifts in market pressure and factors occasioned by national policies, than to the Plan itself. And, whatever the source of this increase in densities, the numbers of dwellings provided has not increased significantly so less land has been used. Thus the core objective of achieving more housing

has not been met, although potentially there is now scope for much more residential and other construction on the land that has been identified as available.

5.2 Recommendations

There are three distinct areas where we make recommendations: forecasting, advice and monitoring/reporting.

On *forecasting***:** since there is little evidence that the matrix is being followed. It or its equivalent cannot readily act as a basis for estimating capacity in order to meet the projected housing need.

The regression estimates that we have produced from LDD evidence on actual, realised densities, show that it is mainly demand factors which have driven the outturns over the last decade. The major variables include not only PTALs, but also distance from any specified point in central London; access to concentrations of employment; a clear distinction between central and suburban, and established differences in overall population density.

These relate to the primary drivers recognised in the current density matrix. However using the regression produces a somewhat different map, reflecting e.g. a wider set of (valued) aspects of accessibility, with a pattern reflecting actual behavioural tendencies rather than planning norms, and (most importantly) covering a very much wider range of relevant contexts than simply the 9 distinguished in the current density matrix (or any other simple alternative).

The regression, applied to super output areas can generate an expected mean density for new building in each area, which will tend to be around the upper limit on the current density matrix. Our recommended approach to forecasting densities on new sites for the SHLAA would be simply to apply a version of this projected norm (modified in the light of projected PTAL changes).

On *prescription and advice to local authorities*: given the need both for additional housing (at the London or wider regional level, rather than purely locally) and to reduce dependence on the private car (again in a wider interest than that of a borough) there remains a clear cut-case for the Plan to encourage higher density levels than might otherwise be accepted by local planners, by setting minimum density standards (in room-related terms) for different kinds of area. One approach would be to set this at a level (say) 33% below that of the regression-based 'norm' for each local area.

On the other hand, we see no case for continuing to set a maximum level, since the appropriate criteria for limiting density (or blocking some forms of higher density development) are judgemental ones. Thus, we would strongly advise that there be no maximum set in place – leaving decisions about what is qualitatively unacceptable to the local authority, or (where it has strategic significance) to the Mayor.

Decisions about density are a matter of negotiation between developers and politicians at the local level within constraints set by wider central government policies on land release. Past experience suggests that there is no way in which the GLA can enforce what is essentially advice. The locus of responsibility above the minimum should therefore clearly lie at the local level.

This is particularly so, given that issues about whether denser developments (significantly above the prescribed minimum) are acceptable or not are primarily ones about built form – which cannot be effectively prescribed by a strategic authority within the Plan.

There are specific issues about tallness (which may be addressed in other reports within this set), which also need to be distinguished from those of density. Seeking higher densities is not a reason to accept tallness for tallness sake. Clearly the detailed analysis is included in other projects but a priori our review suggests that except in very central areas a specific positive case needs to be made in each case.

On *monitoring:* We are concerned about the use of dwellings as a performance measure in planning for new construction. It incentivises building the smallest units that can get through the system (reinforced by current affordability pressures) for dwellings which are intended to last for generations. As the primary density measure we would thus suggest habitable rooms (as this provides the greatest information). If only information on bedroom is available then this is still clearly better than using simply the dwellings density. Confounding the two (as in the present matrix) can be worse than either, producing both confusion and an exaggerated view of the acceptable limit(s).

There is a strong case for adding evidence on overall useable space - using an agreed definition - as this provides better information on the flexible use of space which is becoming more relevant than more narrowly defined measures.

Overall it would be highly desirable to monitor a range of variables - dwellings; habitable rooms/bedrooms; sq. meterage; and indeed expected first tenure as this also impacts on likely space and service usage.

On r*eporting and Analysis:* at the present time data are collected but there is almost no analysis of what is actually happening – especially in relation to what is supposed to be the performance target. The objective of annual monitoring should be to learn from what is going on. There is ten years of experience of what has been happening but almost no analysis that could help decisions.

Reporting currently lies within the responsibility of the GLA but if we are to learn from experience it would make more sense if local authorities (and the Mayor in relation to call-ins) were to submit evidence on what they have done and why they had made the decisions - in other words report on their own activity in relation to Plan implementation.

Overall

No single measure of density can provide the information to support the range of objectives that are identified.

It is important that responsibility should lie where the relevant decisions are made. When the decision making power lies with local authorities they should also take responsibility for those decisions.

There is a clear case for setting a minimum density standard (with neighbourhood level values that reflect an understanding the drivers of density outcomes), using relevant objective indicators to calculate appropriate values for each LSOA, publishing these in statistical and mapped form (in place of the density matrix) for the information of boroughs and prospective developers. But it should be up to boroughs to determine any local maxima and the most suitable built form, taking account in an appropriate way of the impacts of phasing and mixed use.

It is crucial that both the strategic and local planning authorities work with a realistic appreciation of the balance between market forces and planning policies. A starting point is to recognise how and how far realised densities within London are affected by actors' responses to shifts in the tightness of the land market across the Wider South East, and not simply the chosen strategies and targets of the London Plan.

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Appendix A1: A Simple Explanation of Regression Analysis: What It Tries to Do and How.

Regression analysis is a (fairly simple) statistical procedure, working from data for a series of characteristics (variables) of a set of cases (observations), which tries to establish for one of the variables representing an outcome:

- which of the other characteristics is more strongly associated (or correlated) with this outcome, than is likely to occur just by chance (by more than, say, 1 chance in 100) when the influence of the other variables (or factors) is being controlled for, by looking at them all together; and
- how big the implied effect is of a specific characteristic – for example how much higher densities tend to be if a project occurs in a specific borough, or a km further away from the city-centre;
- what (average) value for the outcome variable would be predicted given a the a particular set of characteristics and the estimated/implied effects of each; and finally
- what proportion of the variation in the outcome measure across cases could be accounted for (statistically) by these predicted values, and the pattern of associations underlying it.

If there are good reasons for expecting factors represented by the included variables to have a causal effect on the outcome in question – without likely effects in the reverse direction, or other important influences which have been ignored – then regression results of this kind can provide supporting evidence of the causal effect, its size/direction and statistical significance (or lack of it), and how changes in circumstances might alter outcomes. Where the logic and controls are less clear, they may at least provide evidence on prevailing patterns of association.

Appendix A2: Illustrating how the Plan's Habitable Rooms-based Density Standards get translated into Dwelling Unit-Based Measures

The process through which translation of the SRQ's density standards from a habitable room to a dwelling unit basis has led to a great expansion of the range of acceptable densities can be illustrated with a couple of examples.

For the first we focus just on the top left hand component of the matrix, relating to areas with low PTAL values and a suburban character, where acceptable densities for new development are at their lowest, ranging between 150 and 200 habitable rooms per hectare (Figure A2.1). We can express the size of this range as a proportion of the mid-point value. In this example this gives a figure of 29% for the spread of the SRQ's habitable rooms density criterion.

Figure A2.1

Indicative Average Dwelling Size	**Setting**	**Public Transport Accessibility Level (PTAL) 0 to 1**
	Suburban	**150 - 200 hr/ha**
	3.8 - 4.6 hr/unit	35 - 55 u/ha
	3.1 - 3.7 hr/unit	40 - 65 u/ha
	2.7 - 3.0 hr/unit	50 - 75 u/ha

In order to translate these habitable room figures (hr/ha) into corresponding (dwelling) unit densities (u/ha) some guesstimate is required for typical numbers of habitable rooms per dwelling. If an actual figure were available from the planning application, that would presumably be the one to be used. Without this, the SRQ distinguishes three possible size ranges for this setting (suburban). Elsewhere in the table the same three size ranges are offered for urban and central settings. Some size ranges are probably much more common in some settings than in others.

From this starting point, the best predictor of how room density standards (hr/unit and hr/ha) would convert into dwelling-based ones (u/ha) would involve some rough average room ratio, such as the mid-point of the relevant size range. In the case of the largest of the three size ranges (with between 3.8 and 4.6 habitable rooms per unit) using the mid-point estimate (of 4.2) would imply a dwelling density range between 36 and 48 per hectare (i.e. dividing the low and high hr/ha, 150 and 200, by 4.2) – with the proportionate density range remaining at 29%.

The calculations underpinning the dwelling unit-density version of the density standards in the Plan's SRQ, involves use of an extreme (a high or low) value from the hr/unit ranges, rather than a mid-point. Specifically, it can be seen that: lower-end values of the hr/ha range have been used to compute the acceptable upper limit on dwelling units per hectare u/ha; and higher-end values to compute the lower limit. This leads to a significantly wider proportional gap in the u/ha figures between upper and lower limits than for the habitable rooms measure. In the illustrative case (low PTAL, 'suburban' and a room ratio within the highest range) this approach yields a range of acceptable unit densities between 32.6 and 52.6 per hectare; these

are rounded in the published matrix to the nearest 5, i.e. 35-55, which represent a proportionate range of 47% (rather than the original 29%).

In practice, it is unclear if and how practitioners do actually assign cases to one of these three size-bands. Significantly, no such information is recorded in the London Development Database, and AMR reports of the proportion of developments falling inside/outside the permitted density range in terms of dwellings per hectare to do so by running the three size bands together, into a single spread from 2.7 to 4.6 habitable rooms per unit. The applicable upper limit for dwelling densities is then taken to be the upper limit in habitable rooms terms divided by 2.7 and the applicable lower limit to be the lower limit in habitable rooms terms divided by 4.6. Others within the implementation system may be operating in a similar way, since we read/hear almost nothing about how the habitable rooms per dwelling categorisation is handled in practice. Its effect is, however, clearly to stretch further the range of densities which is taken to be acceptable in any area, disproportionately to the initial habitable rooms range. In the case of low PTAL, suburban areas this extended range involves a lower limit of 32.6 dwellings per hectare (rounded to 35) and an upper limit of 74.0 (rounded to 75). This would represent 73% of the mid-point value, as compared with 29% on the habitable rooms basis.

As a second example, we take the case of high PTAL areas of central character, (the sub-matrix from the bottom right of Exhibit 2.1). Here the prescribed density range in terms of habitable rooms is between 650 and 1100 per hectare (Figure A2.2), a spread equivalent to 51% of the mid-point value. This is substantially greater than in the first example, but again the way in which the SRQ matrix makes the conversion to a dwelling basis greatly extends the spread. In this case lower/upper limits in of 140/405 dwellings per hectare represent a spread equal to 97% of the midpoint.

Figure A2.2

Indicative Average Dwelling Size	**Setting**	**Public Transport Accessibility Level (PTAL) 4 to 6**
	Suburban	**650 - 1100 hr/ha**
	3.8 - 4.6 hr/unit	140 - 290 u/ha
	3.1 - 3.7 hr/unit	175 - 355 u/ha
	2.7 - 3.0 hr/unit	215 - 405 u/ha

Appendix A3: Illustrative LSOA level Regressions of Dwelling Unit Density and Bedroom-Dwelling Ratios in New Developments on Accessibility and Area Character Indicators.

	Dwelling Units per Hectare (logged)	Bedroom: Dwelling Ratio (logged)	Bedrooms per Hectare (logged)
Constant	2.870	1.284	4.161
PTAL score	0.083	-0.022	0.061
Distance from centre (km)	(-0.001)	-0.008	-0.009
Job accessibility	0.238	-0.079	0.155
Central character (LB)	-0.198	0.321	0.123
Suburban character (LSOA)*Outer borough (only)	-0.308	0.136	-0.172
Pop. Density in 2001(logged)	0.530	-0.180	0.349
R squared (proportion of variance accounted for)	0.539	0.182	0.594
N (number of observations	4129	4129	4129

Source: data from GLA's Development DataBase – completed residential developments 2008-15.

Notes: 1. variable definitions are as for Table 3.3, and the equation specification is as for column (7) in that Table (reproduced as the 3rd column in this Table); 2. All regression coefficients are highly significant (at the 0.1% level or better), except for the bracketed one for distance in the dwelling unit regression (which is completely insignificant).3; all regressions are weighted in relation to the (square root of) the number of dwellings involved.

This Table illustrates how well the regression approach to predicting likely densities transfers from the bedroom density basis, advocated as a planning standard in chapter 3, to the dwelling unit basis required for capacity assessments in SHLAAs. The logical link between these two density measures is the bedroom: dwelling ratio, a cross LSOA regression for which is presented here alongside the dwelling unit density regression and the comparable bedroom density regression estimates from Table 3.3. Logically bedroom densities are simply the product of dwelling densities and bedroom: dwelling ratios: expressed in logged terms they simply add up, as should the coefficients in regressions estimated (as here) on the same set of independent variables.

While dwelling densities and bedroom ratios both contribute positively to bedroom densities and are each significantly related to each of the included area indicators, the signs of the relationships between these tend to be opposite to each other. This pattern reflects some trade-offs between accommodating more dwellings versus ones with more bedrooms. Thus better PTAL and job accessibility scores are associated both with more dwellings per hectare and fewer bedrooms per dwelling. And suburban character/low past population densities are associated with fewer dwellings per hectare and more bedrooms per dwelling. Less predictably, greater physical distance from the centre seems to reduce bedroom densities primarily through lowering the numbers of bedrooms per dwelling; while the borough level central character effect raises bedroom densities (in new developments) solely by raising the

ratio of bedrooms per dwelling. Further evidence of the trade-off between dwelling numbers and bedroom can be found if the residual from either of the first two regressions is included in the other, attracting highly significant negative coefficients. In the case of the bedroom ratio this then appears much the strongest predictor – as would be that for bedroom density, suggesting that (however measured) more intense development is associated with a strong bias toward units with fewer bedrooms.

Nothing much should be read into these relationships because these are not designed as causal models with clearly separable influences. As descriptive/predictive representations of the patterns of variation, this simple form of regression appears almost as effective in reproducing the spatial pattern of (new) dwelling densities as it was for bedroom densities – though it accounts for much less of the spatial variation in numbers of bedroom per (new) dwelling.

Appendix A4: Density Policy in Manchester

Core Strategy Development Plan Document Adopted 11th July 2012
Density used also in terms of economy, mentions density of businesses uses. Density is treated in terms of broad design, neighbourhood and transport considerations but no figures are given. Thus in e.g.8.16; In order that Manchester can continue to provide housing to support its sustainable economic growth and the regeneration of its inner areas, housing will be supported in the Regional Centre. It will be important that this complements the centre's overarching economic character now and in the future. The Council would expect the Regional Centre to be a location where apartment development is appropriate. However the exact mix of housing and density will need to be informed by its location relative to the City Centre and public transport facilities (especially the Metrolink).

And part of Policy CC1: The City Centre and fringe will be considered a suitable location for the consideration of high density buildings and commercially led mixed use schemes. The focus for employment growth will be in B1a high density offices and the Council will give particular encouragement and support for such development in the following locations: City Centre, Civic Quarter Mayfield Spinningfields and Granada lands The Corridor (Oxford Road Corridor, Great Jackson Street and First Street) Piccadilly City Centre Fringe, City Centre North extending into Strangeways and Collyhurst Ancoats Chancellors Place Birley Fields/Manchester Science Park.

Provision of a range of economic development uses, such as retail, leisure, entertainment, cultural and tourism facilities will be encouraged in the City Centre, in line with Policy C1, to support the development of a vibrant employment location attractive to businesses, employees and visitors to the City Centre.

New, and the enhancement of existing, infrastructure provision which supports the agglomeration role of the City Centre and Fringe will be supported. Proposals will be expected to show how they contribute to decentralised low and zero carbon energy infrastructure in the Regional Centre as set out in the Energy policies. Developments which lead to the more intensive use of employment land (in terms of floor space provided) will be supported.

Guide to Development in Manchester Supplementary Planning Document and Planning Guidance Adopted April 2007
2.7 We wish to encourage the most appropriate form of development to enliven neighbourhoods and sustain local facilities. The layout of the scheme and the design, scale, massing and orientation of its buildings should achieve a unified urban form which blends in with, and links to, adjacent areas. Increased development density can be appropriate where it is necessary to reinforce community identity, promote a more economic use of land, increase demand for local facilities and contribute to safer, self-policed streets. However density levels must be informed by the character of an area and the specific circumstances of a proposal.

7 Housing Density and Mix 7.1 Under UDP Part 1 Policy R1.1 the City Council is looking to further regeneration by creating sustainable communities. Density of population is a key issue if this objective is to be delivered and the Council's aspiration is for a sufficient urban density to ensure vibrant neighbourhoods and efficient services. Different character areas will, however, have different densities of buildings and different building forms; our aim will be to ensure that there is a sufficient mix of people and activities to support and sustain strong local communities. 7.2 New housing development should not be viewed in isolation and proposals must be designed having regard to not only the immediately adjoining

buildings but also the townscape of the wider area. Developments should be informed, both in terms of design and layout, by the wider context. It is the character and identity of an area that will determine appropriate densities and form, and clearly this will vary across the City. 7.3 As set out in UDP Part 1 Policy H1.2 the emphasis is on seeking a range and diversity in terms of type and size of new housing to provide a quality range of housing. This will enhance the character of parts of the City, from high density flats, where appropriate, to lower density detached dwellings. 7.4 Parts of the City have seen the loss of family housing in favour of flats to such an extent that the character and sustainability of these areas is jeopardised. We believe that the balance of development in such areas should now revert to the provision of a range of family housing more traditionally characteristic of these parts of the City, which can offer choice to local people and assist the sustainability of these neighbourhoods.

Providing for Housing Choice - Supplementary Planning Document and Planning Guidance Adopted 2nd September 2008

References density in relation to supply of affordable housing – number of units that would be expected on a site and so likelihood of meeting threshold for affordable housing i.e. avoiding 'underdevelopment' to avoid affordable housing provision.

Appendix A5: Questionnaire to international experts

The following e-mail was sent to country experts:

The questions we want to ask are in relation to the country's land use planning regulations; how it is applied in major cities particularly with respect to development control relating to new residential building:

i) Is the concept of density is recognised in your planning system at national and city level?
ii) How is it measured? – e.g. is it measured in relation to number of dwellings; habitable rooms; sq. metres; population – or indeed simply implemented through plot ratios, building height?
iii) What are the stated/understood objectives – e.g. to increase the numbers of dwellings built given land shortages; to ensure built form is appropriate to the area – including e.g. height restrictions; to use existing infrastructure more effectively; to plan for additional service/infrastructure provision (e.g. school places);
iv) Is the approach national or local; and
v) Anything else you would like to add?

We received responses from experts in eleven countries:

Australia
France
Germany
Hong Kong
Ireland
Italy
Netherlands
New Zealand
Norway
Portugal
Sweden

Cities that were identified as having city specific approaches within the national framework included:
Amsterdam
Auckland
Dublin
Milan
Paris
Stockholm