Hertfordshire County Council

A Guide to the Hertfordshire Demographic Model

2021

Hertfordshire

Contents

1.0 Introduction

HCC has a number of roles to deliver local infrastructure and as such is required to ensure that the impact of new development is mitigated in a number of areas. In order to determine likely levels of service(s) uptake, appropriate developer obligations and, to inform a strategic overview, HCC requires a method of projecting the populace likely to arise from new development. HCC has therefore established a Development Model (hereinafter referenced as “the model”).

The model provides HCC with the necessary baseline evidence to support a request for planning obligations through the appropriate mechanism. It ensures that HCC is able to meet the 3 tests in respect of planning obligations, namely: that they are necessary to make the development acceptable in planning terms, directly related to the development, and fairly and reasonably related in scale and kind.

Information relating to pupil yield, across all school age stages, from new build housing is necessary for assessing schools capacity and the potential development of new schools. New housing developments can place additional pressures on school places through inward migration into an authority and by the redistribution of the existing population into areas where existing schools are at capacity or are not located within a reasonable distance.

Hertfordshire County Council (HCC) is the Local Authority with responsibility for **Education** and as such has a statutory responsibility for the provision of education services including sufficient school places for nursery, primary, secondary and sixth form age pupils. Provision must also be made available for children with special needs and sufficient child care spaces in the early year’s sector.

As Local **Libraries** Authority, HCC has a duty to provide a comprehensive and efficient library service for everyone who lives, works, or studies in the County under the 1964 Public Libraries and Museums Act. It is committed to maintaining and modernising its libraries to continue to meet the changing needs of service users and to cope with additional demand brought about by new development.

Legislation[1] requires that local authorities have a “responsibility to ensure young people have access to sufficient educational leisure-time activities which are for the improvement of their well-being and personal and social development, and sufficient facilities for such activities; that activities are publicised; and that young people are placed at the heart of decision making regarding the youth work / positive activity provision.”

The focus of HCC **Youth** Connexions is prevention and early intervention. It supports young people by providing high quality informal education opportunities to promote young people’s personal and social development, enabling them to make informed decisions, have a place in their community and ultimately, to reach their potential and make a successful transition to adulthood.

The Hertfordshire **Fire and Rescue** Service (HFRS) has two major functions - keeping people safe through community fire safety initiatives [Prevention & Protection] and saving lives through operations [Response].

As Fire Authority, Hertfordshire County Council is responsible for making arrangements to obtain the necessary information for the purposes of: providing a swift and effective 24/7 emergency response to: extinguish fires, with the aim of protecting life and property; rescuing people from road traffic collisions, water and height; and dealing with other emergencies such as wide-area flooding, chemical incidents and large animal rescues. HFRS also play a major role in civil protection, working in partnership with other public bodies and private sector organisations to ensure an integrated approach to dealing with large scale civil emergencies.

Hertfordshire County Council, as the **Waste** Disposal Authority (WDA), is responsible for the disposal of almost 530,000 tonnes of Local Authority Collected Waste (LACW) produced by Hertfordshire's residents each year. This waste is either collected at the kerb side by the district and borough councils in the role of the Waste

[1] The Education and Inspections Act 2006, Part 1, Section 6: Education Act 1996, Section 507B.

Collection Authorities (WCAs) or deposited by residents at Household Waste Recycling Centre's (HWRC's).

Hertfordshire County Council as the Local **Highway** Authority is responsible for providing a safe, efficient and resilient transport system that serves the needs of business and residents across Hertfordshire and minimises its impact on the environment.

The County Council will make best use of the existing road network and where necessary, introduce targeted schemes to deliver a reliable and readily useable transport network which encourages economic growth and allows access for everyday facilities. The County Council promotes and supports sustainable travel to help reduce car traffic and contribute to improved health and quality of life.

The methodology for this work is supported by the COMET model which is a countywide multi-modal transport model. COMET provides information on current travel patterns across Hertfordshire and will be used to consider the future impact on travel patterns and areas of congestion based on expected areas of growth. Highways impacts are not considered within the Development Model.

Increased levels of development ultimately have an impact on HCC services. The model provides a projection of residents likely to occupy a particular development and this document provides an overview of the model applied by the authority, the outcome of which informs discussions with developers to understand how best to mitigate the impact on HCC services.

1.1 The Hertfordshire Development Model

In Hertfordshire, a model has been developed by the HCC Property Intelligence Services Team. The model operates based on 2011 census data tabulated by dwelling size (number of bedrooms), type and tenure for All Households and Migrant Households customised outputs. The model allows for the population likely to be resident in a new development to change with time and for the overall population to conform to an age structure in line with the wider community.

HCC recognises that demographic modelling can be approached using a variety of different methodologies, discussed further in Technical Appendix 1, however the authority considers the Development Model to be appropriate as:

- The process of creating the customised table outputs incorporated into the HCC model involves the base data passing ONS Statistical Disclosure Controls (SDC) and as such the data are considered robust and non-identifying.
- A census is considered the most comprehensive and accurate survey of the population and it's characteristics at the time it is taken, local authority average person and household response rates within Hertfordshire (95% and 96% respectively) were higher than that reported for England overall (94% and 95% respectively).
- Specific consideration is taken of the demographic characteristics of wholly moving (Migrant) households which differ substantially to that of the population of the whole (All Households). Cohorts are aged "year on year" as a development progresses and therefore provide a more accurate projection of likely populace than other methods such as those which apply a flat or average yield per 100 dwelling rate.

The model is based on hierarchical data sourced from the Office for National Statistics (ONS) as customised table outputs for the geography of the area covered by Hertfordshire County Council. Detail on how the census tables are applied within the model is available in Technical Appendix 2. The ONS produced, upon commission by the authority, the following four customised table outputs[2]:

- CT0173 - Tenure of household by accommodation type by number of bedrooms – All Households - *All occupied households in unshared dwellings (excluding caravans and other mobile or temporary structures).*
- CT0174 - Tenure of household by age by accommodation type by number of bedrooms – All Households - *All usual residents living in households in*

[2] These tables are publicly and freely available upon request from the Office for National Statistics via: Census.CustomerServices@ons.gsi.gov.uk or can be downloaded from their published census data sets.

unshared dwellings (excluding caravans and other mobile or temporary structures).

- CT0478 - Tenure by bespoke accommodation type by number of bedrooms – Migrant Households - *Wholly moving households (excluding caravans/temporary structures) in unshared dwellings.*
- CT0479 - Age by tenure by bespoke accommodation type by number of bedrooms – Migrant Households - *All usual residents living in wholly moving households (excluding caravans/temporary structures) in unshared dwellings.*

Following ONS policy the data tables are publicly and freely available from their website. Data contained within these tables is identical in dwelling and person counts to requests made to the ONS by consultants for similar outputs although of aggregate age groups, for example CTO-339 and CTO-324 also available on the ONS website.

The model can operate at different levels of complexity to account for the level of information available at any given point in the planning application process. The more detail provided for input into the model, the more detailed the result:

- **Unit numbers** –this level of data represents the projected population wherein the least amount of data with regard to a development is known (typically the total development size only) although consideration can also be given to a specific bed size mix. This data level is beneficial in providing a strategic overview of likely demand for proposed District housing development with a long projection horizon where the application of a specific detailed mix is inherently rigid and questionable.
- **Unit numbers and the type of unit mix** – this level of data represents the projected population wherein the type mix of the overall unit number is also known, so consideration is also given to the type of proposed dwelling (house or flat) by bed size.
- **Unit numbers and the type & tenure of unit mix** – this level of data represents the projected population wherein the most detailed level of

information is available with regard to overall unit number, dwelling bed size, type and tenure.

1.2 How the model operates

The 2011 Census customised data outputs for All Households and Migrant Households provides information relating to the number of persons by age versus total number of households, or it can be drilled down by bed size, type and tenure (or any combination thereof). These tables, of which there are 330 in total (165 each for All Households and Migrant Households), provide the underlying raw data used in calculating population by sector, and by varying level of detail, from each of the detailed approaches applied by Hertfordshire County Council (Section 1.1).

The approach that HCC applies in projecting the number of people likely to be resident within a given development is dependent upon the level of information available for each particular development. However, there is a commonality in that the methodology is dependent on the ONS customised table outputs as their base data, although to varying degrees of detail, and the calculation processes are generally identical. Figure 1 illustrates the broad process for the model whilst Figure 2 displays the model main screen.

Two pieces of information are critical to the model operation: the development overall size (the total number of dwellings it is proposed to construct) and the trajectory (the number of dwellings completions per annum). Figure 2 displays the model main input screen where a user enters the available proposed development details. For instances where only the number of proposed units is known the entry table allows the user to enter only the Development Size. Additional detail such as bed size mix, type and tenure for a proposed development can be provided when known in order to refine projected population yields. When the development details are complete the user selects the button to enter the trajectory data as displayed in Figure 3. The trajectory may be provided by the applicant or, where not provided, based on a reasonable assumption given consideration of the total development size.

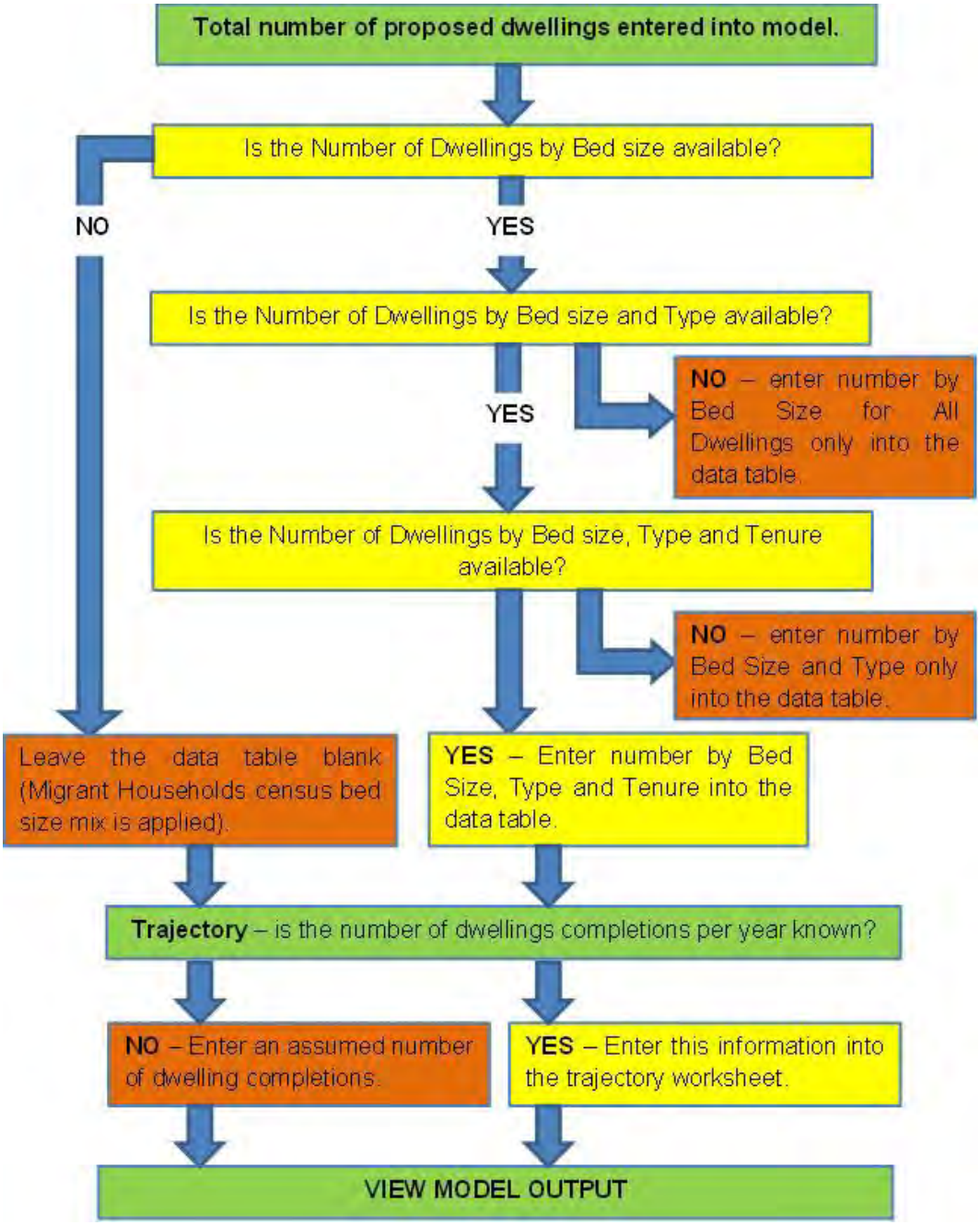


Figure 1. The Hertfordshire Development Model broad processes.

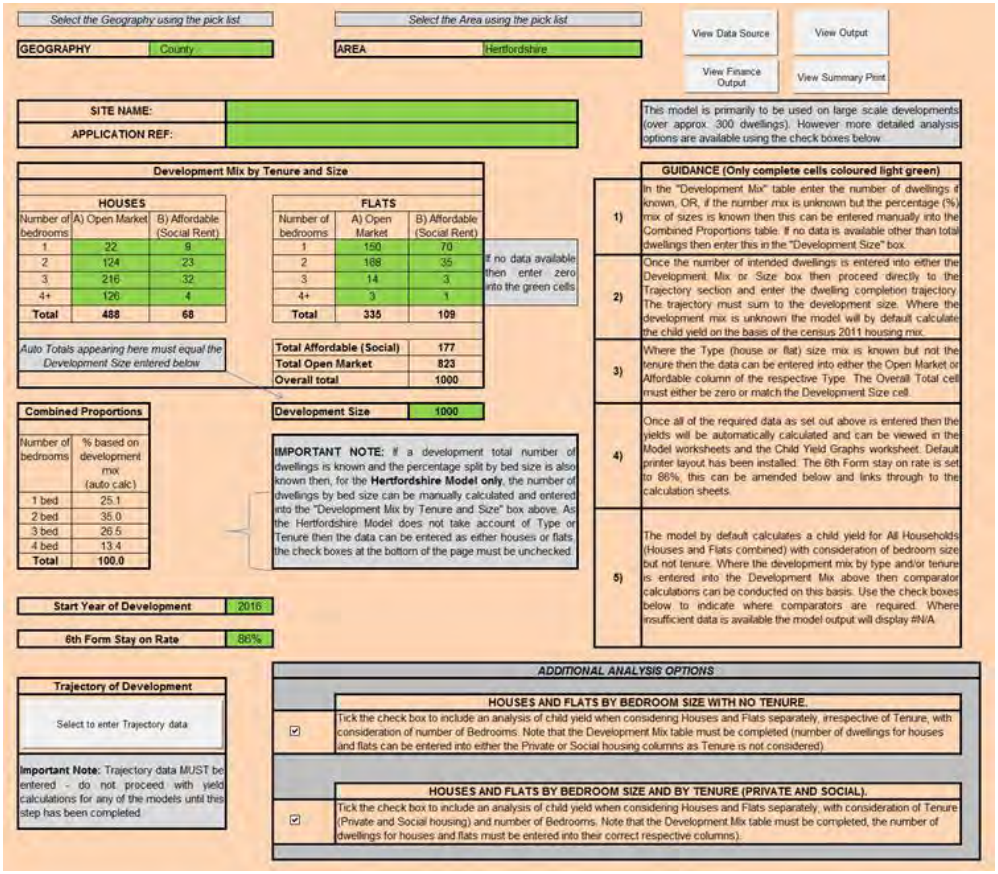


Figure 2. The model main screen for proposed development data entry.

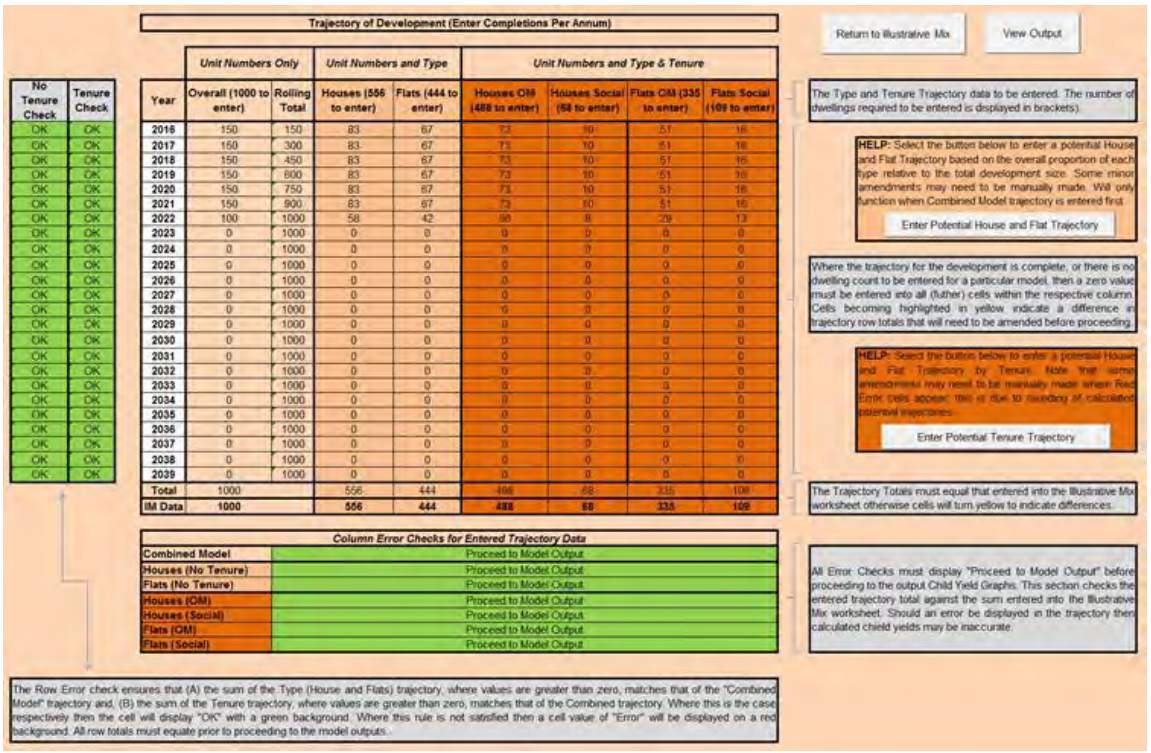
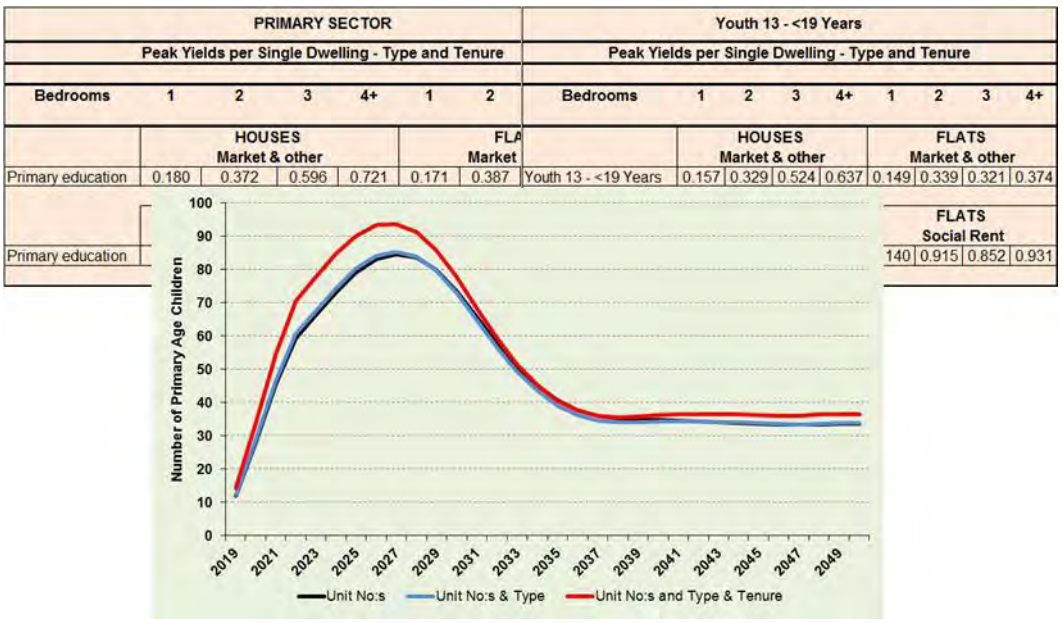


Figure 3. The model trajectory sheet with conditional format error checking.

The model has the functionality to include very detailed trajectories but in most instances an applicant may not have a high level of detail on trajectories for individual types and tenures. The user is able to input a high level trajectory and allow the model to calculate the more detailed scenarios by applying a proportional split between the houses and flats across type and tenure.

1.3 Model outputs

The model uses the number of dwellings by bed size to calculate single dwelling population yield values as determined from the Census Migrant Household data. These yield figures are then multiplied by the dwelling percentage representation by bed size in order to calculate a yield per 100 dwellings by age. The yield per 100 dwellings values by age are linked to the underlying model sheets which utilise the build trajectory to calculate the number of persons by age as the development progresses. Technical Appendix 3 provides further detail on the specifics of the model process. Model outputs are both tabular and graphed. Figure 4 displays the graphed projected population yield output for a selected age range – for example primary education. More detail on the worksheets that sit behind the model is available in Technical Appendix 4.



PRIMARY SECTOR						
Peak Yields per Single Dwelling - Type and Tenure						
Bedrooms	1	2	3	4+	1	2
	HOUSES Market & other				FLA Market	
Primary education	0.180	0.372	0.596	0.721	0.171	0.387

Youth 13 - <19 Years								
Peak Yields per Single Dwelling - Type and Tenure								
Bedrooms	1	2	3	4+	1	2	3	4+
	HOUSES Market & other				FLATS Market & other			
Youth 13 - <19 Years	0.157	0.329	0.524	0.637	0.149	0.339	0.321	0.374

	FLATS Social Rent			
Primary education	140	0.915	0.852	0.931

Figure 4. The graph and tabular model outputs for population yielded from a proposed development for a selected age group.

1.4 Calibrating the Demographic Model with the PYS

The scope of the authority PYS provides an excellent observed statistical base to which HDM mainstream pupil projections can be compared using “real world” new build development aggregations for which yields are known.

Comparison between the HDM and PYS was conducted using the PYS 59 cohort; this cohort has previously been used to determine mainstream pupil yields associated with the emerging development typology classification adopted for use at the Local Plan stage. The PYS 59 cohort consists of 6,261 new build dwellings overall of which 1,220 (19.2%), 2980 (46.8%) and 2,161 (34%) were observed in Tier 1, Tier 2 and Tier 3 developments respectively. Comparisons in yields were conducted for all Tiers and for the cohort overall. The following typology Forms of Entry (FE) to dwellings counts, and within tier average development mixes, were observed from previous work:

- Tier 1, 1FE primary per 400 dwellings: *These sites are typically greenfield sites with a dominance of houses (typically 80/20 houses/flats), a higher proportion of 3+ bed properties and a higher proportion of detached or semi-detached houses. There tends to be a dwelling unit density of 22 to 40 per hectare (dph).*
- Tier 2, 1FE primary per 500 dwellings: *These sites are typically PDL with a mix of houses and flats, and a higher proportion of terraced, maisonettes or flats. There is generally a 50/50 Split between smaller (1 & 2-bed) and larger (3-bed+) family homes, while houses are most likely to be terraced. There tends to be a dwelling unit density of 40 to 60 per hectare (dph).*
- Tier 3, 1FE per 1,000 dwellings (excluding Watford)[1]: *These sites are typically PDL with a dominance of 1-2 bed properties and are mainly flatted developments (at least 75% flats). There tends to be a dwelling unit density of >=60 per hectare (75 to 100 is quite common).*

Figure 1 displays an example output of primary mainstream yields projected for Tier

[1] Flatted developments in Watford produce abnormally high yields when compared to similar sites in other Hertfordshire authorities. A different strategic planning ratio is therefore applied to Tier 3 developments in Watford when assessing local plan growth scenarios.

1 developments versus that observed from the PYS. It can be observed that, in this instance, the accumulation of mainstream yields follows a consistent pattern with that projected from the HDM. There was a 4.1% difference in the HDM peak yield to the current PYS Tier 1 cohort count, it should be noted however that yields are still annually increasing although at a decreasing rate. It is anticipated that PYS yields will increase further in 2021 either narrowing the gap to the HDM projections or, for Tier 1 developments, surpassing HDM forecasts.

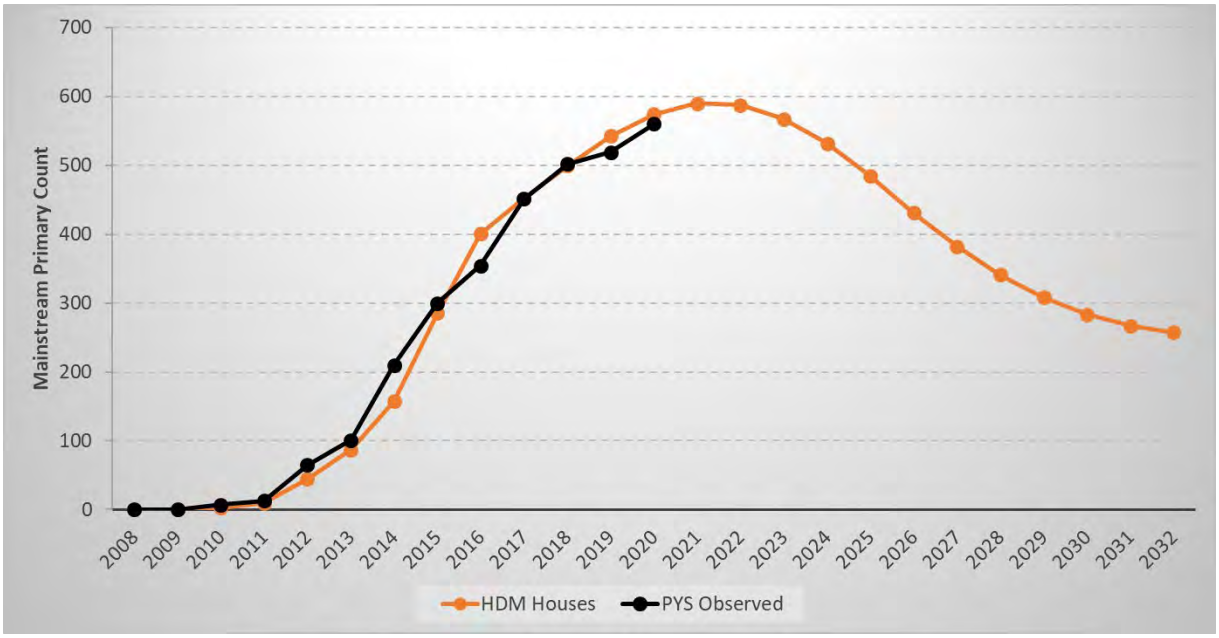


Figure 1. Typology Tier 1 PYS observed primary mainstream pupil counts versus HDM projected applying the aggregate development dwelling type, bed size and, tenure mix (Type Outputs).

Whilst HDM projected mainstream primary yields were close to that observed in Tier 1 developments a higher degree of variance was observed with Tier 2 and 3. Generally as the percentage contribution of houses to a mix decreased, and conversely a higher contribution of flats, then the larger the difference between the HDM projected primary mainstream yields and that observed from the PYS. Provisional evidence indicates that this likely occurs due to a higher level of resident churn (in and out movements) within Tier 2 and 3 in conjunction with lower proportions of AR/SR in contrast to Tier 1 (primarily for the flatted element).

Functions were incorporated into the HDM to provide an indication of typology for an entered mix based on the typology classifications listed above. HDM projected

mainstream yields are subsequently reduced according to the typology-based Type and Tenure (highest level of detail) differences observed between PYS and HDM. The percentage reduction applied to a specific mix is not set to the Tier average difference observed for that typology but rather on a linear interpolated reduction related to the percentage contribution of houses to the entered mix. For example, a development is entered to the HDM from which the mix indicates a Tier 1 proposal such that: *there is a dominance of houses (typically 80/20) and a higher proportion of 3+ bed properties.* However, the representation of larger family houses is less than that observed from the PYS Tier 1 cohort and it can logically be expected that the percentage difference to the HDM projections will be greater and lie between the Tier 1 average reduction and that of Tier 2.

The higher difference occurs due to a lower representation of larger, higher yielding, family dwellings. The percentage reduction point is determined by the linear interpolation of the applied reduction between the known percentage contribution of Tier 1 houses to the known percentage contribution of Tier 2 and/or Tier 3 houses and the calculated percentage difference to the HDM. The interpolated value based on a proposal mix is applied to reduce HDM projected mainstream yields accordingly, outputs are therefore specific to each unique development (Figure 2).

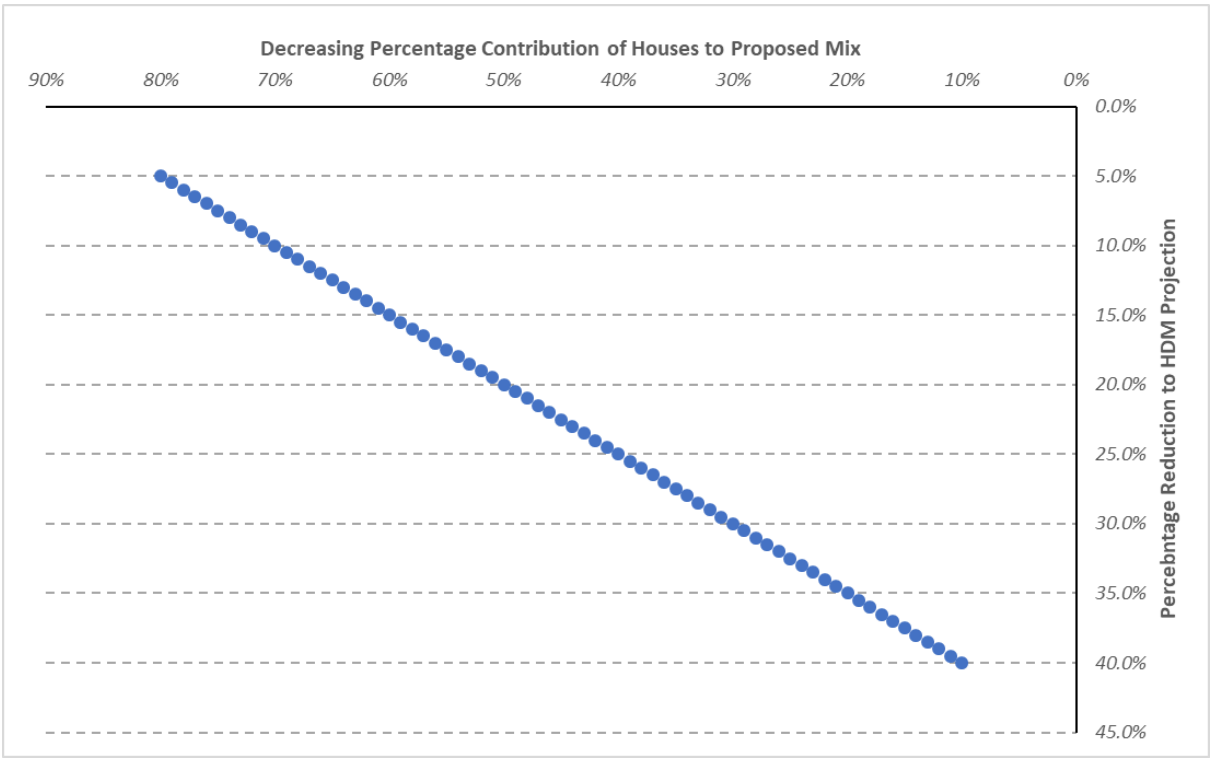


Figure 2. Example increasing percentage reduction to the HDM mainstream

education outputs with decreasing representation of houses to a proposed mix (data is for illustration of method only; it does not represent observations from the PYS to HDM comparison study).

Figure 2 displays an example relationship between reducing contribution of houses to a mix and increasing percentage reduction to HDM calculated yield. The data presented is for illustrative purposes only and does not reflect actual observations from the PYS to HDM comparison.

A criticism previously raised was that the authority did not update Long Term Average (LTA) mainstream yields within projections to reflect post-2011 census yield rates. The LTA is the overall yield that a development would be expected to attain once enough time has passed post-peak and reflects the wider housing stock yields, it is sometimes referred to as the "All Households" yield. The HDM inclusion of only 2011 census based All Household yields was suggested to not take account of inter-census period changes to overall dwelling stock numbers nor changes in the demographic profile of the authority area. A statistical randomised dwelling sample of 2,525 dwellings was undertaken (Figure 3) of which 22.6% were flats and 77.4% houses, this is reflective of the overall dwelling stock split of 22.4% flats and 77.6% houses.

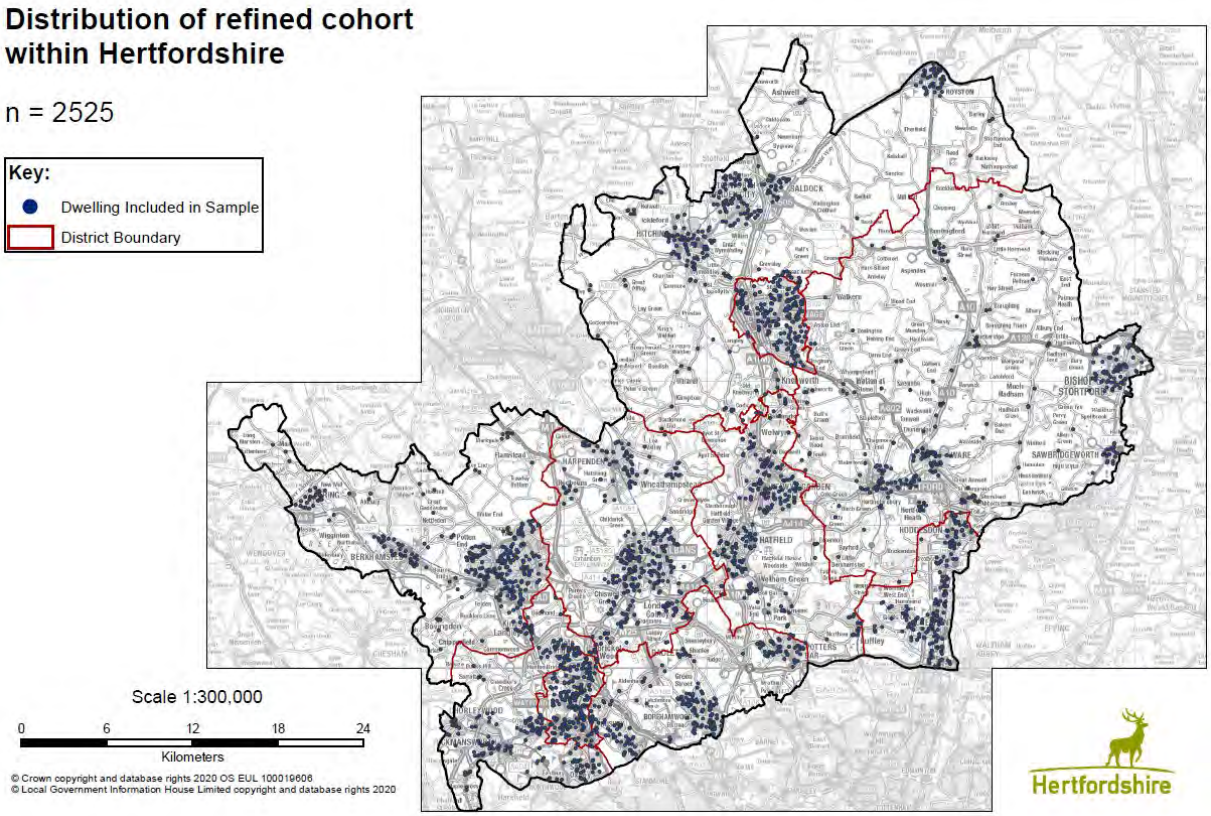


Figure 3. The randomised LTA update dwelling sample and scatter throughout Hertfordshire.

Whilst the industry standard confidence level is 95% +/- 5% it was considered prudent to aim for 95% +/- 2%; based on this criteria Figure 4 indicates a sample size of 2,401 dwellings would be required.

The inclusion of dwellings above this threshold was to provide a buffer for exclusion of some poor-quality School Census addresses which are impossible to geolocate to Unique Property Reference Number (UPRN) level. It can be noted that in deriving the figure of 2,401 dwellings that the population proportion displaying the characteristic of interest threshold of 50% has been applied. The PYS has demonstrated that houses can have a primary pupil yield up to, and in excess of 50 per 100 dwellings, or 50%. The 50% demarcation in sampling is the “worst case” scenario due to the presence of a higher level of uncertainty and hence the sample size required at this mid-point is the largest.

Figure 1: Sample size lookup table

Population Proportion	Precision (at the 95 per cent confidence level)							
	±12%	±10%	±8%	±5%	±4%	±3%	±2%	±1%
50%	66	96	150	384	600	1,067	2,401	9,604
45% or 55%	66	95	148	380	594	1,056	2,376	9,507
40% or 60%	64	92	144	369	576	1,024	2,305	9,220
35% or 65 %	60	87	136	349	546	971	2,184	8,739
30% or 70%	56	81	126	323	504	896	2,017	8,067
25% or 75%	50	72	112	288	450	800	1,800	7,203
20% or 80%	42	61	96	246	384	683	1,536	6,147
15% or 85%	*34*	*48*	76	195	306	544	1,224	4,898
10% or 90%	*24*	*35*	54	138	216	384	864	3,457
5% or 95%	*12*	*18*	*28*	72	114	202	456	1,824

If you are expecting non-response or a difficulty in locating your sample selections then it is prudent to over sample to ensure that the sample size achieved provides the required level of precision.

The figures in ***bold and italics*** denote sample sizes of less than the recommended minimum.

Figure 4. Required sample size based on the percentage representation of the characteristic of interest, level of precision and, confidence interval (Source: National Audit Office – Statistical & Technical Team – A practical Guide to Sampling).

Address cleansing of January 2019 School Census records (extracted based on a

postcode match to the sample dwelling cohort postcodes), and cross-refencing of subsequently allocated UPRN to that of the sample cohort determined a count of mainstream pupils for Units Only, Houses Only and, Flats Only. These updated values are shown in Table 1 below.

Table 1. Sample derived LTA mainstream sector yields per 100 dwellings at Units Only, House Only and, Flats Only (2019).

	Dwellings	N2	PRIMARY	SECONDARY	POST-16
UNITS ONLY	2525	36	472	303	71
	Yield per 100	***1.4***	***18.7***	***12.0***	***2.8***
HOUSES	1954	30	425	286	69
	Yield per 100	***1.5***	***21.8***	***14.6***	***3.5***
FLATS	571	6	47	17	2
	Yield per 100	***1.1***	***8.2***	***3.0***	***0.4***

Once bed size and tenure information for the sample cohort based on each individual dwelling UPRN is obtained the authority can calculate updated type, bed size and tenure specific LTA yields for inclusion in development modelling. In the interim, HCC is conducting a 2020 LTA administrative update based on a larger sample cohort size of 6,000 dwellings. It is intended that this will both further reduce the confidence interval <1.5%, within which the true population mean will lie, and permit initial examination of special school LTA yields by sector.

1.5 Conclusion

Hertfordshire County Council has statutory requirements for a number of service areas. In particular, when considering the outputs of the model, to provide sufficient school places for its populace. Part of this process is to have robust and transparent processes which reflect that due diligence has been undertaken in estimating the most likely pupil yield arising from a particular development. The authority is confident that the contributions requested from developers as a result of the projection model, aligned with actual observed yields from the county council's Pupil Yield Study, are accurate and fair and are also supported by additional pieces of work which the county council has previously undertaken. Projected yield, and other data, arising from the model will be used to inform discussion on residential planning applications as sites come forward for delivery.

TECHNICAL APPENDIX 1: OTHER METHODS FOR THE PROJECTION OF POPULATION ARISING FROM NEW BUILD DEVELOPMENTS.

Historically estimates of the population, in particular child yield for education contributions, resulting from new housing developments have been debatable between authorities and developers although good data to support these negotiations has often been limited. Many factors influence both whether a contribution is sought from a proposed development by a local authority and also the scale requested (whether financial, land or other). General factors that influence whether a contribution is sought include:

- Development size (total number of dwellings).
- Development location.
- School capacity in the area (for primary and secondary aged pupils).
- Early years (childcare and pre-school) capacity in the area.
- Development composition, published literature indicates that sometimes the following are excluded from providing an education contribution:
    - Bed Sits, Studio and one bedroom properties[3]
    - Sheltered accommodation.
    - Hostels.
    - Student accommodation.
    - Specialist elderly housing such as rest homes and nursing homes.
    - Redevelopment or housing development schemes which do not increase the number of family houses.

Factors that influence the scale of the contribution from a housing development generally include:

- Dwelling Type – House or Flat.
- Dwelling Size – Number of bedrooms.

[3] For example; Bracknell Forest (Planning Obligations, Supplementary Planning Document February 2015): Cambridgeshire County Council (Revisions to child yield multipliers for new developments September 2015): Essex County Council (The Essex County Council Developers' Guide to Infrastructure Contributions 2015).

- Dwelling Tenure – Market or Social Housing (often cross referred to as Affordable).

A number of methods have been applied by local authorities to determine pupil yields arising from new developments, these include:

- Demographic methods.
- Surveys of new build housing.
- Census data typically relating to person age and household counts for “All Households” and “Migrant Households” for application in statistical modelling.

Hertfordshire County Council has previously undertaken a review of local authority processes in determining pupil yields from new developments which examines in greater depth each of these methods (June 2012).

1.1 DEMOGRAPHIC RATIOS

Generally the application of demographic ratios is the simplest method to determine population yield from a development. However it should be noted that within published literature generally no distinction is made between older housing stock and new build properties, for dwelling type, size or tenure. This method therefore discounts the fact that wholly moving (Migrant Households) have a difference demographic age structure than the population as a whole and at best is suggestive of what a long term average yield would be in comparison to a local authority as a whole. Additionally this method has only tended to be applied by local authorities where a proposed development does not specify the type or tenure of housing that will be built. Whilst focus herein is predominantly on child yield the method is applicable to all age groups.

The Department for Communities and Local Government estimated that as at the 31st March 2016 there were 483,260 domestic dwellings in Hertfordshire (Source: DCLG Housing Statistics Table 125 - Local Authority Level). The Office for National Statistics (ONS) Mid-Year Estimates 2015 indicated that there were 264,254 children aged 0 to <18 years giving rise to an overall yield of 55 children per 100 dwellings

(Table 1). Applying the aggregated number of children within each year of age determined that in Hertfordshire, per 100 dwellings, there would be a yield of 13 children to Early Years (0 to <4 years), 22 to primary (4 to <11 years), 14 to secondary (11 to <16 years) and 6 to Post-16 education (note the latter excludes any applicable Post-16 stay on rate). In relation to the total population there would be a yield of 241 persons per 100 dwellings of which 67 would be aged 55+ and 40 aged 65+.

Table 1. Example yields per 100 dwellings for commonly requested population sectors based on the most recent DCLG dwelling estimates and ONS Mid-Year Estimates data (2015/16). For comparative purposes a selection of data for 2012 is also displayed.

	0 - 3 Years	*4 - 10 Years*	*4 - 8 Years*	*11 - 15 Years*	*16 - 17 Years*
2015 MYE	60,895	107,129	78,817	68,053	28,177
2016 Dwellings	483,260				
Yield per 100	**12.6**	**22.2**	**16.3**	**14.1**	**5.8**

	13 - 19 Years	*0 - 17 Years*	*Age 55+*	*Age 65+*	*Total Pop.*
2015 MYE	94,070	264,254	322,141	194,328	1,166,339
Yield per 100	**19.5**	**54.7**	**66.7**	**40.2**	**241.3**

	0 - 3 Years	*4 - 10 Years*	*11 - 15 Years*	*16 - 17 Years*	*0 - 17 Years*
2012 MYE	61,266	97,040	68,959	28,684	255,949
2012 Dwellings*	470,428				
Yield per 100	**13.0**	**20.6**	**14.7**	**6.1**	**54.4**

**Determined from Address Point files.*

Since 2012 there has been an increase in the overall yield of children per 100 dwellings resulting from an additional 8,305 children aged 0 to 18 years (Table 1). The rise in overall number of children has been driven by an increase of 10,089 primary aged children offset by a slight decrease in the Early Years, Secondary and

Post-16 cohorts of 371, 906 and 507 children respectively. Overtime the primary cohort will age and transition into the secondary sector resulting in an approximate 14% rise ([10,089/68,959]*100) in this cohort. Sector yields per 100 dwellings calculated using this method would be applied to a known development size to determine a proxy measure of numbers of children irrespective of the dwelling bed size, type or tenure. For example the calculated 22 primary age children per 100 dwellings arising from Table 1 equates to 1 Form of Entry (FE, 210 primary age pupils) arising from 950 dwellings. Tables 2 and 3 display the yield per 100 dwelling values by age group for 2011 Census derived All Households and Migrant Household data sets. It can be observed that the yield values within the Early Years (0 to 3 years) sector are significantly higher in Migrant Households than All Households whilst the primary yields are relatively comparable.

Table 2. Example yields per 100 dwellings for commonly requested population sectors based on the 2011 Census <u>All Households</u> customised table outputs for Hertfordshire.

	0 - 3 Years	*4 - 10 Years*	*4 - 8 Years*	*11 - 15 Years*	*16 - 17 Years*
Population	59,396	93,828	67,569	68,918	28,463
Households	451,608				
Yield per 100	**13.2**	**20.8**	**15.0**	**15.3**	**6.3**

	13 - 19 Years	*0 - 17 Years*	*Age 55+*	*Age 65+*	*Total Pop.*
Population	93,884	250,605	290,132	166,589	1,097,683
Yield per 100	**20.8**	**55.5**	**64.2**	**36.9**	**243.1**

New build developments will be populated by persons that move into a development and indications of their numbers can be sourced from ONS defined wholly moving households. The Office for National Statistics (ONS) states that: "*Migration tends to be concentrated at young adult ages… future net migration has a much greater effect on the projected number of women of childbearing age and hence the projected number of births, than on projected deaths* (ONS SNPP 2014 – 29th

October 2015)". The demographic profile of migrant households therefore tends to differ observably from the population as a whole and given the dominance of the young fertile adult groups the likely number of births will be higher. It is a matter of natural progression that these high birth numbers will transition over time into the Early Years, Primary and Secondary sectors.

Table 3. Example yields per 100 dwellings for commonly requested population sectors based on the 2011 Census Migrant Households customised table outputs for Hertfordshire.

	0 - 3 Years	*4 - 10 Years*	*4 - 8 Years*	*11 - 15 Years*	*16 - 17 Years*
Population	8,503	7,046	5,400	3,222	1,030
Households	**32,846**				
Yield per 100	**25.9**	**21.5**	**16.4**	**9.8**	**3.1**
	13 - 19 Years	*0 - 17 Years*	*Age 55+*	*Age 65+*	*Total Pop.*
Population	3,981	19,801	6,951	3,453	71,334
Yield per 100	**12.1**	**60.3**	**21.2**	**10.5**	**217.2**

A significant limitation of the demographic ratios method is the inability to age the high yield per 100 dwellings in the Early Years sector into the primary cohort as a development ages resulting in an under-estimation of the number of children likely to require a school place in the future. The "Units Only" model projects a primary pupil yield of 426 pupils for 1,000 dwellings on the basis of the Migrant Household bed size mix however the summary primary yield per 100 dwellings within the underlying data set was 21.5 pupils (Table 3).

This is not dissimilar to those values displayed in Table 1 and equates to a projected primary yield difference of 211 (426 – 215) pupils and occurs as the application of flat rates does not allow for the cumulative transition of the higher yield per 100 dwellings age 0 to 3 cohorts into the primary sector over time. **It is therefore not necessarily the immediate number of primary age children arising from a**

development but the transition of higher yield births into this sector which increases demand on school places.

Any yield calculation method which does not consider this factor is likely to under-project future school place demand. Account is also not given to the higher "birth rates" within a new development as it ages and transitions to a rate equivalent to All Households of an identical dwelling mix (Figure 1). The effect of discounting the transition of the younger cohorts into the primary sector is in this example a significant under representation of likely yield. It is of note that the transition from a peak yield following a development completion to that expected from Hertfordshire overall can take many years and as such consideration cannot be given to the long term average in isolation.

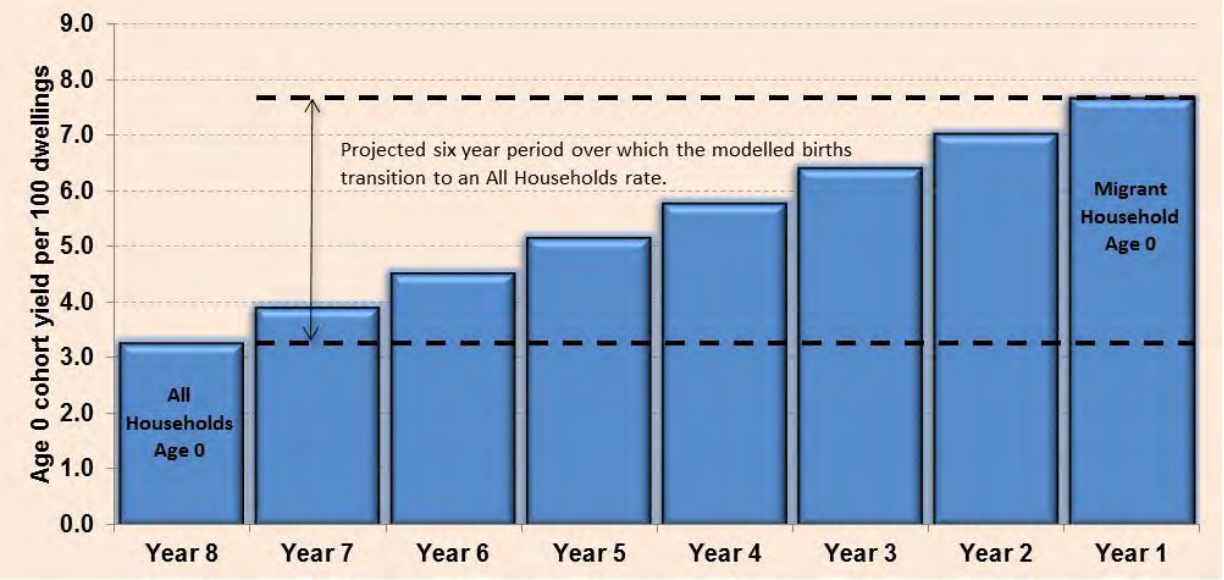


Figure 1. The transition of the Age 0 yield per 100 dwellings from Migrant Households (Year 1) for per annum completed dwellings in a development to that of the All Households yield (Year 8). The data displayed is representative of the Units Only development of 1,000 dwellings with 2011 census bed size mix.

Overall the impact of migration on population change can be significant with the ONS National Population Projections (2014) indicating that nationally 51% of population change to the end of their projection horizon will occur as a result of this element. This rises to 68% if taking into account the indirect contribution of future migration to

population change through its effect on births and deaths. **The demographic characteristics of migrant populations are generally sufficiently different to that of the population as a whole that they are considered by the ONS as a separate group**, much the same way that Special Populations are in the creation of their mid-year estimates.

1.2 HOUSING SURVEYS

Yields determined from surveys and that of a census tend to be more specific than demographic ratios and take into account factors such as accommodation type (house or flat), size (number of bedrooms) and tenure (affordable and market housing) which are generally accepted to influence overall child yield from a development[4]. These methods also allow for the hypothesis that new builds can give rise to a higher pupil yield in comparison to all housing stock and are therefore considered more precise. Surveys tend to be specific to particular areas where new developments have occurred and their robustness is directly proportional to the sampling methodology and response rates however they are generally resource intensive and costly.

HCC initiated a programme of research between 2008 and 2011 over concerns as to potential primary yield increasing as a result of the 22% rise in live births, and the 18% rise in the general fertility rate, between 2002 and 2011 within the authority. The project was an extension of an original body of work, funded by the Royal Statistical Society, which examined the accuracy of several beliefs relating to temporal variation in the age profile of residents on new developments in Hertfordshire. Primary and Secondary pupil yield data was sourced from the Schools Census following geo-coding and matching to identified and completed housing development sites of an urban, semi-urban and rural setting type. The authority's demographer determined that the sample size was statistically robust at county level.

[4] *Social* housing is provided by a landlord on the basis of housing need, and rents are no higher than target rents set by the government for housing association and local authority rents. Market housing relates to owner-occupied and private rented housing, which does not meet the affordability and access criteria for social housing or intermediate housing.

Whilst neither dwelling type, tenure or bed size data was collected during the survey a mean yield of 23.2 primary pupils per 100 dwellings was determined although statistically applying a yield of 42.8 children per 100 dwellings would result in an under-prediction of calculated primary age yield in only 2.5% of observations. The mean yield of 23.2 pupils per 100 dwellings and the adjusted yield of 42.8 equated to one Form of Entry arising from between 900 and 500 dwellings respectively. Applying a one Form of Entry arising from this number of dwellings at a strategic level minimises the risk to the authority of under predicting pupil yield arising from new developments. The 1FE per 500 dwellings is also supported by analysis of 2011 census data as determined from the Development Model.

1.3 APPLICATION OF CENSUS DATA

Every ten years the census gives a complete picture of the nation and allows the comparison of different groups of people across the United Kingdom because the same questions are asked, and the information is recorded, in the same way throughout England, Wales, Scotland and Northern Ireland (Office for National Statistics). Public services such as schools, health, roads and libraries amongst others need to be planned and a census provides information that government needs to develop such policies and allocate funding. As a result of each census a multitude of data tables are produced, across a broad range of subjects, allowing for the statistically robust analysis and insight of the nation's characteristics across multiple geographies.

Information on population demographics and housing is collected as part of the census which provides data on accommodation and about the way households live. Application of census data within this context is generally dependent on the age profile yield from ONS customised table outputs relating to "All Households" and "Migrant Households". **All Households represents the overall population within a defined geography whilst Migrant Households represents wholly moving households in the twelve months prior to the census and which tend to have observably different demographic characteristics.** ONS customised 2011 census table outputs underpin the Hertfordshire Development model and are discussed extensively within Technical Appendix 2.

TECHNICAL APPENDIX 2: APPLICATION OF THE 2011 CENSUS ALL HOUSEHOLDS AND MIGRANT HOUSEHOLDS DATA TABLES.

The 2011 Census customised data outputs for All Households and Migrant Households provides information relating to the number of persons by age versus total number of households, or it can be broken down by dwelling bed size, type and tenure (or any combination thereof) for incorporation into the model. The 2001 census data was dependent on a relationship established between dwelling Number of Rooms to dwelling Number of Bedrooms in order to determine bed size. This was necessary as the 2001 census asked only for the household number of rooms and not the number of bedrooms, this distinction was corrected for the 2011 census which directly provides number of bedrooms. Whilst the 2011 census number of bedrooms data is directly applicable within the models as a result of statistical disclosure controls the bed size range was capped at 4+ bedrooms.

The customised outputs contained a series of sub-tables relating to (A) All Households (houses and flats combined i.e. B + C), (B) House or Bungalow and, (C) Flat, Maisonette or Apartment. An example of the All Households (ONS Table CTO174 & CTO173) sub-table is shown in Table 1 for all bed sizes in aggregate at Hertfordshire County Council geography. This is an age specific aggregation of the number of persons occurring in All Households (B and C combined) by tenure for Hertfordshire. Aggregation of the single year of ages for children aged 0 – 17 years allows for sector totals to be derived for pre-school (0 to <4 years), primary (4 to <11 years), secondary (11 to <16 years) and post-16 (16 + 17 years).

It is important to note that whilst the data displayed in Table 1 is theoretically an aggregation of Houses and Flats by Tenure, this being the constituent parts, the aggregate in this instance is for a “dwelling” of non-stated type. This distinction is of significance as at this level no distinction is made as to the proportional representation of the Type factor which Technical Note 1 determined to have an impact on projected development yield. It follows from the above classification that further sub-tables are available following an identical structure of persons by age for household type (Categories A, B and C above) by tenure and bed size.

Table 1. Summary data for All Households arising from ONS Table CTO174 & CTO173 - Accommodation type for households and age of persons by number of bedrooms by tenure – *All households and all persons in households in Hertfordshire* (Data shown is for all bed sizes in aggregate and for the age range 0 to 16 years only due to table size).

	Owner occupied: Owns outright	Owner occupied: Owns with a mortgage or loan and shared ownership	Rented from: Council (local authority)	Rented from: Housing Association/Registered Social Landlord	Rented from: Private landlord or letting agency	Rented from: Other	Total
TOTAL HOUSEHOLDS	134949	170855	41567	40695	54306	9236	451608
Total Persons by Age	*269786*	*495415*	*96300*	*90178*	*127145*	*18859*	*1097683*
0 years	686	8020	1510	1448	3080	303	*15047*
1 year	756	8018	1557	1486	2777	284	*14878*
2 years	758	8067	1641	1525	2542	245	*14778*
3 years	832	8279	1652	1518	2186	226	*14693*
4 years	892	8256	1581	1500	1941	238	*14408*
5 years	881	8045	1493	1533	1703	192	*13847*
6 years	980	7796	1408	1361	1571	190	*13306*
7 years	1089	7988	1365	1361	1478	175	*13456*
8 years	1109	7463	1290	1295	1229	166	*12552*
9 years	1174	7707	1421	1357	1235	146	*13040*
10 years	1362	7738	1396	1349	1218	156	*13219*
11 years	1409	7903	1385	1370	1241	162	*13470*
12 years	1498	8148	1473	1342	1161	145	*13767*
13 years	1638	7973	1487	1389	1088	143	*13718*
14 years	1686	8067	1529	1429	1097	162	*13970*
15 years	1837	7964	1583	1422	1050	137	*13993*
16 years	1972	8113	1571	1349	1053	156	*14214*

Table 2. The number of "All Households" residents and dwellings by bed size and the respective percentage (%) dwelling representation by bed size relative to all dwellings.

		Bed Size			
Units Only		*1*	*2*	*3*	*4+*
Persons	1,097,683	74,947	220,330	473,749	328,657
Dwellings	451,608	55,571	111,715	181,086	103,236
% dwelling mix by size		12.3%	24.7%	40.1%	22.9%
Units & Type - Houses		*1*	*2*	*3*	*4+*
Persons	930,773	14,258	130,285	460,547	325,683
Dwellings	353,351	9,778	65,318	175,921	102,334
% dwelling mix by size		2.2%	14.5%	39.0%	22.7%
Units & Type - Flats		*1*	*2*	*3*	*4+*
Persons	166,910	60,689	90,045	13,202	2,974
Dwellings	98,257	45,793	46,397	5,165	902
% dwelling mix by size		10.1%	10.3%	1.1%	0.2%
Units & Type & Tenure – Open Market Houses					
		1	*2*	*3*	*4+*
Persons	799,477	8,924	99,604	378,021	312,928
Dwellings	304,930	5,697	51,793	148,273	99,167
% dwelling mix by size		1.3%	11.5%	32.8%	22.0%
Units and Type & Tenure – Social Houses					
		1	*2*	*3*	*4+*
Persons	131,296	5,334	30,681	82,526	12,755
Dwellings	48,421	4,081	13,525	27,648	3,167
% dwelling mix by size		0.9%	3.0%	6.1%	0.7%
Units and Type & Tenure – Open Market Flats					
		1	*2*	*3*	*4+*
Persons	111,728	35,135	64,543	9,499	2,551
Dwellings	64,416	24,995	34,788	3,870	763
% dwelling mix by size		5.5%	7.7%	0.9%	0.2%
Units and Type & Tenure – Social Flats					
		1	*2*	*3*	*4+*
Persons	55,182	25,554	25,502	3,703	423
Dwellings	33,841	20,798	11,609	1,295	139
% dwelling mix by size		4.6%	2.6%	0.3%	0.0%

Table 3. The number of "Migrant Households" residents and dwellings by bed size and the respective percentage (%) dwelling representation by bed size relative to all dwellings.

		Bed Size			
Units Only		*1*	*2*	*3*	*4+*
Persons	71,334	10,753	21,918	24,111	14,552
Dwellings	32,846	8,254	11,497	8,714	4,381
% dwelling mix by size		25.1%	35.0%	26.5%	13.3%
Units & Type - Houses		*1*	*2*	*3*	*4+*
Persons	48,036	1,423	9,610	22,707	14,296
Dwellings	18,252	1,030	4,813	8,130	4,279
% dwelling mix by size		3.1%	14.7%	24.8%	13.0%
Units & Type - Flats		*1*	*2*	*3*	*4+*
Persons	23,298	9,330	12,308	1,404	256
Dwellings	14,594	7,224	6,684	584	102
% dwelling mix by size		22.0%	20.3%	1.8%	0.3%
Units and Type & Tenure – Open Market Houses					
		1	*2*	*3*	*4+*
Persons	41,267	1,050	7,850	18,784	13,583
Dwellings	16,004	723	4,061	7,087	4,133
% dwelling mix by size		2.2%	12.4%	21.6%	12.6%
Units and Type & Tenure – Social Houses					
		1	*2*	*3*	*4+*
Persons	6,769	373	1,760	3,923	713
Dwellings	2,248	307	752	1,043	146
% dwelling mix by size		0.9%	2.3%	3.2%	0.4%
Units and Type & Tenure – Open Market Flats					
		1	*2*	*3*	*4+*
Persons	17,638	6,546	9,816	1,076	200
Dwellings	10,993	4,918	5,518	474	83
% dwelling mix by size		15.0%	16.8%	1.4%	0.3%
Units and Type & Tenure – Social Flats					
		1	*2*	*3*	*4+*
Persons	5,660	2,784	2,492	328	56
Dwellings	3,601	2,306	1,166	110	19
% dwelling mix by size		7.0%	3.5%	0.3%	0.1%

These tables, of which there are 330 in total (165 each for All Households and Migrant Households), provide the underlying raw data used in calculating child yield by sector, and by varying level of detail, within the model applied by Hertfordshire County Council. Combination of customised table outputs CTO173 and CTO174 for All Households determined that there were 451,608 households in total within Hertfordshire of which 12.3% were 1 bedroom dwellings, 24.7% were 2 bedroom, 40.1% were 3 bedroom and 22.9% were 4 and above bedroom dwellings (Table 2).

In relation to the Migrant, wholly moving households in the year prior to the 2011 census date, customised output for Hertfordshire it was observed that there were a total of 32,846 households. Of these 25.1% were 1 bedroom households, 35.0% were 2 bedrooms, 26.5% were 3 bedrooms and 13.3% were 4 or more bedrooms (Table 3). In comparison the proportion of 1 and 2 bedroom households within the Migrants cohort was observably higher than that of the All Households.

Conversely the proportion of 3 and 4 (or more) bedroom households in Hertfordshire within the All Households customised output was higher than that of the Migrants cohort. In both instances the census household mix, as defined within Table 2 and 3, determined a particular age yield profile based on the proportional representation of these bedroom sizes. An amendment to the proportional mix would likely result in a different age yield being determined which would be an important component of any model. With respect to the percentage representation by dwelling type All Households had 78.4% Houses and 21.7% Flats whilst Migrant Households had a lower proportion of Houses at 55.6% and 44.4% Flats.

The dominant tenure for All Households and Migrant Households was Open Market Houses at 67.6% and 48.8% respectively followed by Open Market Flats at 14.3% and 33.5%. Affordable flats had a higher proportional representation in Migrant Households at 10.9% than that observed for All Households at 7.5%. Broadly speaking occupancy rates by type and tenure were similar between All Households and Migrant Households and in both instances affordable dwellings generally had a higher value (Tables 4 and 5). The latter point suggests that affordable dwellings are generally used more efficiently than that of the equivalent Open Market residences.

Table 4. The "All Households" percentage (%) contribution of households by Type and Tenure to total households for the Hertfordshire model and respective total population occupancy rates by bed size.

		Occupancy Ratio by bed size				
	% Contribution	*∑*	*1*	*2*	*3*	*4+*
Units Only	**100.0%**	2.4	1.3	2.0	2.6	3.2
Units and Type						
Houses	**78.4%**	2.6	1.5	2.0	2.6	3.2
Flats	**21.7%**	1.7	1.3	1.9	2.6	3.3
Units and Type & Tenure						
OM Houses	**67.6%**	2.6	1.6	1.9	2.5	3.2
Aff. Houses	**10.7%**	2.7	1.3	2.3	3.0	4.0
OM Flats	**14.3%**	1.7	1.4	1.9	2.5	3.3
Aff. Flats	**7.5%**	1.6	1.2	2.2	2.9	3.0

Dividing the number of persons by the number of households by size (number of bedrooms) determines a "per dwelling" person yield by single year of age for both All Households and Migrant households (Table 6). For example within Migrant Households there were a total of 2,518 persons aged 0 for all bedroom sizes and a total number of 32,846 households which gives a specific age yield per dwelling of 0.08 in this instance. The 3 bedroom dwelling size count of persons aged 0 was 925 whilst the number of households was 8,714 giving rise to a single dwelling yield aged 0 of 0.106 and so forth. As Table 6 displays the data can be further broken down to provide single dwelling yields by age and bed size for Type and Type & Tenure. Aggregation of the Single Year of Age (SYOA) data presented within Table 6 allows for school stage totals to be determined per single dwelling for All Dwellings and by dwelling size for Type and Type & Tenure combined.

Table 5. The "Migrant Households" percentage (%) contribution of households by Type and Tenure to total households for the model and respective total population occupancy rates by bed size.

		Occupancy Ratio by bed size				
	% Contribution	*∑*	*1*	*2*	*3*	*4+*
Units Only	**100.0%**	2.2	1.3	1.9	2.8	3.3
Units and Type						
Houses	**55.6%**	2.6	1.4	2.0	2.8	3.3
Flats	**44.4%**	1.6	1.3	1.8	2.4	2.5
Units and Type & Tenure						
OM Houses	**48.8%**	2.6	1.5	1.9	2.7	3.3
Aff. Houses	**6.8%**	3.0	1.2	2.3	3.8	4.9
OM Flats	**33.5%**	1.6	1.3	1.8	2.3	2.4
Aff. Flats	**10.9%**	1.6	1.2	2.1	3.0	2.9

The yield per dwelling values readily lend themselves for transformation to commonly applied ratios of child yield per 100 dwellings through multiplying the single year of age yield by specific bedroom size to the relevant development composition by bed size. This is discussed in greater detail in Technical Appendix 3. Where a development mix is unknown, such that just the development overall size is known, then the 2011 Migrant Household bed size mix ratios are applied (Units Only). Where the development mix is known, i.e. number of dwellings by bedroom size for all types and/or tenures combined, the specific mix is applied in the calculation process (Units and Type/Units and Type & Tenure). This therefore allows for yields to be calculated specific to the development mix characteristics but also enables the determination of yields wherein the mix is unknown through application of the census ratios. The Census development mix ratios for All Households and Migrant Households are as shown in Tables 2 & 3.

Table 6. The yield per dwelling by Single Year of Age for 3 Bed dwellings for "Migrant Households".

Age (Years)	*Units Only*	*Units and Type*		*Units and Type & Tenure*			
		Houses	***Flats***	***OM Houses***	***Social Houses***	***OM Flats***	***Social Flats***
0	0.106	0.109	0.072	0.101	***0.157***	0.053	***0.155***
1	0.104	0.107	0.070	0.096	***0.178***	0.057	***0.127***
2	0.093	0.094	0.074	0.080	***0.194***	0.049	***0.182***
3	0.085	0.087	0.060	0.072	***0.191***	0.044	***0.127***
4	0.072	0.071	0.077	0.060	***0.149***	0.068	***0.118***
5	0.063	0.065	0.034	0.054	***0.138***	0.027	***0.064***
6	0.053	0.055	0.036	0.044	***0.128***	0.030	***0.064***
7	0.050	0.051	0.038	0.040	***0.126***	0.023	***0.100***
8	0.046	0.047	0.029	0.037	***0.111***	0.021	***0.064***
9	0.045	0.046	0.038	0.038	***0.098***	0.034	***0.055***
10	0.043	0.044	0.026	0.038	***0.087***	0.025	***0.027***
11	0.042	0.043	0.027	0.036	***0.092***	0.019	***0.064***
12	0.039	0.038	0.039	0.032	***0.081***	0.038	***0.045***
13	0.031	0.031	0.026	0.026	***0.067***	0.025	***0.027***
14	0.033	0.033	0.034	0.027	***0.075***	0.025	***0.073***
15	0.025	0.025	0.017	0.021	***0.058***	0.013	***0.036***
16	0.028	0.028	0.026	0.025	***0.052***	0.021	***0.045***
17	0.025	0.026	0.021	0.021	***0.058***	0.017	***0.036***
18	0.022	0.020	0.046	0.017	***0.047***	0.025	***0.136***
19	0.017	0.016	0.033	0.013	***0.034***	0.025	***0.064***

The difference between All Household and Migrant Household yield per 100 dwellings can be investigated on the basis of an example development applied to "Units Only". This applies 1000 dwellings of unknown Type or Type & Tenure, with a 7 year build trajectory and applying the 2011 census Migrant Household bed size mix (1 bed = 25.1% of development total, 2 bed = 35.0%, 3 bed = 26.5% and 4+ bed = 13.3%). Figure 1 displays the observably higher Migrant Household yield per 100

dwellings of the young adult cohorts predominantly from 25 through to 39 years which relates to those cohorts whom are of reproductive age.

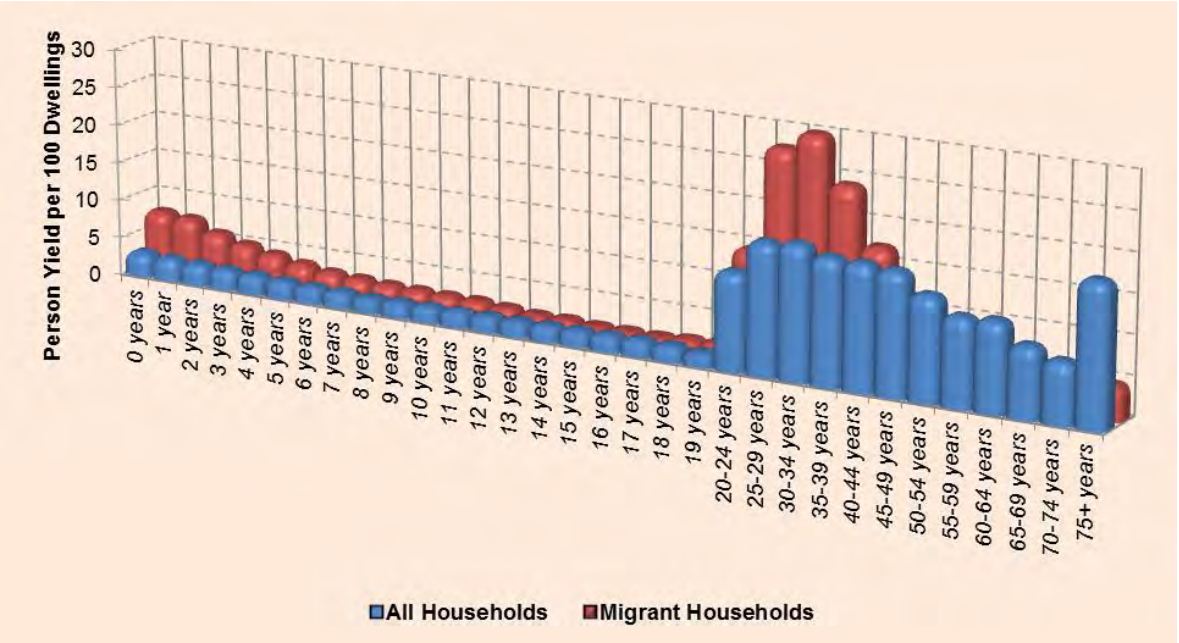


Figure 1. The yield per 100 dwellings for Migrant Households and All Households based on the 2011 census data tables for Hertfordshire in consideration of All Dwellings (Bed size mix reflects that of Migrant Households – Table 2).

It is also of note that the Migrant Household yields are twice those of All Households in the Age 0, 1, 2 and 3 cohorts. Whilst the primary age yields are higher for the Migrant Households this is predominantly in the age 4 to 6 cohorts with a tapering to an equivalent yield of All Households beyond this point. It is therefore observable that it is not necessarily a higher yield in primary age cohorts arising from Migrant Households which determines the yield arising from a new development but the ageing of the early years into the primary sector and beyond. The long term effects would be of particular relevance for a development with an extended trajectory.

Figure 2 displays the difference in yield per 100 dwellings by age between Migrant Households and All Households for the “Units Only” example given above wherein positive values indicate a higher Migrant Household yield. For the specified

development mix it can be observed that the Migrant age 7 to 11 yield is only marginally higher than that of All Households whilst, for the secondary sector, this position is reversed with All Households having a higher yield.

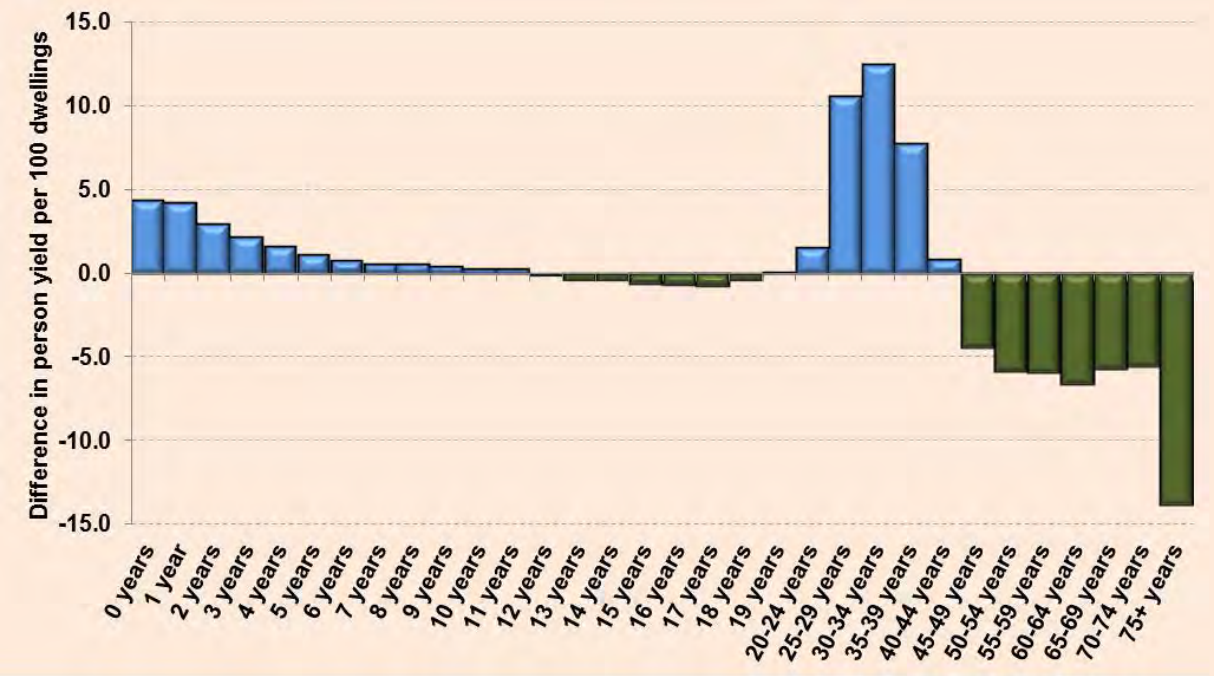


Figure 2. The difference in yield per 100 dwellings between Migrant Households and All Households based on the "Units Only" example (Bed size mix for both reflects that of the 2011 census Migrant Households – Table 2 – Positive values are a higher yield in Migrant Households).

Of particular note however is the observably higher yield per 100 dwellings within the adults aged 20 to 39 years which supports the ONS position that migrant households tend to be dominated by younger adults. This cohort is of reproductive age and applying age specific fertility rates to the number of females would determine a higher number of births than that experienced by the equivalent number of All Households. The higher number of births would be in addition to the greater Age 0 to 4 yields per 100 dwellings already present in Migrant Households which Figure 2 displays supporting the hypothesis that wholly moving households tend to have higher proportions of younger children.

Whilst the differences in these yields per 100 dwellings are observable context can be provided by dividing the Migrant Household yields by the All Households. On this

basis the age 0, 1, 2, 3, 4, 5 and 6 year old Migrant Households yields per 100 dwellings for the specified development mix are 234%, 238%, 203%, 180%, 162%, 147% and 134% higher than that of the All Households respectively. However, it is not just the migrant yields arising immediately from the completed dwellings which have an impact on projected early years and primary child numbers. As a development progresses and dwellings become occupied they will, over time, transition into a yield per 100 dwellings rate that reflects that of All Households i.e. a development over time is expected to reflect the demographic characteristics of Hertfordshire overall.

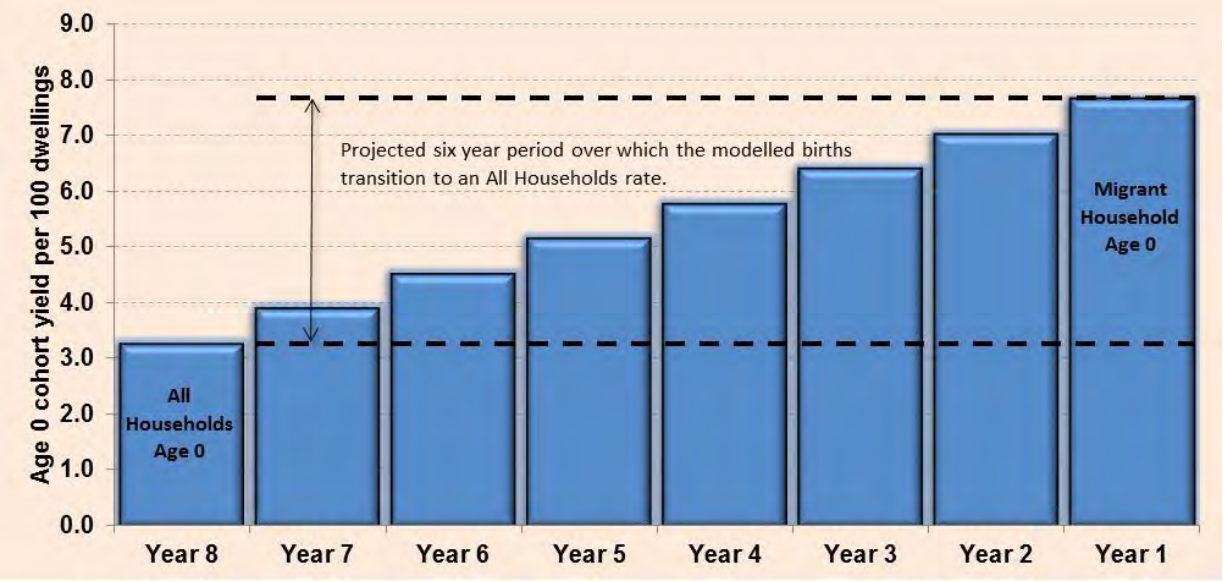


Figure 3. The transition of the Age 0 yield per 100 dwellings from Migrant Households (Year 1) for per annum completed dwellings in a development to that of the All Households yield (Year 8). The data displayed is representative of the "Units Only" example specific development mix.

As such the number of births that arise from a development, which age into early years and beyond, will reduce to that expected of All Households although this is a transitionary period over a number of years within which the births arising for dwellings completed will still exceed that of All Households. For the "Units Only" example the expected age 0 cohorts that will transition into completed dwellings over time is as shown in Figure 3, note that these values are specific to the applied development mix.

It can be observed from the specified development mix that not only is the Age 0 (or effective birth) yield per 100 dwellings twice that of All Households but over a number of years, whilst the development transitions to a yield rate of Hertfordshire overall, that the number of modelled births will be higher. This position is supported by the observably higher per 100 dwelling yields occurring within the reproductive age cohorts (Figure 2). A final observation is with regards to the older adult cohorts aged 45 and above. Figure 2 clearly presents that the yield per 100 dwellings of this cohort is considerably greater in All Households than that of Migrant Households. The dominance of the younger adults aged 20 – 39 years and the relatively lower number of older persons aged 45+ provides Migrant Households a demographic profile which is sufficiently different to the population as a whole that they are often considered as a separate group within projection models.

TECHNICAL APPENDIX 3: HOW THE DEVELOPMENT MODEL OPERATES.

1.0 SINGLE DWELLING YIELDS AND APPLYING THE DEVELOPMENT BED SIZE PERCENTAGE SPLIT

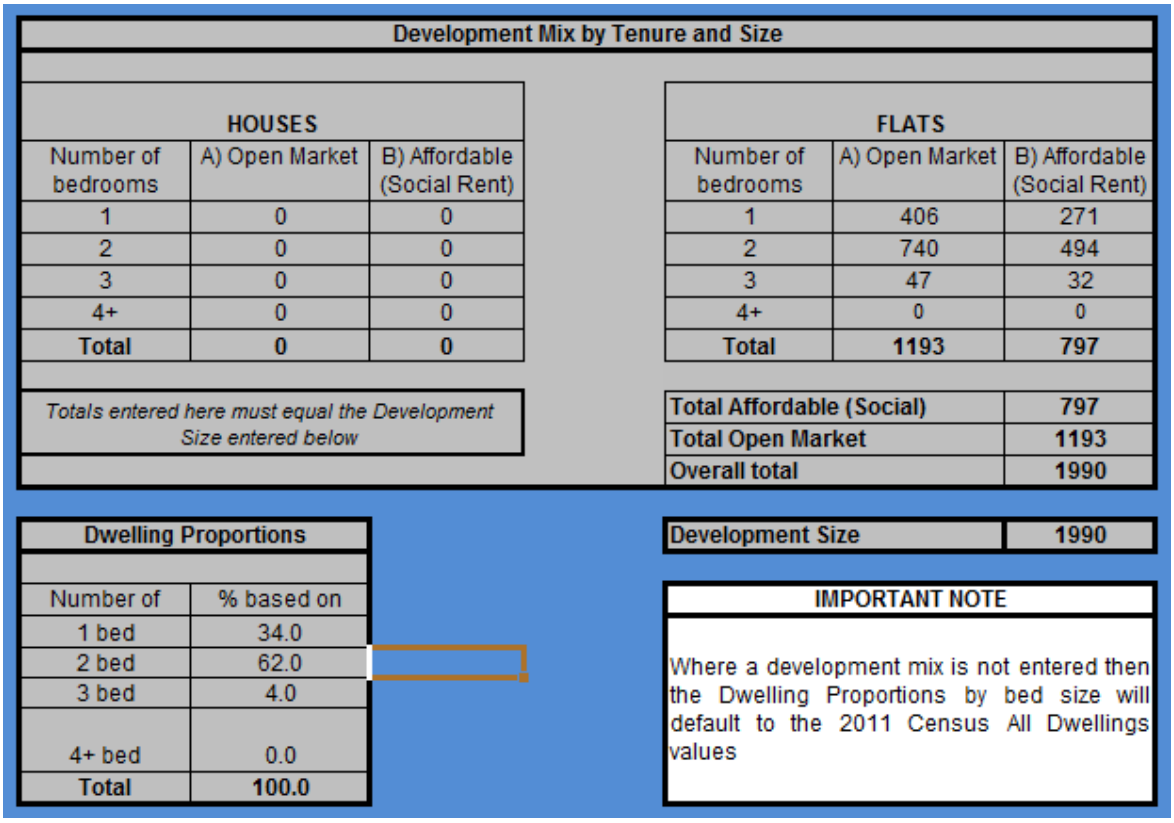
The 2011 census All Households and Migrant Households customised data tables allows for the determination of number of persons and number of households by bed size. This is applicable at all levels of detail for the “Units Only”, “Units and Type” and, the “Units and Type & Tenure” drill downs available in the model. It can be observed that the aggregate number of persons and households at the highest level of detail (Units and Type & Tenure) equals that at the lowest level of detail (Units Only).

Within this context the Units Only level of detail considers all households to be an aggregate count of unspecified dwelling type whilst for Units and Type & Tenure the specific number of houses and flats by tenure is known. Given that the number of dwellings by bed size is known and that the number of persons by bed size is also known then it is possible to calculate yield per dwelling ratio values by bed size for each level of detail. This is applied within the Development model as a number of hidden and protected calculation worksheets relating to All Households and Migrant Households.

The layout and processes of each of the worksheets is identical between All Households and Migrant Households. Each of the worksheets contains a table linked to the Illustrative Mix and represents the number of dwellings by bed size, Type and where applicable Tenure (Figure 1). Where type and tenure is not being considered then the Units Only level of detail will use the Development Size data and apply the census Migrant Household Bed Size Mix in the calculation processes.

Figure 2 displays the next table included within these worksheets which shows the 2011 census number of residents and households relevant to the level of detail specified (i.e. “Units Only”, “Units and Type” and, the “Units and Type & Tenure”).

Within this is displayed the bed size percentage mix used to multiply the single dwelling yield by age and bed size values derived from the census data into a yield per 100 dwelling rates by age. Each of the tables display the “Census Proportion” which represents the underlying census data bed size split and this is applied wherein a development mix by bed size is not specified (Units Only).



Development Mix by Tenure and Size

HOUSES		
Number of bedrooms	A) Open Market	B) Affordable (Social Rent)
1	0	0
2	0	0
3	0	0
4+	0	0
Total	**0**	**0**

FLATS		
Number of bedrooms	A) Open Market	B) Affordable (Social Rent)
1	406	271
2	740	494
3	47	32
4+	0	0
Total	**1193**	**797**

Totals entered here must equal the Development Size entered below

Total Affordable (Social)	**797**
Total Open Market	**1193**
Overall total	**1990**

Dwelling Proportions	
Number of	% based on
1 bed	34.0
2 bed	62.0
3 bed	4.0
4+ bed	0.0
Total	**100.0**

Development Size	**1990**

IMPORTANT NOTE

Where a development mix is not entered then the Dwelling Proportions by bed size will default to the 2011 Census All Dwellings values

Figure 1. The development mix by tenure and size matrix contained within each of the yield by single dwelling worksheets.

The Development Proportion is displayed below the Census Proportion, where bed size data is entered into the models then the development mix will be applied rather than the census proportions. Detailed population data by age and bed size is presented from the relevant underlying census base data tables and is specific to the particular level of detail being applied (Figure 3).

AREA	Hertfordshire

Known Development Total Size with Census Proportional Mix or Development Proportional Mix, by bedroom size, No Type or Tenure Split.

ONS Customised Tables Census 2011 - CTO173 and CTO174

2011 Census Geographic level = Hertfordshire and Districts

All Tenures	BEDROOMS	1	2	3	4+	Check
Residents	1,097,683	74,947	220,330	473,749	328,657	OK
Households	451,608	55,571	111,715	181,086	103,236	OK
% household mix relative to all households		12.3%	24.7%	40.1%	22.9%	

TOTALS	Bedrooms	*1*	*2*	*3*	*4+*
	Census Proportion	12.3	24.7	40.1	22.9
	Development Proportion	34.0	62.0	4.0	0.0

Figure 2. 2011 Census number of resident and households with the census or development proportions applied in the calculations displayed.

	All	1 Bed	2 Bed	3 Bed	4+ Bed	
Total Persons	1,097,683	74,947	220,330	473,749	328,657	OK

	SYOA	Persons	Persons by number of bedrooms				Check
A	0 years	15,047	986	4,963	6,189	2,909	OK
	1 year	14,878	684	4,499	6,488	3,207	OK
	2 years	14,778	447	4,003	6,599	3,729	OK
	3 years	14,693	364	3,501	6,746	4,082	OK
B	4 years	14,408	291	3,026	6,718	4,373	OK
	5 years	13,847	207	2,603	6,638	4,399	OK
	6 years	13,306	184	2,222	6,334	4,566	OK
	7 years	13,456	144	1,915	6,423	4,974	OK
	8 years	12,552	129	1,619	5,942	4,862	OK
	9 years	13,040	134	1,641	6,163	5,102	OK
	10 years	13,219	119	1,597	6,103	5,400	OK
C	11 years	13,470	125	1,420	6,187	5,738	OK
	12 years	13,767	119	1,357	6,419	5,872	OK
	13 years	13,718	96	1,294	6,390	5,938	OK
	14 years	13,970	97	1,278	6,560	6,035	OK
	15 years	13,993	113	1,310	6,416	6,154	OK
D	16 years	14,214	116	1,265	6,540	6,293	OK
	17 years	14,249	177	1,292	6,495	6,285	OK

Figure 3. The 2011 Census population data used within the model sheets to calculate single dwelling yield values by bed size and age.

The specific number of households by bed size data shown in Figure 2 is applied to the detailed bed size population by age data displayed in Figure 3 in order to determine single dwelling yield values by age and bed size (Figure 4). The single dwelling yields arise from the underlying census data relative to “Units Only”, “Units and Type” and, the “Units and Type & Tenure” and are not as yet adjusted to take account of the development bed size mix.

		All	1 Bed	2 Bed	3 Bed	4+ Bed
	SYOA	All	Child Yield per dwelling by SYOA			
A	0 years	0.03	0.018	0.044	0.034	0.028
	1 year	0.03	0.012	0.040	0.036	0.031
	2 years	0.03	0.008	0.036	0.036	0.036
	3 years	0.03	0.007	0.031	0.037	0.040
B	4 years	0.03	0.005	0.027	0.037	0.042
	5 years	0.03	0.004	0.023	0.037	0.043
	6 years	0.03	0.003	0.020	0.035	0.044
	7 years	0.03	0.003	0.017	0.035	0.048
	8 years	0.03	0.002	0.014	0.033	0.047
	9 years	0.03	0.002	0.015	0.034	0.049
	10 years	0.03	0.002	0.014	0.034	0.052
C	11 years	0.03	0.002	0.013	0.034	0.056
	12 years	0.03	0.002	0.012	0.035	0.057
	13 years	0.03	0.002	0.012	0.035	0.058
	14 years	0.03	0.002	0.011	0.036	0.058
	15 years	0.03	0.002	0.012	0.035	0.060
D	16 years	0.03	0.002	0.011	0.036	0.061
	17 years	0.03	0.003	0.012	0.036	0.061

Figure 4. Age and Bed size specific single dwelling yield values calculated within the relevant “Units Only”, “Units and Type” and, the “Units and Type & Tenure” underlying data sheets for All Households and Migrant Households.

1.1 CALCULATING THE YIELD PER 100 DWELLINGS BASED ON THE PERCENTAGE REPRESENTATION BY BED SIZE

The single dwelling yields are calculated by dividing the total number of persons of a particular age within a particular bed size household by the total number of households of that bed size. It therefore follows that if one were to multiply the single

dwelling yield, by age, for a particular bed size by the total number of households of that bed size then it would realise the census total number of people of that age and vice versa with households. An alternative way of expressing this is as a percentage value given that the total number of households is known and the breakdown by bed size is also known.

For example consider the “Migrant Households” census data for Units Only (i.e. no Type or Tenure level of detail). The total number of households was 32,846 of which 8254, 11497, 8714 and 4381 were 1, 2, 3 and 4+ bedroom dwellings respectively. It therefore follows that the percentage representation of these bed sizes was 25.1% for 1 bed, 35.0% for 2 bed, 26.5% for 3 bed and, 13.3% for 4+ bed. The migrant population by age and bed size as determined from the census, in the case of Units Only, was therefore resident in this bed size proportionate mix. This is intrinsically linked to the single dwelling yield values by age and bed size due to the inter-relationship of these parameters. If one were to multiply a particular age yield per dwelling value for a particular bed size by the proportional representation of that bed size household relative to all households then it would derive the total number of persons of that age in that bed size as at the census date.

Considering again the Units Only level of data, although this equally applies to Type and Tenure by bed size, the Age 0 yield per dwelling by bed size is as shown in Table 1 as *(A)*. The percentage representation of the total number of households of each bed size relative to the total households is given as *(B)*. Multiplying these figures together gives a yield per dwelling taking into account the percentage representation of the households relative to the total households *(C).* Multiplying these figures by one hundred gives an Age 0 yield per 100 dwellings *(D)* by bed size taking into account the proportionate bed size mix. The summation of these values by bed size gives an overall Age 0 yield per 100 dwellings which takes into account the percentage representation of the bed size mix. Based on the data in Table 1 the Migrant Household yield per 100 dwellings for Units Only (no Type nor Tenure distinction) for Age 0 children would therefore be (0.669 + 2.746 + 2.813 + 1.430) 7.66 children.

Table 1. The application of the bed size percentage mix in order to calculate a yield per 100 dwellings specific to a development or the census. Data shown is for "Migrant Households" and the Units Only (no Type or Tenure distinction) Age 0 cohort.

	1 Bed	2 Bed	3 Bed	4+ Bed
(A) Yield per Dwelling	0.027	0.078	0.106	0.108
(B) Household % Mix	25.1%	35.0%	26.5%	13.3%
(C) A x B	0.007	0.027	0.028	0.014
(D) Yield per 100 dwellings (C x 100)	0.669	2.746	2.813	1.430

Within the model worksheets, as discussed later, the summary yields by age are multiplied by each year dwelling completions to determine the overall yield which will arise. The number of completions by bed size each year is unlikely to be known and therefore taking into account the bed size proportional representation in the yield calculations themselves accounts for this element. The yield per 100 dwellings by bed size taking into account the percentage bed size mix can be reverse calculated to check that the number of children matches that observed from the census. This can be done simply using the following equation:

$$\left(Bed\ size\ yield\ per\ 100\ dwellings\ \times \left[\frac{Total\ No: Households}{100}\right]\right)$$

Applying this derives 220, 902, 924 and 470 Age 0 children resulting from the development proportional mix which matches that observed from the census (with the exception of minor rounding errors). An alternative way of expressing the yield per 100 dwellings with respect to the development proportionate bed size mix is displayed in Table 2 for the Age 0 cohort in the Units Only level of detail. The starting point in this instance is the number of households by bed size *(A)* from which the ratio value for a 100 households is determined *(B)*. The total household 100 dwelling ratio value (328.46) is divided by the respective bed size ratio to determine a 1 household ratio *(C)* which is in effect the same as the household percentage mix.

The single dwelling yield for Age 0 children by bed size *(D)* multiplied by the 1 household ratio *(C)* determines the dwelling yield *(E)* by bed size. The per dwelling yield multiplied by 100 calculates the Age 0 yield per 100 dwellings which matches that calculated within Table 1 (minor differences due to rounding in applied data).

Table 2. The application of the 100 household ratio in order to calculate a yield specific to a development, or census, bed size mix. Data shown is for "Migrant Households" and the "Units Only" Age 0 cohort.

	1 Bed	***2 Bed***	***3 Bed***	***4+ Bed***	***Total***
(A) All Dwellings	8254	11497	8714	4381	32846
(B) 100 household ratio (A/100)	82.54	114.97	87.14	43.81	328.46
(C) 1 household ratio	0.251	0.350	0.265	0.133	N/A
(D) Single dwelling yield	0.027	0.078	0.106	0.108	N/A
(E) per dwelling yield (C x D)	0.007	0.027	0.028	0.014	0.08
(F) per 100 dwelling yield (E x 100)	0.670	2.746	2.816	1.434	**7.67**

It can therefore be observed that there is no difference in applying the percentage bed size mix as opposed to using the single dwelling yield multiplied by the representation of that bed size (by Type and Tenure where relevant) within the development and transforming to a per 100 dwellings figure. Both methods take into account the number of households by bed size relative to the total number of households. The proportionate bed size mix must always be taken into consideration as it enables the calculation of the bed size aggregate person yield per 100 dwellings required for the different levels of detail within the model. The percentage bed size mix values as observed from the census for "Migrant Households" for "Units Only", "Units and Type" and, the "Units and Type & Tenure" are displayed in Technical Appendix 2 - Table 3.

The proportionate representation by bed size for the respective level of detail is applied to the single dwelling yields within the worksheets to determine the age and bed size yield per 100 dwellings (Figure 5). The area circled in Figure 5 represents the age and aggregate yield per 100 dwellings taking into account the development percentage bed size mix. These figures are linked through to the model worksheets for both All Households and Migrant Households for the relevant “Units Only”, “Units and Type” and, the “Units and Type & Tenure” modelling.

		All	1 Bed	2 Bed	3 Bed	4+ Bed
	SYOA	All	Yield per 100 dwellings based on development percentage by bed size			
A	0 years	3.5	0.60	2.75	0.14	0.00
	1 year	3.1	0.42	2.50	0.14	0.00
	2 years	2.6	0.27	2.22	0.14	0.00
	3 years	2.3	0.22	1.94	0.15	0.00
B	4 years	2.0	0.18	1.68	0.15	0.00
	5 years	1.7	0.13	1.44	0.15	0.00
	6 years	1.5	0.11	1.23	0.14	0.00
	7 years	1.3	0.09	1.06	0.14	0.00
	8 years	1.1	0.08	0.90	0.13	0.00
	9 years	1.1	0.08	0.91	0.14	0.00
	10 years	1.1	0.07	0.89	0.13	0.00
C	11 years	1.0	0.08	0.79	0.14	0.00
	12 years	1.0	0.07	0.75	0.14	0.00
	13 years	0.9	0.06	0.72	0.14	0.00
	14 years	0.9	0.06	0.71	0.14	0.00
	15 years	0.9	0.07	0.73	0.14	0.00
D	16 years	0.9	0.07	0.70	0.14	0.00
	17 years	1.0	0.11	0.72	0.14	0.00
	18 years	1.0	0.17	0.72	0.13	0.00
	19 years	1.1	0.28	0.76	0.10	0.00
	20-24 years	11.0	3.44	7.03	0.51	0.00

Figure 5. The single dwelling yields multiplied by the development bed size representation determines the age and bed size specific yield per 100 dwellings applied in the model sheets.

It is important to note that the method by which the percentage bed sizes are calculated differs between the levels of detail. For “Units Only” the development percentage bed size representation is determined by the number of dwellings by size divided by the total dwellings in the development. For “Units and Type” the percentage representation of houses is calculated as the number of houses of a

particular bed size divided by the total number of houses only. The percentage representation of flats is similarly determined by dividing the number of flats by bed size with the total number of flats only. A similar principle is applied within the “Units and Type & Tenure” wherein the percentage representation of Open Market Houses is determined by the number of Open Market Houses by particular bed size divided by the total number of Open Market Houses and so forth. This may appear contrary to expectations given that “Units Only” applies the total number of dwellings however a detailed explanation for this is given in Technical Appendix 2.

TECHNICAL APPENDIX 4: THE MODEL WORKSHEETS

The model worksheets represent the most complex part of the process in projecting population and contain the detailed calculation functions. Whilst the physical model is the intellectual property of HCC, the methodology that has been adopted to create these worksheets is explained in detail below. The model contains seven principle calculation sheets which incorporate elements from the relevant All Households, Migrant Households and Illustrative Mix sections, as discussed in Technical Appendix 3, to predict the likely population arising from a proposed development mix.

1.0 OVERVIEW OF THE MODEL WORKSHEETS

As can be observed from Figure 1 there are four principle matrices to each of the model sheets, these are:

- Population Age Distribution per 100 Dwellings (top right of Figure 1 – cells highlighted in brown)
- Unborn child yield per 100 dwellings (top left of Figure 1 – cells highlighted in yellow)
- Timescale for development completion (middle table of Figure 1)
- Population by age yielded from the proposed development (large table at the bottom of Figure 1)

In addition to each of these matrices there is a separate summary table which summarises the population counts by single year of age to service specified aggregate groups, this is discussed later in the Technical Appendix.

1.1 THE POPULATION AGE DISTRIBUTION AND UNBORN CHILD YIELD PER 100 DWELLINGS

The population age distribution by single year of age is automatically completed from the age specific bed size aggregate yield per 100 dwellings information arising from the development mix as determined with respect to Migrant Households (Technical

Appendix 3). This represents the anticipated population yield that is likely to arise per 100 dwellings from the development based on the proportionate bed size mix. Each of the model sheets links to the specific tables with respect to Units Only, Units and Type, Units and Type & Tenure.

SITE NAME:	
APPLICATION REF:	

Adapted from data from the Office for National Statistics licensed under the Open Government Licence v.1.0.

(A)	Unborn child yield (per 100 dwellings)							AGE DISTRIBUTION - CHILDREN PER 100 DWELLINGS (SOU																
AGE	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
YIELD	3.41	3.58	3.76	3.94	4.12	4.29	4.47	4.65	3.36	2.46	1.62	1.56	1.14	0.99	0.75	0.82	0.73	0.68	0.69	0.75	0.43	0.56	0.54	0.53	0.55	1.03

(B)	TIMESCALES FOR DEVELOPMENT (YEARS), COMPLETIONS PER ANNUM AND RUNNING TOTALS																							
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL
Completions per annum	51	51	51	51	51	51	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	335
Running Total	51	102	153	204	255	306	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335

(C)		Number of children by age yielded from proposed development																						
Dwellings	Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44
51	2010	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	9	18	13	8	5
51	2011	5	4	3	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17	34	26	17	11
51	2012	7	6	5	4	3	2	2	1	1	1	1	1	1	1	1	1	1	1	1	2	24	49	43	28	17
51	2013	9	9	8	6	5	3	3	2	2	2	2	1	1	1	1	1	1	1	1	2	29	62	57	39	25
51	2014	11	11	10	8	7	5	4	3	3	2	2	2	2	2	2	2	1	1	2	2	34	73	72	51	33
51	2015	13	13	12	11	9	8	6	4	4	3	3	2	2	2	2	2	2	2	2	2	38	83	85	63	41
29	2016	14	14	13	12	11	10	8	6	5	4	3	3	3	2	2	2	2	2	2	2	38	85	93	72	49
0	2017	13	14	14	13	12	11	10	8	6	5	4	3	3	3	2	2	2	2	2	2	33	75	91	76	53
0	2018	13	13	14	14	13	12	11	10	8	6	5	4	3	3	3	2	2	2	2	2	28	67	88	79	58
0	2019	12	13	13	14	14	13	12	11	10	8	6	5	4	3	3	3	2	2	2	2	25	59	84	81	62
0	2020	12	12	13	13	14	14	13	12	11	10	8	6	5	4	3	3	3	2	2	2	22	52	79	81	66
0	2021	12	12	12	13	13	14	14	13	12	11	10	8	6	5	4	3	3	3	2	2	19	46	73	81	69
0	2022	11	12	12	12	13	13	14	14	13	12	11	10	8	6	5	4	3	3	3	2	18	41	68	79	71
0	2023	11	11	12	12	12	13	13	14	14	13	12	11	10	8	6	5	4	3	3	3	17	36	63	77	73
0	2024	11	11	11	12	12	12	13	13	14	14	13	12	11	10	8	6	5	4	3	3	16	32	57	74	74
0	2025	11	9	11	11	12	12	12	12	13	13	14	14	13	12	11	10	8	6	5	4	16	29	52	71	74
0	2026	11	9	9	11	11	12	12	12	13	13	14	14	13	12	11	10	8	6	5	4	16	26	48	67	73
0	2027	11	9	7	9	11	11	12	12	12	13	13	14	14	13	12	11	10	8	6	5	16	24	43	63	72
0	2028	11	9	7	7	9	11	11	12	12	12	13	13	14	14	13	12	11	10	8	6	18	23	39	59	70
0	2029	11	9	7	6	7	9	11	11	12	12	12	13	13	14	14	13	12	11	10	8	20	22	36	55	68
0	2030	11	9	7	6	6	7	9	11	11	12	12	12	13	13	14	14	13	12	11	10	24	21	33	51	66
0	2031	11	9	7	6	5	6	7	9	11	11	12	12	12	13	13	14	14	13	12	11	29	22	31	48	63
0	2032	11	9	7	6	5	5	6	7	9	11	11	12	12	12	13	13	14	14	13	12	34	23	29	44	60
0	2033	11	9	7	6	5	4	5	6	7	9	11	11	12	12	12	13	13	14	14	13	40	25	28	41	57
0	2034	11	9	7	6	5	4	4	5	6	7	9	11	11	12	12	12	13	13	14	14	45	28	27	39	54
0	2035	11	9	7	6	5	4	3	4	5	6	7	9	11	11	12	12	12	13	13	14	50	32	27	36	51
0	2036	11	9	7	6	5	4	3	3	4	5	6	7	9	11	11	12	12	12	13	13	54	35	28	35	48
0	2037	11	9	7	6	5	4	3	2	3	4	5	6	7	9	11	11	12	12	12	13	56	39	30	33	45
0	2038	11	9	7	6	5	4	3	2	2	3	4	5	6	7	9	11	11	12	12	12	57	42	32	33	43
0	2039	11	9	7	6	5	4	3	2	2	2	3	4	5	6	7	9	11	11	12	12	58	45	34	32	41
0	2040	11	9	7	6	5	4	3	2	2	2	2	3	4	5	6	7	9	11	11	12	58	48	36	33	39
335	LTA	11	9	7	6	5	4	3	2	2	2	2	2	2	2	2	2	2	2	3	4	50	100	88	56	39

Figure 1. The principle calculation matrices within the model worksheets.

The unborn child yield per 100 dwellings table (specified as cells -7 to -1 years) is used to calculate the Age 0 yield per 100 dwellings once the first year of development is completed, this Age 0 yield is in addition to the Age 0 yield arising from the number of developments to be completed in Year 2, and each year thereafter, for which the Age 0 yield rate from the Child Age Distribution table is applied. The model assumes that once the initial year of dwellings is completed that seven years after this point Age 0 yield will be equivalent to that arising from All Households. As such the yield per 100 dwellings in the -7 column is derived from the All Households single year of age yield per 100 dwellings relative to the development

proportional mix. The values within the -1 through to the -6 cells represent the incremental decrease in yield rate per 100 dwellings for Age 0 children from the initial higher Migrant Household yield to that experienced within All Households once the dwellings have aged 7 years. As this represents the difference in Age 0 yield minus the -7 yield with the result divided by the number of steps then the incremental decrease will always be uniform in size year on year.

It is perhaps easier to understand the Age 0 calculation process using an example. Consider that in Year 1 of a development there were 220 dwellings built, the anticipated Age 0 yield is calculated by multiplying the number of dwellings completed by the Age 0 yield per 100 dwellings arising from the Child Age Distribution table. If the Age 0 yield is 6.8 per 100 dwellings then the Age 0 yield in Year 1 in effect becomes (220/100) x 6.8 = 15 children. In Year 2 there were 390 dwellings built which becomes (390/100) x 6.8 = 26 Age 0 children. However, there is also an Age 0 yield arising from the 220 developments completed in the previous year for which the -1 year cell becomes the multiplier per 100 dwellings.

The multiplier for years -1 to -6 is the stepped difference between -7 and Age 0 which are the All Households and Migrant Household Age 0 yields per 100 dwellings determined from the relevant bed size proportionate mix. For the example presented herein it is assumed that -1 = 6.27, -2 = 5.75 and, -3 = 5.23 per 100 dwellings. The Age 0 yield for the dwelling already completed in the first year of the development is therefore calculated as (220/100) x 6.27 (the unborn yield rate for -1 as the Age 0 yield for already completed developments decreases over time to the All Households rate at -7) = 14 children. The total Age 0 children yielded within Year 2 would therefore be 40 children.

In Year 3 there were 580 dwellings completed which becomes (580/100) x 6.8 = 40 Age 0 children. However there is also the Age 0 yield from the previous two years of dwelling completion to add. The Age 0 yield arising from the previous year's completions would be [(390/100) x 6.27 (-1 unborn yield) = 24 Age 0 children] + [(220/100) x 5.75 (-2 unborn yield) = 13 Age 0 children]. The total Age 0 cohort therefore becomes 40 + 24 + 13 = 77. In Year 4 there were 540 dwelling completions which becomes (540/100) x 6.8 = 37 Age 0 children. Added to this are the Age 0

yields from the three previous years dwelling completions which are [(580/100) x 6.27 (-1 unborn yield) = 36] + [(390/100) x 5.75 (-2 unborn yield) = 22] + [(220/100) x 5.23 (-3 unborn yield) = 12]. The total Age 0 yield in year 4 would therefore be 107 children.

The Age 0 calculation process continues in this manner year on year although once the development is completed there will be no migrant Age 0 component adding to the total yield within this band. In this instance the Age 0 cohort will arise solely from the dwellings completed in previous years until the development is 7 years past the overall year of completion at which point the Age 0 contribution arises solely from the total number of dwellings built overall multiplied by the All Household yield rate (-7 unborn children data). As such seven years after development completion the number of children born year on year will be uniform.

1.2 TIMESCALES FOR DEVELOPMENT COMPLETION

The number of dwelling completions each year entered into the Trajectory worksheet automatically appears within the Timescales for Development table in the model sheets. The “Running Total” row within this table is an annual summation of the build total across the trajectory. The Total column sums each row of data respectively and conditional formatting checks the row totals against one another, where there is discrepancy then the cell background will flag as red indicating to the user that an error has occurred. The number of dwelling completions each year is used to directly calculate the number of persons in conjunction with the yield per 100 dwelling rates.

1.3 POPULATION BY AGE YIELDED FROM THE PROPOSED DEVELOPMENT

The main yield for the development trajectory is based on a matrix which calculates by year of dwelling completions the population likely to arise (Figure 2). Dwelling completions information entered into the “Trajectory” worksheet automatically populates the “Dwellings” column of the matrix, the development start date links as

the first date within the Year column, subsequent years are simple “plus one” functions from the initial date.

Dwellings	Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
67	2016	4	3	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1
67	2017	7	7	5	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1	2	3
67	2018	10	10	9	6	4	3	3	2	2	2	1	1	1	1	1	1	1	1	2	3
67	2019	14	13	12	10	7	5	4	3	3	2	2	2	2	2	2	2	2	2	2	3
67	2020	16	17	15	13	11	8	6	5	4	3	3	2	2	2	2	2	2	2	3	4
67	2021	19	19	18	17	15	12	9	7	5	4	4	3	3	3	3	2	2	2	3	4
42	2022	**20**	**21**	21	19	17	15	12	9	7	5	5	4	4	3	3	3	3	3	3	4
0	2023	19	20	**21**	21	19	17	15	12	9	7	5	5	4	4	3	3	3	3	3	3
0	2024	18	19	20	**21**	21	19	17	15	12	9	7	5	5	4	4	3	3	3	3	3
0	2025	17	18	19	20	**21**	21	19	17	15	12	9	7	5	5	4	4	3	3	3	3
0	2026	17	17	18	19	20	**21**	21	19	17	15	12	9	7	5	5	4	4	3	3	3
0	2027	16	17	17	18	19	20	**21**	21	19	17	15	12	9	7	5	5	4	4	3	3
0	2028	16	16	17	17	18	19	20	**21**	21	19	17	15	12	9	7	5	5	4	4	3
0	2029	16	16	16	17	17	18	19	20	**21**	21	19	17	15	12	9	7	5	5	4	4
0	2030	16	16	16	16	17	17	18	19	20	**21**	21	19	17	15	12	9	7	5	5	4
0	2031	16	14	16	16	16	17	17	18	19	20	**21**	21	19	17	15	12	9	7	5	5
0	2032	16	14	14	16	16	16	17	17	18	19	20	**21**	21	19	17	15	12	9	7	5
0	2033	16	14	12	14	16	16	16	17	17	18	19	20	**21**	21	19	17	15	12	9	7
0	2034	16	14	12	12	14	16	16	16	17	17	18	19	20	**21**	21	19	17	15	12	9
0	2035	16	14	12	10	12	14	16	16	16	17	17	18	19	20	**21**	21	19	17	15	12
0	2036	16	14	12	10	10	12	14	16	16	16	17	17	18	19	20	**21**	21	19	17	15
0	2037	16	14	12	10	8	10	12	14	16	16	16	17	17	18	19	20	**21**	21	19	17
0	2038	16	14	12	10	8	8	10	12	14	16	16	16	17	17	18	19	20	**21**	21	19
0	2039	16	14	12	10	8	6	8	10	12	14	16	16	16	17	17	18	19	20	**21**	21
0	2040	16	14	12	10	8	6	6	8	10	12	14	16	16	16	17	17	18	19	20	**21**
0	2041	16	14	12	10	8	6	6	6	8	10	12	14	16	16	16	17	17	18	19	20
0	2042	16	14	12	10	8	6	6	6	6	8	10	12	14	16	16	16	17	17	18	19
0	2043	16	14	12	10	8	6	6	4	6	6	8	10	12	14	16	16	16	17	17	18
0	2044	16	14	12	10	8	6	6	4	4	6	6	8	10	12	14	16	16	16	17	17
0	2045	16	14	12	10	8	6	6	4	4	4	6	6	8	10	12	14	16	16	16	17
0	2046	16	14	12	10	8	6	6	4	4	4	4	6	6	8	10	12	14	16	16	16
444	**LTA**	**16**	**14**	**12**	**10**	**8**	**6**	**6**	**4**	**4**	**4**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**6**

Figure 2. The matrix for calculating population yield arising from a proposed development.

The calculation process for determining the Age 0 children arising from the proposed development with each progressive year is as explained in Section 1.1 above. The yields arising from the first year of dwelling completions are the simplest calculations within the matrix. They are based on the dwellings completed in the first year divided by 100 and multiplied by the relevant age yield per 100 dwellings for migrant households as shown in Figure 1. The cell backgrounds for population yields within the initial year of the build programme are highlighted a different colour to delineate the fact that their calculation functions are different from other cells. For the second year of dwelling completions the yield for Age 0 children is as described previously. The Age 1 second year yield is calculated as the number of dwellings completed in Year 2 multiplied by the Age 1 migrant household yield per 100 dwellings and adding the roll forward Age 0 children from Year 1, this functionality therefore extends diagonally across the matrix for all years and person ages. It should be noted that

people occurring within previous years of dwellings completions are assumed to not migrate in a similar manner to the application of cohort survival modelling. Where a household did leave a development then it would be replaced by persons typified by the same demographic characteristics of wholly moving households (Technical Appendix 2).

Highlighted numbers which appear as bold within each column represent the maximum or peak number of that age to facilitate determining in which year of development they occur. This is a conditional format set on the basis of each individual cell value versus the age column peak value as shown at the base of the matrix (in turn a simple “Max” function). The row of data appearing in Year 8 of a development has a different cell colour to delineate a change in formula within the Age 0 calculations.

The change in function at Year 8 reflects the fact that those dwellings completed in Year 1 have an Age 0 yield dependent on the -7 unborn child yield (Figure 1) arising from the single year of age average yield of All Households dependent on the development proportional mix. Therefore at this point a sum function is incorporated within the equation so that further years of Age 0 calculations will incorporate the All Households (-7 unborn) average yield for all dwellings completed in the 7th year plus prior to the current year of dwelling completions.

Following this point a functional statement has been introduced to the equations for which the purpose is to compare the single year of age yield arising from the development to the expected Long Term Average value. Should the yield from the development be larger than that from the LTA then the development yield value is returned. If the Long Term Average value is higher than the calculated development yield then the LTA is returned. The single year of age LTA values are as shown at the bottom of the matrix and are derived from the All Households single year of age yield for the development proportional bed size mix. These yield values are then multiplied by the total number of dwellings built in the development divided by 100 (the yield rates are per 100 dwellings) to derive the long term average number of children expected for each year of age. It is important to emphasise that the functional statement is not an artificial raising of the child yield post development but

rather an algorithm to smooth the transition from peak value to the expected long term average.

The final point to make is with regards to the calculation of total population especially with consideration of the cohort age 75+. As a development progresses then the oldest cohorts will age and, in real life, would be subject to higher mortality rates than the general population. The age 75+ cohort would include persons significantly older than this whom would not be expected to survive over a thirty year projection horizon and as such they must be removed. This would prevent artificial inflation of the total cohort number arising from the proposed development which would otherwise impact on the financial contributions sought for library, waste and other sectors. Whilst various methods were trialled to reduce the cohort size the simplest method was determined by applying a 0.8 multiplier to the group. This reduces the percentage representation of the initial Age 75+ cohort following year 1 of development inception, and as it ages over time, by that shown in Figure 3. It can be observed that the initial cohort is represented at 100% in Year 1, reducing to only 10% surviving by Year 10 and 1% by Year 20.

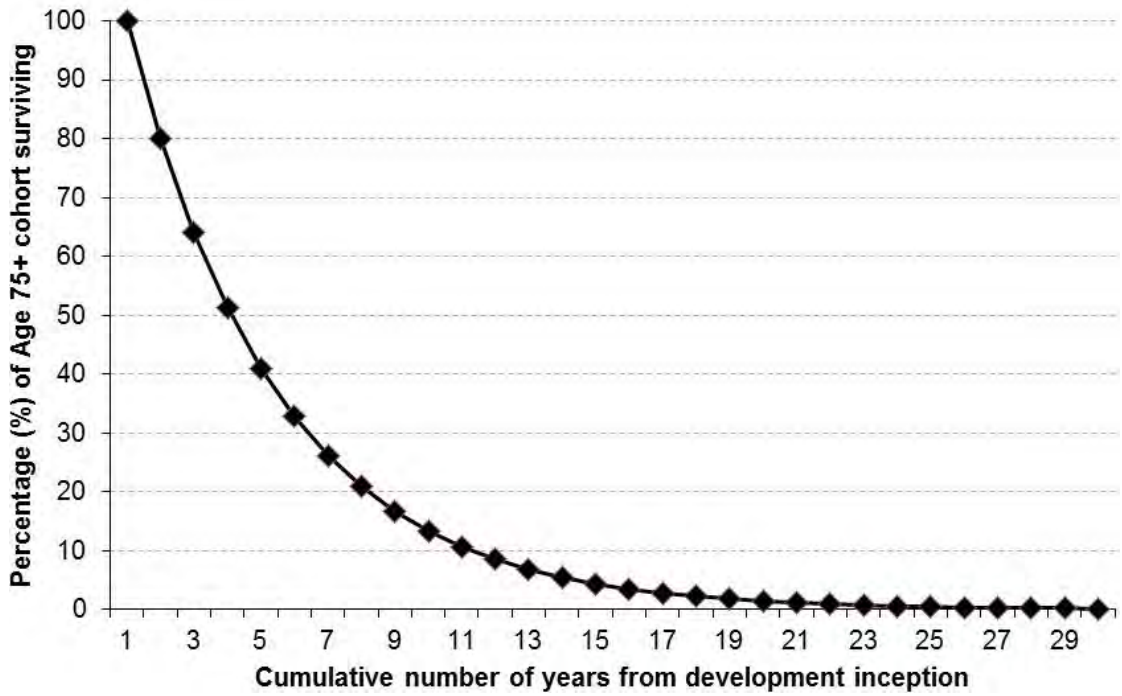


Figure 3. The percentage (%) survival rate, over a thirty year projection period, of the initial Age 75+ cohort arising from a proposed development.

1.4 THE SUMMARY POPULATION YIELDED FROM THE PROPOSED DEVELOPMENT

The final table within the model worksheets is an aggregation of age groups to those specified by, and required for, service delivery (Figure 4). The summary table displays the year on year variation in sector yield resulting from the proposed development as the trajectory progresses. Pre-school age children are determined from the sum of those aged 0 to <4, Primary are those aged 4 to <11, secondary those aged 11 to <18 years and so forth for the requested population age groups. The secondary yield takes account of the Post-16 stay on rate entered to the Illustrative Mix. Conditional formatting has been set within the summary numbers table to highlight in the cell background where the sector peak values occur. The peak values are determined within a separate table beneath the summary numbers table and are derived using a simple “Max” formula related to the summary table array.

(D) *Number of Persons Yielded from the Development*

Nursery/Child Care					0 to <4	5 to <14	13 to 19	Primary (4 to	11 to 17	First (4 to	Middle (9 to	to 17			Total
0 Years	1 Year	2 Year	3 Year	4 Year	years	years	years	<11 years)	Years	<9 Years)	<13 Years)	years)	Age 55+	Age 65+	Population*
12	11	7	5	4	36	19	14	18	10	15	7	7	43	23	345
24	23	18	12	9	77	40	25	40	20	33	14	13	87	46	700
35	35	30	23	17	123	66	36	67	31	55	22	20	131	68	1063
45	46	42	36	27	168	96	46	103	42	86	31	28	177	91	1435
54	56	53	47	40	209	136	57	149	54	126	42	35	223	115	1814
62	65	63	58	51	248	186	69	204	68	173	54	44	272	139	2201
70	73	72	68	62	283	246	81	266	83	226	70	53	323	163	2593
77	81	80	77	72	316	315	95	334	101	281	90	63	375	189	2991
84	88	88	86	81	346	390	111	406	122	335	117	75	431	215	3394
91	95	95	93	90	374	471	129	479	149	385	153	89	489	243	3803
86	91	95	95	93	367	538	138	531	174	417	188	100	507	248	3871
81	86	91	95	95	353	605	153	574	209	442	226	115	528	255	3936
77	81	86	91	95	335	668	179	607	252	458	263	138	552	263	3997
74	77	81	86	91	318	721	214	627	301	464	296	169	579	273	4056
72	74	77	81	86	304	760	258	635	356	460	324	207	609	284	4111
70	72	74	77	81	293	784	308	631	411	448	346	248	642	296	4166
70	70	72	74	77	286	794	364	618	466	430	363	291	678	310	4219
70	70	70	72	74	281	793	422	599	515	409	373	332	717	325	4271
70	61	70	70	72	270	782	479	576	555	390	374	367	758	341	4314
70	61	61	70	70	261	764	531	551	586	375	367	396	801	359	4357
70	61	53	61	70	244	741	574	530	605	363	353	419	846	378	4390
70	61	53	53	61	235	716	607	505	610	347	335	434	893	399	4423
70	61	53	46	53	229	682	627	476	605	325	318	439	941	421	4448
70	61	53	46	46	229	643	635	445	592	299	304	434	990	445	4473
70	61	53	46	40	229	604	631	411	572	269	293	421	1039	470	4490
70	61	53	46	40	229	562	618	379	550	239	286	404	1088	497	4505
70	61	53	46	40	229	519	599	343	526	213	273	384	1136	525	4514
70	61	53	46	40	229	479	576	308	506	194	253	367	1183	554	4522
70	61	53	46	40	229	437	551	276	483	178	229	352	1228	583	4523
70	61	53	46	40	229	396	530	253	455	167	199	342	1270	613	4523
70	61	53	46	40	229	352	505	233	425	159	173	326	1310	643	4517
70	**61**	**53**	**46**	**40**	**229**	**213**	**136**	**196**	**126**	**151**	**83**	**87**	**1000**	**662**	**3553**

Figure 4. The summary population age group table as specified for service delivery.

Often the primary peak yield arising from a proposed development will occur four years after the pre-school peak as the highest Age 0 yield transitions into primary

stage. It follows that the secondary peak will be seven years after the primary peak as these children transition into the secondary sector. Long term average(LTA) numbers are calculated to determine the likely number of children by sector which will be yielded from the proposed development once it transitions to All Households.

1.5 POPULATION YIELD GRAPHS AND PRINTOUT WORKSHEET.

The “Yield Graphs” worksheet is populated with an aggregation of the output data arising from all of the model worksheets, it is a table and graphical output of the calculation processes undertaken to derive a development yield over time within the age band sectors. For example the “Units and Type & Tenure” output is the summation of the four model sheets which calculate a development yield wherein a distinction by bed size is made for Houses and Flats by Tenure. The only selectable field within this worksheet relates to the whether the user wishes to display Numbers of Persons or relevant calculated Forms of Entry data. Clicking in the green cell presents a pick list from which a user can select the relevant data item (Figure 5).

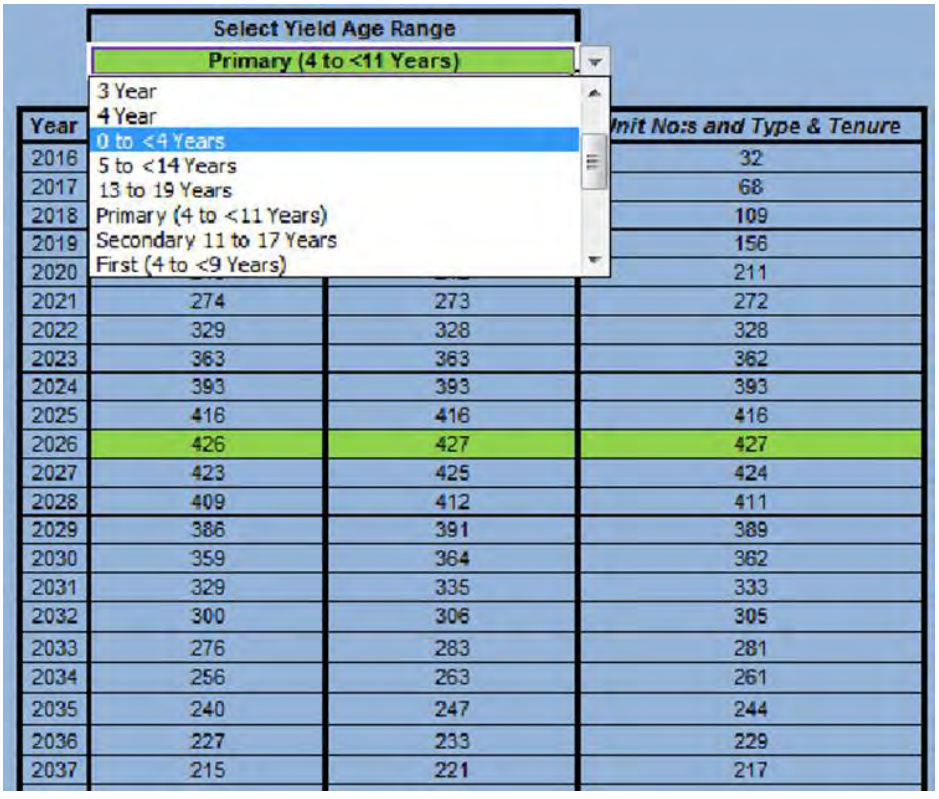


Figure 5. The “Units Only”, “Units and Type” and “Units and Type & Tenure” populace yielded over the trajectory period.