WRMP19 METHODS – POPULATION, HOUSEHOLD PROPERTY AND OCCUPANCY FORECASTING

SUPPLEMENTARY REPORT

Report Ref. No. 15/WR/02/8

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Report Title	**WRMP19 Methods: Population, Household Property and Occupancy Forecasting** **Supplementary Report**
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WRMP19 METHODS – POPULATION, HOUSEHOLD PROPERTY AND OCCUPANCY FORECASTING SUPPLEMENTARY REPORT

Executive Summary

Objectives

Household demand typically accounts for about half of the water put into supply by UK water companies. Reliable and robust projections of household population, properties and occupancy are therefore an essential requirement of water resources planning for the future. The primary aims of this project have been to:

- Identify and appraise appropriate methods for forecasting population, household properties and occupancy.
- Recommend methods that provide an appropriate balance of simplicity and accuracy, and are supported by industry regulators and government.
- Provide guidance that water companies can follow to produce water resource zone (WRZ) population, property and occupancy forecasts for the next set of water resources management plans (WRMPs) and beyond.

These objectives have been achieved by the three project outputs:

- The **Guidance Manual** provides practical guidance to water companies on how to carry out population, household property and occupancy forecasting for the next set of WRMPs and beyond.
- A detailed **Worked Example** provides a practical example of how to follow the guidance and undertake the calculations.
- The **Supplementary Report** sets out information and technical detail to support development of the new methodology. In particular, it describes the findings from:
    - Engagement with regulators, government, water companies, local authorities and other sectors to obtain views on the project requirements and the forecasting methods that should be considered.
    - Technical review of potential forecasting methods.

Conclusions

The stakeholder engagement found that:

- Trend-based population and household projections, from official statistics, are widely used as the starting point or the sole basis for forecasting by the majority of UK public sector bodies and utilities.

- Finalised, evidence-based Local Development Plans in England should be available for most local authorities for use in the development of the 2019 WRMPs.

- As advised by DCLG, WRMPs for water companies in England should take account of the housing growth set out in Local Development Plans, and ensure that the availability of water supplies can support housing and economic development. The Water Resources Planning Guideline for 2019 WRMPs (2016, currently in preparation) is likely to provide policy guidance on this.

- The new methodology should be flexible, enabling each water company to choose the level of analysis that is appropriate for the supply-demand characteristics of the WRZ. For some WRZs a simple approach is appropriate. There should be improved flexibility for companies with WRZs where there is a greater supply-demand issues to address, with options to apply more sophisticated methods.

- Improved understanding of how to assess the uncertainty of population, household property and occupancy forecasts is needed.

The review of alternative forecasting methods used in the UK and elsewhere found that:

- There are three population and household forecasting approaches suitable for consideration: trend-based, plan-based and econometric.

- Trend-based forecasts use official statistics that are derived from assumed rates for fertility, mortality and migration. Trend-based forecasts are widely used in the UK because they are derived by well-established and reliable statistical methods, and the assumptions have been subject to expert panel review. The data collation and analysis can be relatively straightforward. Therefore, trend-based forecasting is suitable for widespread use by water companies, especially for population forecasting.

- Plan-based forecasts use local authority household projections and have been used within the water and energy sectors to take account of local authority development plans. The forecasts of local development tend to be of variable quality and completeness. However, local authority plans provide local information that is not derivable from any other source relating to the potential size and location of significant housing developments over the next 5 to 10 years.

- Econometric modelling applies assumptions about how future economic growth may affect employment, housing development and population movements. These models generally work for large geographical areas (usually not smaller than regions), but can provide alternative forecasts for consideration.

- The potential uncertainty in trend-based forecasts can be estimated by applying the typical variations in past projections. Alternatively, a scenario approach can be applied to any of the above forecasting methods to derive ranges of forecasts for different assumptions.

Recommendations

Based on the findings from the stakeholder engagement and the evaluation of alternative forecasting methods, it is recommended that the following principles, incorporated in the Guidance Manual, can be applied by water companies:

1. The approach used by each water company to forecast population, household properties and occupancy should be consistent with:

    - The policy guidance in the Water Resources Planning Guideline (or equivalent), and

    - The supply-demand balance "problem characteristics" of its WRZs. Supply-demand "problem characterisation" is described in a parallel UKWIR project (UKWIR, 2016, WRMP19 Decision-Making Process, in preparation).

2. Water companies in England should ensure their WRMPs take account of housing growth set out in Local Development Plans. Guidance is also provided on the approach taken to local housing growth projections in Wales, Scotland and Northern Ireland.

3. The extent to which a water company makes use of other local authority information (in addition to that in Local Development Plans) or engages with its local authorities in determining household and population forecasts is likely to vary according to the WRZ problem characterisation, and the extent to which housing growth could affect WRMP forecasts or be constrained by supply-demand considerations.

4. Trend-based population, household and occupancy forecasts using official statistics may be developed to provide a useful starting point. The forecasts can be used or, if required, adapted to derive plan-based forecasts that take explicit account of local authority housing projections.

5. Water companies should recognise that some local authority projections may be in draft form. Companies may need to consider the extent to which proposed housing developments will occur and whether location or timing of development may change.

6. Uncertainty assessment should be carried out on population and household forecasts by deriving appropriate evidence-based ranges or scenarios, and using deterministic or stochastic approaches to explore and quantify the potential uncertainty.

Benefits

- Improvement and simplification of the approach to forecasting population, properties and occupancy.

- Improved understanding of uncertainty in projections to enable development of more resilient WRMPs.

- Financial benefits due to a more cost-effective approach to producing the forecasts and better demand forecasts that will allow water company investment to be targeted where and when it is needed.

For further information please contact UK Water Industry Research Limited, 8th Floor, 50 Broadway, London, SW1H 0RG quoting the report reference number

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Glossary

Term / Acronym	
DCLG	Department for Communities and Local Government DCLG produces official household estimates and projections for England, which are currently published at: https://www.gov.uk/government/statistical-data-sets/live-tables-on-household-projections Household projections for Northern Ireland, Scotland and Wales are produced by NISRA, NRS and Welsh Government, respectively. DCLG also produce planning guidance for local authorities in England, which can be found at: http://planningguidance.planningportal.gov.uk/
Defra	Department for Environment, Food and Rural Affairs
DNO	Distribution network operator - in the energy industry
Dwelling	Term used in official statistics and by local authorities to refer to accommodation used or available for use by an individual household. Reported numbers of dwellings typically include households with no usual residents (e.g. second homes and vacant dwellings), and includes shared dwellings (with two or more shared household spaces).
Econometric forecast/model	Term used in this report to refer to a population or household forecasting method that uses alternative assumptions about how future economic growth may affect housing development and population movements.
Household	The definition of a "household" in the 2011 Census was: "one person living alone; or a group of people (not necessarily related) living at the same address who share cooking facilities and share a living room or sitting room or dining area". Water companies usually use the term "household" to refer to a property that is recorded on their customer billing system as a household. This is different from the household dwellings measured by official statistics. See Section 2.2 for more details.
LA	Local authority
Local authority	The term "local authority" is used in this report to include all types of local authority including council, district, metropolitan, London

	borough and Unitary authorities.
LSOA	Lower Super Output Area LSOA is the lowest geography level at which mid-year population estimates are provided. The size of a LSOA varies between 400 and 1200 households. See also OA.
MYE	Mid-year estimate
Non-household	Water companies usually use the term "non-household" to refer to a property that is recorded on their customer billing system as a non-household. Some non-households have people living in them. See Section 2.2 for more details. Ofwat's regulatory criteria of what constitutes a non-household may change from the current definition before WRMP19.
NIRSA	Northern Ireland Statistics and Research Agency NISRA produce population and household statistics for Northern Ireland, which are currently published at: http://www.nisra.gov.uk/demography/default.asp3.htm
NRS	National Records of Scotland NRS produce population and household statistics for Scotland, which are currently published at: http://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme
NRW	Natural Resources Wales
OA	Output Area OAs were created for recording Census data, specifically for the output of census estimates. OA is the lowest geographical level at which census estimates are provided. The size of an OA varies between 40 and 250 households.
OAN	Objectively Assessed Need – one of the documents that each local authority produces to establish evidence for its housing growth projection. See also SHMA and SHLAA.
Occupancy	Term used in this report to refer to the average number of residents in a set of households, calculated as the usually resident population divided by the number of households.

ONS	Office for National Statistics. ONS produces official population estimates for each local authority (LA) across the UK and each LSOA in England and Wales. Also, ONS produce population projections for each local authority in England. For Northern Ireland, Scotland and Wales, ONS produce national level population projections, with LA-level projections produced by NISRA, NRS and Welsh Government, respectively. These are currently published at: http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Population+Change ONS also produce official statistics for the UK from the 2011 census, published at: http://www.ons.gov.uk/ons/rel/census/2011-census/index.html
Plan-based forecast	Term used in this report to refer to a population and household forecast that uses local authority planning projections for households and adjusts ONS population forecasts accordingly.
Population	Water companies calculate estimates and forecasts of the population that is usually resident in their customer properties. This is different from the usually resident population reported in official statistics. See Section 2.2 for more details.
Projections	DCLG, NISRA, NRS, ONS and Welsh Government produce "projections" of future population and households, based on a set of underlying demographic assumptions regarding fertility, mortality and migration based on local trends. They are not forecasts and do not attempt to predict the impact that future government or local policies, changing economic circumstances or other factors might have on demographic behaviour. In their WRMPs, water companies use these projections (or other information) to derive "forecasts" of what may happen for the purpose of planning future water supply and demand.
Region	Term used in Section 4.9 of this report to refer to Government regions – there are 9 nine regions across England.
RMSE	Root mean square error, a measure of the typical magnitude of the difference between predicted and measured values See Section 4.9 for more details.
SHLAA	Strategic Housing Land Availability Assessment – one of the documents that each local authority produces to establish evidence

	for its housing growth projection. See also OAN and SHMA.
SHMA	Strategic Housing Market Assessment – one of the documents that each local authority produces to establish evidence for its housing growth projection. See also OAN and SHLAA.
Trend-based forecast	Term used in this report to refer to a population and household forecast that uses principal projections published by ONS (population) and DCLG (households), or the equivalent organisations in Wales, Scotland or Northern Ireland. The forecasts are derived from assumed future rates for fertility, mortality and migration.
UKWIR	UK Water Industry Research Limited
WG	Welsh Government Welsh Government produce population and household statistics for Wales, which are currently published at: http://gov.wales/statistics-and-research/mid-year-estimates-population/?lang=en http://gov.wales/statistics-and-research/household-projections/?lang=en
WRMP	Water Resources Management Plan - a comprehensive plan of future actions to maintain adequate water supply reliability over a 25 year planning horizon. All water companies have to produce a WRMP every 5 years.
WRMP 2019 / WRMP19	The next programme of water resources management plans, due to be published in 2019.
WRZ	Water resource zone – the primary geographical unit that is used in water resources planning. A WRZ is defined as the largest possible water supply zone in which all resources, including external transfers, can be shared and hence all customers experience the same risk of supply failure from a resource shortfall.

1 Introduction

1.1 Aims

The key aims of the UKWIR/Environment Agency project "WRMP 2019 Methods: Population, Household Property and Occupancy Forecasting" are to:

- Identify and appraise appropriate methods for forecasting population, properties and occupancy.
- Recommend methods that provide an appropriate balance of simplicity and accuracy, and are supported by industry regulators.
- Provide guidance that water companies can follow to produce water resource zone (WRZ) population, property and occupancy forecasts for 2019 water resources management plans (WRMPs) and beyond.
- Provide answers to specific questions such as:
    - What methods do water companies and other sectors use to forecast population, properties and occupancy?
    - Are there other alternatives, not currently in use, that may provide a suitable new approach?
    - For each method: what data are required? What is the geographical coverage of the data? How much effort is required to implement it? What are the advantages and disadvantages?
    - Which methods should be used for WRMP 2019 (i.e. programme for preparation of 2019 WRMPs) and beyond?
    - How should water companies select and implement a method?
    - What uncertainties affect the results and how can these be quantified?

1.2 Background and need

Household demand typically accounts for about half of the water put into supply by UK water companies. Reliable and robust projections of household population, properties and occupancy are therefore an essential requirement of water resources planning for the future.

Water companies in England and Wales followed guidance jointly provided by the Environment Agency, Ofwat, Defra and Welsh Government on how to produce projections for their 2014 WRMPs. This guidance was based on government advice: the method was complex and required water companies to gather data from local authorities, analyse them and break the results down to WRZs.

In light of this experience, the Environment Agency, Defra, Department for Communities and Local Government (DCLG) and water companies agreed that a simpler and more cost-effective approach to producing population, properties and occupancy projections should be developed for the 2019 WRMPs, together with a better understanding of the associated uncertainty. Efficient and effective dialogue with local authorities is also required as described further in this document. Discussions have also been held with Natural Resources Wales (NRW) and the Welsh Government in developing this guidance document concerning the methodology and datasets appropriate to water companies operating wholly or mainly in Wales.

1.3 Report structure

There are three main outputs for the project:

- **Guidance Manual** (separate report) which provides practical guidance to water companies on how to carry out population and household property forecasting for WRMP 2019 and beyond.
- A detailed **Worked Example** (separate report) which provides a practical example of how to follow the guidance and undertake the calculations.
- **Supplementary Report** (this report) which sets out information and technical detail to support development of the new methodology:
    - **Section 2** summarises how official population and household statistics are produced and their use by water companies
    - **Section 3** reports on the engagement with stakeholders
    - **Section 4** presents technical detail on potential alternative methods
    - **Section 5** outlines the proposed approach for 2019 WRMPs
    - **Section 6** presents conclusions and recommendations.

2 Population and households

2.1 Producers of official population and household statistics

The UK organisations that produce and publish official population and household statistics are:

- Office for National Statistics (ONS)
- Department for Communities and Local Government (DCLG)
- Northern Ireland Statistics and Research Agency (NISRA)
- National Records of Scotland (NRS)

- Welsh Government (WG)

The data published by these organisations that are of primary interest to water companies in developing their WRMPs are summarised in Table 1.

The website addresses where the data can be found are presented in the Glossary.

As described in Section 3, local authorities, other utilities and public sectors use these official statistics either directly or as a starting point in their planning of future services.

At the time of writing this document (November 2015), the latest available published data are as summarised in Table 2. The expected dates of the next publishing of data by ONS and DCLG are summarised in Table 3: no dates are currently available for the future publishing by NISRA, NRS or Welsh Government.

Table 1 Summary of published official data

Item	Geographical Levels	Data Producer	Usual frequency of production
POPULATION STATISTICS			
Mid-year population estimates	National, LA and LSOA	England – ONS Northern Ireland – NISRA Scotland – NRS Wales – ONS	Annual
Census population estimates	National, LA, LSOA, OA and postcode	ONS (for all 4 nations of the UK)	10 years
Population projections	National	ONS (for all 4 nations of the UK)	2 years
	LA	England – ONS Northern Ireland – NISRA Scotland – NRS Wales – WG	2 years
Variant population projections	National	ONS (a wide range of variants for all 4 nations of the UK)	2 years
	LA	England – none Northern Ireland – NISRA Scotland – NRS Wales – WG	2 years
HOUSEHOLD STATISTICS			
Census household estimates	National, LA, LSOA, OA and postcode	ONS	10 years
Household projections (and latest mid-year estimates)	National and LA	England – DCLG Northern Ireland – NISRA Scotland – NRS Wales – WG	2 years
Variant household projections	National and LA	England – none Northern Ireland – none Scotland – NRS Wales – WG	2 years

Notes:

- LSOA and OA refer to “Lower Super Output Areas” and “Output Areas”, which are used by ONS for reporting census data (see Glossary).
- ONS also publishes population estimates for other geography levels, which are usually of less relevance to water companies such as health authority areas and upper super output areas.
- DCLG uses ONS’s local authority (LA) population projections as the basis for deriving the LA household projections.
- NISRA, NRS and Welsh Government use ONS’s national population projections in deriving the LA population and household projections for their nations.

Table 2 Summary of latest available published population and household statistics

Data type	England	Northern Ireland	Scotland	Wales
LA population mid-year estimates	2014	2014	2014	2014
National population projections	2012-2087 (2012-based)	2012-2087 (2012-based)	2012-2087 (2012-based)	2012-2087 (2012-based)
LA population projections and LA household projections	2012-2037 (2012-based)	2012-2037 (2012-based)	2012-2037 (2012-based)	2011-2036 (2011-based)
Small area population estimates	2013 (LSOA)	2013 (LSOA)	2013 (data zone)	2013 (LSOA)

Note: "Data zones" are usually sized between 500 and 1000 household residents, whereas LSOAs are usually sized between 1000 and 3000 residents.

Table 3 Summary of future publishing of official population and household statistics

Forthcoming data publication	Publisher	Due date	Usual update frequency
Mid-2014 small area (e.g. LSOA) population estimates (for England and Wales)	ONS	Nov 2015	Annual
Mid-2015 LA population estimates (for England and Wales)	ONS	Dec 2016	Annual
2014-based national population projections	ONS	Oct 2015	2 years
2014-based variant national population projections	ONS	Nov 2015	2 years
2014-based LA population projections (for England)	ONS	June 2016	2 years
2014-based LA household projections (for England)	DCLG	Dec 2016	2 years

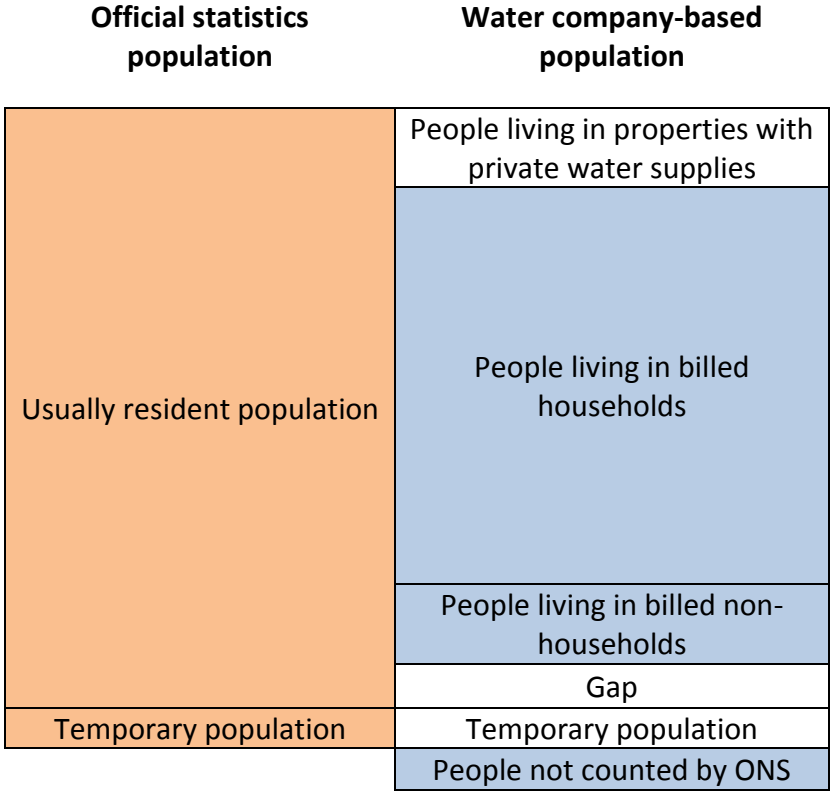
2.2 Definitions of population, households and non-households

Water companies need to calculate population and household numbers that relate to their billed customer base, and so use different definitions of "population" and "household" to the definitions used by the producers of official statistics. The differences are explained below.

2.2.1 Comparing definitions of "Population"

The population base measured and estimated by ONS (and other government statistical agencies) is defined differently from that which needs to be used by water companies. The estimates themselves will therefore also differ. A comparison of the estimates is illustrated in Figure 1.

Figure 1 Comparison of official and water company population evaluations



The **"usually resident population"** estimated by official statistics for an area comprises people who have been in the area or intend to stay for at least 12 months. It also includes people who are usually resident in the area but are temporarily absent, such as through short-term emigration or travel to another area in or outside the UK.

The **"temporary population"** of an area comprises visitors and short-term migrants who are temporarily resident in the area but do not normally reside there.

When water companies determine the population in their water supply area they normally use the official statistics for usually resident population, but **exclude** people who have their own private supply (i.e. not supplied by the water company) or people who are temporarily resident in their area. They **include** the usually resident population counted by ONS such as full-time students, armed forces personnel at bases, and communal population. Some water companies **include** an allowance for population that they believe have not been fully counted in the official statistics, such as illegal or under-recorded immigrants in areas where there may be particularly high numbers.

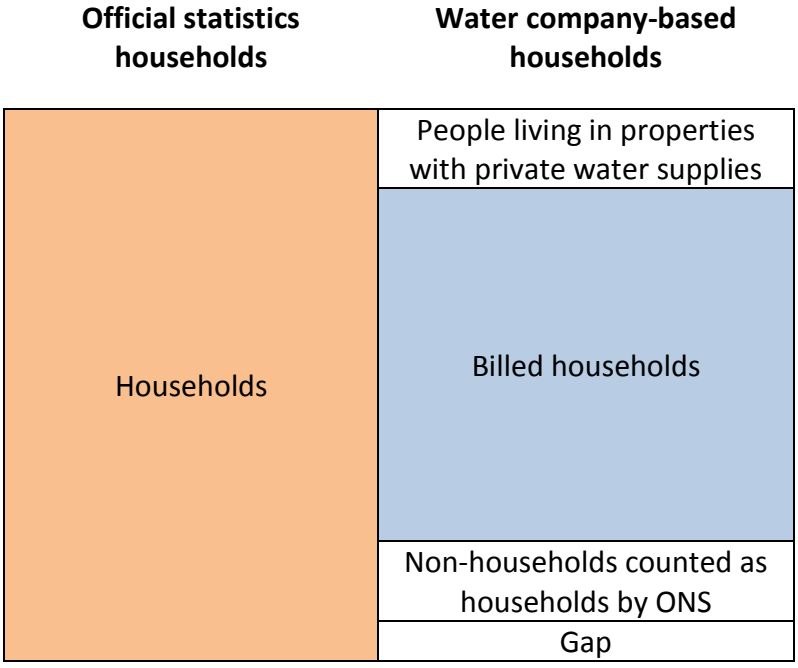
Water companies are required to allocate population to household and non-household customer types. **Non-household population** comprises people living in billed properties that are classed on their billing systems as non-household properties, including people living in communal establishments (e.g. educational establishments, nursing and residential care homes and prisons), farms, shops or other non-household properties that have residents, and some blocks of flats with a single metered supply. Ofwat's regulatory criteria of what constitutes a non-household may change from the current definition before WRMP19.

The official resident population estimates (e.g. produced by ONS) are usually close to but may not exactly match the equivalent values estimated by water companies – shown by "Gap" in Figure 1 – due for example to differences in boundaries and missed properties.

2.2.2 Comparing definitions of "Households"

The number of households measured and estimated by DCLG and other government statistical agencies is defined differently from that which needs to be used by water companies. The estimates themselves will therefore also differ. A comparison of the estimates is illustrated in Figure 2.

Figure 2 Comparison of official and water company household evaluations



When water companies determine the number of households in their water supply area they usually count the number of billed households on their billing system. Therefore, they **exclude** properties that have their own private supply (i.e. not supplied by the water company), and customers that are classed as households in the official estimates (e.g. produced by ONS) but which are classed as non-households on the billing system (e.g. some farms, shops or blocks of flats). The official household estimates are usually close to, but may not exactly match, the equivalent values estimated by water companies – shown by "Gap" in Figure 2 – due for example to differences in boundaries and missed properties.

There are other ways by which a water company can estimate the number of households served by each WRZ if they are concerned that the billing system may undercount households with a shared supply connection or newly constructed houses that are not yet recorded. For example, the Ordnance Survey Address Point data can be used in conjunction with the WRZ boundaries on the company's geographical information system (GIS), but judgement would need to be used to allocate the estimates between households, non-households and no-longer-used properties.

2.2.3 "Non-households"

Water companies are required to classify their customers as either household or non-household, according to defined regulatory criteria. They are also required to categorise people living in properties that are classed as non-households on their billing system as "non-household population".

2.3 Calculation of official population statistics

ONS uses well-established methodologies for deriving mid-year estimates and projections of population that have been developed and improved over many years.

Each year, ONS publishes its latest **mid-year population estimates** for a variety of geographical areas, but those of most importance to the water industry are local authority areas and Lower Super Output Areas (LSOAs). The mid-year estimates are calculated from the latest Census population numbers by adding recorded births and subtracting recorded deaths in each year, and adding estimated net migration in each year.

Population projections are derived from the latest mid-year estimates based on assumed rates for **fertility, mortality and migration** (see ONS, 2015). Each future year's population values are derived from the previous year's by ageing the population, adding estimated births and immigration, and subtracting estimated deaths and emigration, as illustrated in Figure 3. The population projections include estimates by gender and age profile.

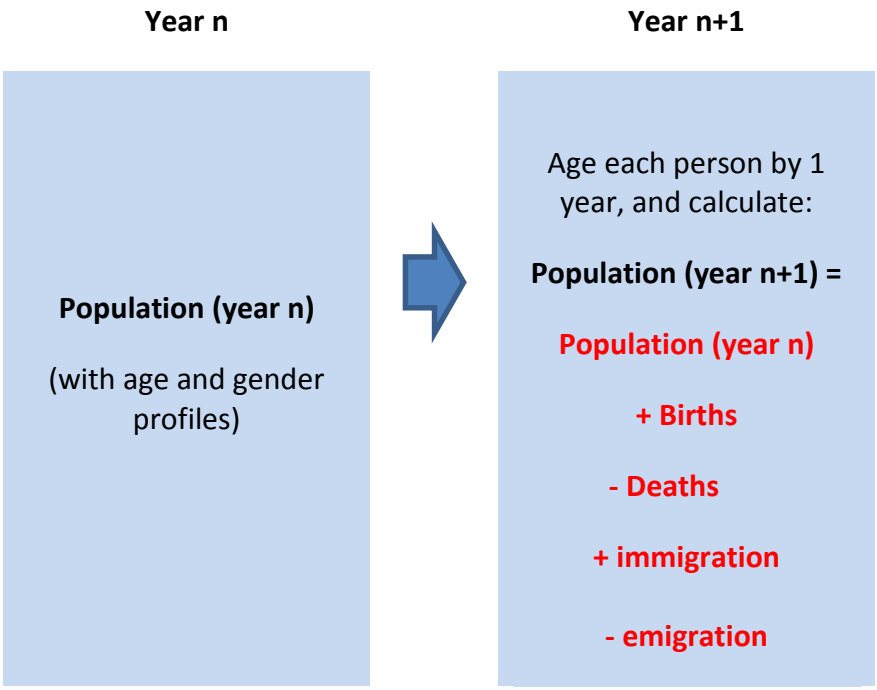
2.4 Calculation of official household statistics

The number of households currently present in each local authority is derived from the latest census and taking account of records of completed home-building and demolitions.

A "household formation rates" approach, also known as a "household representative rates" approach, is used to calculate household projections for each local authority in England by DLCG, as described in their methodology report (DCLG, 2015). A similar method is used by the other government statistic organisations for the other nations.

This involves categorising current households into demographic groups according to the age and sex of the representative household head and the marital/co-habitational/family status of the household. Future household numbers in each group are derived by using the official population projections and estimating the expected changes in each household group and movements between groups.

Figure 3 Summary of the ONS approach to modelling population projections



3 Water company and stakeholder engagement

3.1 Engagement with water companies and stakeholders

An important part of developing this project's revised guidance for WRMP 2019 was engagement with water companies, water regulators, governments, planning agencies and other stakeholders to ensure that:

- The requirements of water companies and stakeholders were identified and taken into account
- Good practice forecasting methods were identified and evaluated.

Table 4 summarises the stakeholders that have been consulted – a full list of organisations is provided at Appendix 1. The findings from the engagement are described in Sections 3.2 to 3.6.

Table 4 Summary of stakeholder engagement

Stakeholder category	Method(s) of engagement	Purpose of engagement
Project Steering Group	Project meetings, issue of draft reports for comment and liaison throughout project.	To guide the development of the project and the outputs.
UK regulators and government agencies (see Section 3.2)	Meetings and/or telephone discussion.	To identify the requirements of regulators and government agencies for the new methodology.
UK water companies (see Section 3.3)	Structured questionnaire and interviews with representatives of each of the 22 principal UK water companies, as well as the Water Resources in the South East group. Request for feedback on findings and the draft guidance manual.	To identify lessons learned from the previous WRMP14 methodology and water industry requirements for the new methodology. To explain the project findings and seek input to the recommended methodology.
UK local authorities (see Section 3.4)	Interviews with a sample of 9 local authorities across the UK.	To identify forecasting methods used by local authorities, assess likely information available for WRMP19 and how water companies can best engage with local authorities during the WRMP process.
Other sectors (e.g. energy, health, transport) (see Section 3.5)	Interviews with a sample of 9 organisations in other public and/or infrastructure provision sectors.	To identify forecasting methods used by other sectors and establish any approaches that could benefit the water industry.
Related UKWIR WRMP19 projects (see Section 3.6)	Meeting with project leads for each of the related projects.	To ensure consistency of approach across the projects, particularly any data dependencies and to ensure consistency of approach to handling data uncertainties.

Note: The Project Steering Group comprised water company, Environment Agency and Natural Resources Wales representatives.

3.2 UK regulators, government and government agencies

The Project Team consulted with several UK regulators, government and government agencies, as listed in Appendix 1, including meetings with DCLG in England. Some key themes have emerged from this dialogue:

- The Environment Agency and Natural Resources Wales recognise that the guidance provided to water companies for their 2014 WRMPs was complex and that a simpler and more cost effective approach to producing population, household and occupancy projections should be developed, together with a better understanding of the associated uncertainty.

- Ofwat expects future guidance to reflect best practice and be practical to implement, although it does not see itself as having a significant role in determining it.

- The Environment Agency firmly considers that dialogue with local planning authorities should remain as an important facet, alongside use of appropriate national statistics, to consider the specific projections produced and ensure local evidence is taken into consideration in finalising forecasts and addressing uncertainties. The Water Resources Planning Guideline for WRMP19 (currently in development) is likely to require companies in England to make use of household projections contained in Local Development Plans for the initial years of the planning horizon.

- The need for a flexible approach dependent on the supply-demand situation companies is recognised by regulators and government departments, but water companies need to clearly explain and justify their approaches.

- DCLG's guidance to local authorities in England on the preparation of Local Development Plans is set out in the National Planning Policy Framework[1]. The guidance concerning housing development (DCLG, 2014) requires that the Department's household projections are the starting point that should be used for planning authorities to meet housing demand. The guidance requires local authorities to identify the Objectively Assessed Need (OAN) for housing together with Strategic Housing Market Assessment (SHMA) and Strategic Housing Land Availability Assessment (SHLAA). These assessments are to provide evidence to support the housing growth projections.

- About 75% of local authorities in England have now published their draft Local Development Plans. These include 15 year projections of housing development – in most cases they have used 2012-based DCLG projections to 2027, but modified to take account of local circumstances.

- Consequently, when water companies develop their 2019 WRMPs most local authorities should have published plans that can be used, although some will be in

[1] http://planningguidance.planningportal.gov.uk/

the process of revising them. The finalised plans will have been subject to Examination in Public by a planning inspector to check that the plans are soundly evidence-based.

- It is important to DCLG that WRMPs allow for the housing growth set out in local development plans, and ensure that the availability of water supplies can support planned housing or economic development. The Water Resources Planning Guideline for 2019 WRMPs (currently in preparation) is likely to provide policy guidance on this.

- Natural Resources Wales said it would welcome early discussion with water companies in Wales about their approach to population and household forecasting.

- The Welsh Government expects local authorities in Wales to take note of its projections but does not prescribe that local authorities have to use them in the preparation of the local development plans (Welsh Government Assembly, 2005). Equally, the Welsh Government would not prescribe which population and household projections water companies with WRZs in Wales should use, but would suggest that the Welsh Government projections be considered as an important starting point.

- The Scottish Government (2014) guidance to Scottish local authorities strongly recommends the use of the National Records of Scotland (NRS) household projections. If the NRS household projections are adjusted, or customized household projections are used, this should be justified along with a comprehensive discussion of the methodology used.

3.3 Water companies

The Project Team contacted all 22 principal water companies in the UK (i.e. excluding the very small companies, such as the island water companies and inset appointees), and undertook a structured questionnaire interview (see Appendix 3), by telephone or face-to-face. A representative of the Water Resources in South East England project (WRSE) was also interviewed to provide a separate view of the experiences and requirements of water companies in South East England.

The purpose of the survey was to identify:

- The methods that were used in the latest WRMPs to forecast population, households and occupancy for water resource zones.

- The issues and needs that should be addressed by the new forecasting methodology (being developed by this project).

- Suggestions for improvements to the existing methods or alternative new methods.

The main points raised during the interviews are summarised below.

3.3.1 Choice of forecast by water companies

Most companies developed trend-based and plan-based forecasts of population and households, with a variety of choice of preferred forecast type, as shown in Table 5.

Table 5 Types of forecast developed and choices made

Type of forecast developed	Type of forecast chosen				Total
	Trend-based	Plan-based	Most-likely	Trend (popn) Other (h'lds)	
Trend-based only	1				1
Plan-based only		2			2
Trend-based + Plan-based	3	1			4
Trend-based + Plan-based + "Most likely"	3	3	6		12
Trend-based for population Plan-based or bespoke for households				3	3
Total	**7**	**6**	**6**	**3**	**22**

Notes:

- Trend-based forecast = forecast based on the official statistics.
- Plan-based forecast = forecast based on LA planning projections for households and adjusts trend-based population forecasts accordingly.
- Most likely forecast = assessment of the most likely outcome using available forecast data.

The companies that used a plan-based forecast in the WRMP chose it in order to comply with the WRMP 2014 regulatory guidance. The companies that used a trend-based or most-likely forecast chose it because it provided the most realistic forecast that was most consistent with their understanding of past and current trends.

Sometimes a water company modified its trend-based forecast to take account of the location of planned localised developments, or modified its plan-based forecast to make it more realistic.

Some companies commented that it was useful to calculate more than one forecast in order to sense-check the forecast and/or gain an appreciation of the uncertainty in the projections.

3.3.2 Water company views on complexity of analysis

Many water companies said that the approach in the guidance for the 2014 WRMPs was too complex, due primarily to the difficulties of obtaining and using local authority plan-based

information or the need to produce more than one forecast. Some companies did not fully follow the guidance because of the complexity involved. This view does not seem to be associated with any particular choice of resource or geography-level used to derive the forecasts (see Table 6).

Table 6 Water company views on level of complexity of methodology, by choice of resource used and level of geography used

	Water company view on level of complexity of the methodology they used			Total
	Too simple	Reasonable	Too complex	
Resource used to develop forecasts:				
• Specialist consultant		7	3	10
• In-house		3	2	5
• Combination		3	4	7
• Total	0	13	9	22
Geography-level chosen to develop forecasts:				
• Local authority		2	3	5
• LSOA		9	4	13
• OA or postcode		2	2	4
• Total	0	13	9	22

3.3.3 Geography level used by water companies

Some companies, in particular some of those with low supply-demand risk, used sub-national official statistics for local authorities as the basis for deriving their population and household forecasts. Typically, they used the base-year property counts on their billing system to estimate the proportion of households in each local authority that were in each WRZ, and these proportions were applied to the projections for each local authority to calculate forecast household numbers for each WRZ.

A group of water companies in South and East England employed a specialist population forecasting consultant to undertake a joint collaborative study. The consultant used LSOA census geography, and so made use of the latest mid-year population estimates at LSOA level published by ONS. LSOAs were assigned or proportionally allocated to each WRZ using a postcode matching routine.

At least one company obtained LSOA digital boundaries for use in their geographical information system (GIS) to enable easy matching of properties on the billing system between LSOAs and WRZs.

Some water companies derived forecasts for their district meter areas (DMAs), which could then be built-up to WRZ forecasts, and/or sewerage land drainage systems, to provide growth projections for use in wider business planning. Smaller geographies for census data needed to be used such as LSOA, or preferably OA or postcode.

3.3.4 Data sources used by water companies

Table 7 summarises the data sources used by nearly all water companies to derive their population and household estimates and forecasts.

Table 7 Sources of data generally used by water companies

Item	Data source	Comment
Base year number of households in each WRZ	Company billing system.	
Base year population in each WRZ	Latest ONS (or equivalent) mid-year population estimates, reconciled as appropriate.	The reconciliation typically includes: allowance for private water supplies, adjustment from latest mid-year to WRMP base year, and reconciling of census and WRZ geographical boundaries.
Forecast households for each WRZ	DCLG/ONS (or equivalent) household projections. LA local plan projections.	The projections are adjusted so that base year numbers matches water company base year estimates.
Forecast population for each WRZ	ONS (or equivalent) population projections.	

3.3.5 Water company views on engagement with local authorities

All companies made contact with the local authorities in their area, with varying levels of engagement and varying levels of success in obtaining required information.

The problems that were frequently experienced were:

- Often local authorities did not respond or provide the data requested. The response rates experienced, for example, by nine water companies in South and East England ranged between 36% and 74% of the local authorities in their areas, despite two phases of attempted engagement.

- The quality and format of the data on development plans varied widely, with few local authorities having completed their local development plans at that time. Some of the local authority growth projections appeared to be unrealistically high, especially for the first 5 to 10 years. One company expressed concern that some projections in its area did not seem to correspond with evidenced need, i.e. Objectively Assessed Need. Some data were incomplete or too provisional in nature to be used.

- The time horizons of the planning data varied and were often much shorter than required in WRMPs. One consequence was that housing needs in the longer term may sometimes have been understated.

- Engagement with local authorities was often very time consuming, especially so for water companies with a large number of local authorities covering their supply area.

- It was noted that a planning authority may allocate land, and grant planning permission, but decisions by developers to build homes are led by market conditions as well as planning decisions. The possibility that decisions by developers can create sharp step changes in house building (both upwards and downward) needs to be acknowledged.

- In a large proportion of cases, companies considered that very little or no improvement in household and population forecasts was achieved by considering information provided by local authorities.

- Where data were provided, this was either trend-based data (already obtained by the company) or plan-based data that did not provide a high degree of confidence to the company. Notable exceptions included some of the larger conurbation authorities who generally have the resources dedicated to demographic projections.

- The projection data provided only extended to 2025 (and often with no intervening year projections), and so required extrapolation to the 25-year WRMP planning horizon.

The benefits of engagement that were experienced included:

- The identification of localised development plans over the next 5 to 10 years often informed the location of household/population growth in the WRZs to aid distribution network planning (and sewerage planning).

- The planning information improved understanding of the basis for housing growth projections, and where appropriate, how best to re-profile trend-based forecasts.

- It sometimes improved good relationships for the future. In one case it encouraged collaboration on water efficiency programmes.

- It sometimes encouraged more involvement by local authorities in the WRMP consultation process.

3.3.6 Problems encountered by water companies

The problems most frequently experienced in developing the population and household forecasts for WRMP 2014 were the difficulties with local authority engagement and use of their data (as described above).

Other problems experienced included:

- A few water companies considered that the ONS population projections understated current or future net inward migration.

- Companies sometimes had difficulties in reconciling census data to match water company needs (e.g. base year data reconciliation, geographical boundary reconciliation and property type reconciliation).

- It was considered there was insufficient guidance on how to quantify uncertainty in the forecasts.

3.3.7 Occupancy assessment by water companies

The average occupancy values derived for each WRZ by water companies were nearly always estimated by dividing the population value by the number of households. The occupancy values were sense-checked for consistency with the company customer surveys and/or official statistics.

Nearly all water companies undertook customer surveys during preparation of their 2014 WRMP which included asking customers about occupancy. Therefore, data exists to enable estimation of the uncertainty in occupancy values, although few companies used this because the uncertainty in population values was considered to provide the primary demographic measure for household demand uncertainty.

The allocation of WRZ population across each customer grouping (e.g. meter status type) was generally based on the estimated occupancy for each group from the customer survey. The forecast values for each customer group were assessed using expert judgement on the best calculation of the expected trend for each group. Several companies questioned the benefit of reporting occupancy values for different meter status types going forward.

Adjustments/reconciliations to population or households or occupancy values were made where necessary to remove any inconsistencies.

3.3.8 Water company suggestions for the new methodology

Many water companies requested that the new methodology should be proportionate, incorporating the flexibility to choose the level of analysis that is appropriate for the supply-demand risk in the WRZ:-

- They asked for the flexibility to choose a simple approach, for example using official statistics in a trend-based method. For WRZs with few or no supply-demand issues the methodology should avoid having to needlessly go to the complexity and

substantial effort of detailed use of local authority information or engagement with local authorities.

- For WRZs with more extensive supply-demand issues there should be improved flexibility in the application of more sophisticated methods than just trend-based forecasting. As companies are the ones owning the risk, they should be allowed to adopt the approach that most is most appropriate as long as this can be clearly justified.

Other suggestions for improvements to the methodology included:-

- It should provide guidance that enables better recognition and quantification of the significant uncertainty in the forecasts, and how to incorporate uncertainty values in stochastic modelling of the supply-demand balance (and ensure consistency with other WRMP19 methodologies in preparation).

- The guidance should enable a company to take fuller account of inward migration than assumed by ONS or equivalent organisation.

- An easy-to-follow flowchart of the key steps and decisions should be included.

- The methodology should take account of the methods used in other sectors.

- A description of how to assess the validity of occupancy values and how to carry out reconciliation adjustments should be included.

- It should provide guidance on how to engage with local authorities and what information and data to collect. The guidance should recognise that local authority information is of varying quality and describe how to decide which, if any, data/information to use.

- The benefits of strong geographic mapping of census boundaries as well as operational boundaries in the calculation of base year estimates should be recognised.

- It should provide guidance on how to use small area census geography to calculate population and household forecasts for small operational areas such as district meter areas (DMAs) and land drainage areas.

- The guidance should address the issues associated with forecasting population change alongside a plan-based household forecast. It should recognise that the building of extra homes does not, of itself, result in increased population.

3.4 Local authorities

In addition to contacting water companies, the project team contacted various local authorities in England and Wales either by phone or email using a structured questionnaire. Nine were consulted and provided information to the project, of which five responded with full replies to the questionnaire.

The purpose of the survey was to identify:

- Data sources and timescales used for forecasting.
- Barriers to provision of information.
- Familiarity and level of engagement with water companies.

The key points raised during the interviews were as follows:

Local authorities generally start with ONS projections (or Welsh Government projections in Wales) for forecasting purposes. They then apply the Local Government Association's POPGROUP methodology tool[2] and/or their own econometric analysis (using in-house or shared resources and external consultancies) to take account of migration, births and mortality. They then take account of local planning information. A series of scenarios are then produced which form the basis for the forecasts which inform their policy on housing provision, economic development requirements, and eventually indirectly informs council infrastructure provision (e.g. schools, retail, green space).

For example the Greater London Authority (GLA) produces annually updated population, household and school roll projections for London local authorities. These include both housing-linked projections (taking into account housing development) and trend-based projections (taking into account trends in fertility, migration and mortality) down to ward level.

Forecasts generally cover a 15-25 year time frame (e.g. 2041 horizon for Greater London Authority, 2035 for the Association of Greater Manchester Authorities, 2036 for Cambridgeshire County Council). They are updated every year, although some of the data for later years is not published due to the greater uncertainty.

Local authorities may use a range of sources to improve on ONS projections, including household occupancy information from DCLG, available forecast models (egg the East of England Forecasting Model), strategic housing market assessments (see below), higher resolution data such as housing trajectories from local housing plans, registrar data to supplement fertility and mortality assumptions, electoral rolls, GP registrations, student numbers from the Higher Education Statistics Agency (HESA) and armed forces numbers. They may also use resources supplied by umbrella bodies (often upper tier authorities), such as East Sussex in Figures[3], a county council research group including demographic modellers.

Most local authorities underlined the importance of referring to Local Plans in making forecasts. These are prepared and maintained by those local planning authorities responsible for 'district matters', i.e. district, London borough, metropolitan district, unitary

[2] A family of software developed to forecast population, households and the labour force, developed by Edge, owned by Local Government Association since 2010; see http://lgalabour.local.gov.uk/web/guest/popgroup

[3]ESIF population projections and estimates can be found at:
http://www.eastsussexinfigures.org.uk/webview/index.jsp?catalog=http%3A%2F%2F10.128.25.249%3A80%2Fobj%2FfCatalog%2FCatalog246&submode=catalog&mode=documentation&top=yes

and National Park Authorities in England and single tier principal areas (cities, counties and county borough councils) in Wales. Local Plans identify areas for economic and housing development, in accordance with section 20 of the Planning and Compulsory Purchase Act 2004 (as amended) and the National Planning Policy Framework (2012). The expectation in the guidance is that local plans will be drawn up for a 15-year time horizon, take account of longer term requirements, and be updated in whole or part every 5 years. The National Planning Policy Framework for example makes clear that that relevant policies for the supply of housing will not be considered up-to-date if the authority cannot demonstrate a five-year supply of deliverable housing sites.

In drawing up their plans, local planning authorities take account of plan-making activity and evidence used by other authorities that have an impact on their areas. For example, a revised regional Strategic Housing Market Assessment, such as that carried out across Oxfordshire by G L Hearn (2014), will affect all authorities in that housing market area, and potentially beyond, irrespective of the status or stage of development of particular Local Plans.

Local authorities identified several barriers and challenges to obtaining information/data for forecasting purposes. These included the following:

- Insufficient access to information or lack of availability, in particular:
    - Release time frames for different data sources vary (e.g. ONS has regular releases but these do not necessarily match local authority timetables)
    - Reliance on third parties to release data (difficult to obtain student numbers/armed forces)
    - Limited resolution of data available, e.g. forecasting population to ward/parish level. Some of the authorities contacted provide ward-level information (e.g. Cambridgeshire County Council, Greater London Authority, Association of Greater Manchester Authorities, East Sussex County Council), but they confirmed these were highly provisional (East Sussex does not for example take migration into account at ward level).
- Incomplete information, in particular:
    - Changes to ONS data require earlier census projections to be reassessed
    - Census based models are flawed because there is no detailed information between census years (e.g. communal establishment rates are based on 2011 data).

A key difficulty for water companies (and upper tier authorities) is the fact that local authorities are not following a common timeframe for producing and revising local plans. East Sussex County Council, for example, publishes forecasts out to 2027 as this is the first common year for the end of the current planning period for the local authorities concerned. This can also cause difficulties where groups of unitary authorities have a lead authority for demographic information (e.g. Conwy for a number of County Boroughs in North Wales.)

The stage in the planning cycle that the local authority has reached can be a major factor in their willingness and ability to provide information, whether to water companies or upper tier authorities. The Greater London Authority for example found it difficult to obtain information from some boroughs for its work on the 2013 London Strategic Housing Land Availability Assessment (SHLAA). The next SHLAA is due in 2016.

Those involved with planning and infrastructure are often not the same as those engaged in forecasts, so some of the forecasting experts the project team spoke to had little knowledge of water companies and WRZs. It was no surprise that planners had greater knowledge, given that early discussion with infrastructure and service providers to understand their investment plans and critical dependencies is an important part of drawing up Local Plans.

All of the local authorities we spoke to were keen to forge improved engagement and join-up with water companies. This was particularly the case for the larger conurbations. The Association of Greater Manchester Authorities (AGMA) was, for example, keen to ensure links between this project and the Greater Manchester Infrastructure Advisory Group, which is working on the AGMA Regional Spatial Framework[4]. AGMA also referenced their work on Future Cities Catapult[5], which is developing a tool that helps align their growth projections with growth projections by the utility companies.

There is a portal[6] for those wanting access to local authority planning contacts and development plans.

3.5 Other sectors

The project team also contacted a range of practitioners from various public sector bodies and private sector infrastructure providers including the energy, health, education and transport sectors. In total nine organisations were consulted either by phone or email.

The purpose of the survey was to identify:

- Whether population, household and occupancy forecasting is undertaken and what data sources are used;
- The barriers or challenges to obtaining relevant information;
- Forecast planning horizons adopted;
- Current engagement with local planning authorities and any recommended approaches to improve the quality of engagement.

The key issues raised are set out in the sections below.

[4] http://www.agma.gov.uk/what_we_do/planning_housing_commission/greater-manchester-spatial-framework/gmsf-initial-consultation1/index.html

[5] https://futurecities.catapult.org.uk/

[6] http://www.planningportal.gov.uk/wps/portal/genpub_DevelopmentPlans?docRef=1103046453506&scope=202&langid=0

3.5.1 Energy

A range of energy sector organisations were contacted, including energy distribution network operators (DNOs), and National Grid. Whilst all respondents indicated that some form of forecasting is carried out, the methodology and the level of detail used varies depending on the spatial scale that the organisation serves and the relevant timescale. Overall, no new methodologies have been identified but some information has been provided on approaches to engagement with local authorities.

The electricity DNOs use a combination of the ONS forecasts for household population, properties and occupancy, historical demand data and modelling techniques to produce their forecasts. They tend to use ONS projections as a baseline but have developed internal forecast models to adjust the projections using historical operational data and expectations around technological development (e.g. electric vehicles and heat pumps) for its distribution area.

Forecasts used by the DNOs extend to 2023 (the current business plan period), with a high-level view developed out to 2030 (and beyond for some locations). During the recent period of slow or negative economic growth, the DNOs found the DCLG/ONS projections were significantly over-estimated. One company updated its projections by running a series of stakeholder workshops to indicate actual and proposed new housing numbers. From this, and gross value added (GVA) growth data, they extrapolated the likely number of jobs created, floor space per job and therefore total floorspace. Using a specialist consultancy, they produced bespoke forecasts for three scenarios (low, medium, high).

DNOs generally engage with local planning authorities on forecasting population and property numbers where they have good contacts. UK Power Networks, for example, have a good working relationship with Greater London Authority, with whom they have a shared understanding on developing their forecasts. The DNOs have found that engagement with local planning authorities relies both on developing good contacts and different types of engagement. For example, one DNO has set up stakeholder groups for each of its main supply areas and is currently developing a 'critical panel of stakeholders' to obtain intelligence as well as providing feedback (both on projections and asset planning more widely).

Perceived barriers and challenges to obtaining the relevant data and information from local authorities includes a significant time-lag between requesting the data and receiving it, leading to significant gaps in plan-based forecasts.

Retail energy suppliers only focus on short-term forecasts (within year) and medium-term forecasts (5 years). This is because customer numbers are unpredictable due to competition, making forecasts beyond this timeframe highly unreliable.

The UK-wide energy transmission networks operator (National Grid) only procures demographic projections at a national level and housing growth data for each of the 13 "Local Distribution Zones" in the UK to forecast population and housing growth. In 2013

National Grid published its Future Energy Scenarios (FES)[7] looking at how the UK's energy landscape may look in in the period up to 2050, but this looked primarily at changes in usage (driven by consumer behaviour and technology) and generation type (driven by government policy) rather than demography.

3.5.2 Transport

No evidence of different approaches to forecasting population and properties was found in the transport sector. The Department for Transport's Road Traffic Forecasts 2015 make only a passing reference to population, confirming that ONS population projections are embedded within the National Trip End Model (NTEM) dataset. They note that while spatial and demographic disaggregation of the forecasts is critical to producing robust forecasts of traffic, understanding aggregate population changes is important in understanding the overall trend in car use.

There is no clear reference to population forecasting in the most recent UK Air Passenger Demand Forecasts.

3.5.3 Education

The Department for Education confirmed that pupil projections are at a national level and are simply based on the ONS national population projections adjusted to reflect school participation rates, changes to the academic year, school census data etc. They confirmed that this use of ONS projections as a basis for forecasts was consistent across government departments.

The House of Commons Public Accounts Committee published a report in June 2013 on capital funding for new school places in response to the Department for Education's slowness in responding to the rising demand for school places using ONS projections. This recommended that "the Department [for Education] should, working with the Office for National Statistics (ONS), the Department of Health and local authorities, model different scenarios in order to manage emerging demand better in both primary and secondary schools."

In its response in September 2013, the Government agreed with Committee's recommendations. However, they went on to note that "The ONS is responsible for monitoring population change. The department already uses ONS-provided data, including variant modelling, to understand change at a national level. Local authority (LA) forecasts are informed by a variety of local factors, including ONS data on live births, local migration patterns and pupil yield from local housing developments. Many LAs also draw on data provided by local health bodies. Internal analysis of LA forecasting indicates that over 90% of authorities forecast pupil numbers for the next 1-2 years with a margin of error of less than 5%, and many are accurate to within 1%."

[7] For background see http://www.nationalgridconnecting.com/building-our-future/ and http://www.nationalgridconnecting.com/the-future-of-UK-energy-demand/

3.5.4 Health

NHS England confirmed that their forecasts of population changes are based on the latest available ONS projections.

Long term demand modelling is done fairly infrequently and usually to feed into work on hospital building and medical training. The general approach is to start with ONS projections and then break these down by age and the impacts of demographic change. This will often be combined with long run trends in treatment patterns. So, for example, if there are currently 1 million elderly people requiring 20 bed-days each per year, and the expectation is that there will be 1.1 million by 2025 but better treatment will reduce bed-days to only 19 per person, then the resource need would increase from 20.0 to 20.9 million bed-days per year.

3.6 Related UKWIR projects for WRMP19 Methods

This project is one of a wider programme of UKWIR projects being undertaken during 2015 and 2016 to develop improved methods for preparing the 2019 WRMPs, listed as follows:

- WRMP19 Methods – Population, Household Property and Occupancy Forecasting (this project).

- WRMP19 Methods – Household Consumption Forecasting
  It will provide guidance on a range of appropriate methods for forecasting household consumption rates used in WRMPs.

- WRMP19 Methods – Decision Making Process
  It will provide an improved investment appraisal and optimisation methodology that enables robust development of water company WRMPs.

- WRMP19 Methods – Risk Based Planning
  It will provide guidance on a range of methods to assess the influence of uncertainty on WRMP investment decisions.

- Integration of Behavioural Change into Demand Forecasting and Water Efficiency Practices
  It will examine methods for incorporating customer behavioural characteristics in household consumption forecasts and water efficiency planning.

A meeting of project leads, and representatives from UKWIR, a water company, Environment Agency and Natural Resources Wales, was held to discuss the scope of the projects and check consistency of approach.

It was agreed that the demand forecasting projects should provide guidance on how to quantify uncertainty, but not on how to incorporate uncertainty in the supply-demand balance as this is being addresesd by the Risk Based Planning and Decision Making Process projects.

The Decision Making Process project is developing a method for “problem characterisation”

for WRZ supply-demand issues and the implications for the scale of investment required to address them. The assessment can be applied to individual parts of the supply-demand balance calculation. So, for example, if the population and household property forecasts for a WRZ have small effect on the issues to be addressed, the use of a simple forecasting approach could be appropriate within this methodology. Readers are referred to the guidance provided within the "WRMP19 Methods – Decision Making Process" (UKWIR 2016, in preparation) report for further information.

4 Evaluation of forecasting methods

4.1 Background

Water companies have specific requirements of population and household forecasts:

- Water companies require projections of population and households reaching 25 years in to the future for their WRMPs to ensure they can provide adequate long-term water supply security.

- Water companies rely on official statistics (as produced by ONS, DCLG, NIRSA, NRS or Welsh Government) as they do not have the resources or skills to develop population and household projection methodologies from scratch. They thereby make use of established population projection methodologies, so that the projections are acceptable, credible and transparent.

- The water industry needs to understand and quantify the risk associated with any population forecast used, and to be able to act appropriately in response to that risk.

- There are some practical ways in which the official forecasts as supplied 'off the shelf' do not directly meet water company requirements. In particular official forecasts do not provide the required geography (Water Resource Zones), and also may not extend as far into the future as is required.

- Water companies therefore need to create ***derived forecasts*** that give figures for the required resource zones and to the required future planning horizon.

4.2 Methods available

The review of literature (see following sections) and consultation with stakeholders (see Section 3) found that:

- The most established population projection methodologies currently in use are **trend-based** 'cohort survival' methods. These are almost universally used in national and sub-national population projections by statistics agencies across the world (Wilson and Rees, 2005), and by UK public sector bodies and utilities as the starting point (and often the sole source) for developing their forecasts.

- **Plan-based methods**: some UK utilities (including the water and energy sector) have sought to use local authority plans as a further source of household projections, particularly to identify growth areas.

- **Econometric methods** are also sometimes used, and there has been academic research into other approaches such as stochastic methods.

Stochastic modelling techniques that run multiple projections based on simulation of statistical distribution of the uncertain parameters has been used by some forecasters, as reported by Wilson and Rees (2005). It requires one or more of the above methods as the basis for deriving the alternative forecasts and its main purpose is as a means of exploring uncertainty. So it is not identified here as a separate method for producing forecasts.

Hence, the primary methods available for forecasting population and households are:

- Trend-based forecasting
- Plan-based forecasting
- Econometric modelling
- "Hybrid" approach, using a combination of the above methods

These are alternative methods for deriving principal forecasts, but in each case scenarios can be developed to derive a variety of forecasts around the principal projection and these can then be used in either a deterministic or stochastic assessment of uncertainty.

The methods are summarised in Table 8 and described further in Sections 4.3 to 4.6.

Table 8 Summary of potential forecasting methods

Method	Outline description	Use of scenarios
Trend-based forecasting	Uses official statistics of principal projections for population and households, as published by ONS, DCLG, NISRA, NRS or Welsh Government.	Variant forecasts: applying alternative assumptions about future population changes (for fertility, mortality and migration) to those assumed in the central trend-based population projection.
Plan-based forecasting	Uses local authority projections for households and may adjust population forecasts accordingly.	Planning scenarios: applying alternative assumptions about development growth rates and/or locations of development.
Econometric modelling	Applies assumptions about how future economic growth may affect housing development and population movements.	Economic scenarios: applying alternative assumptions about economic growth rates and the relationships to housing development and population movements.
Hybrid approach	A combination of projections and scenarios from two or more of the above methods may be utilised.	

4.3 Trend-based methods

Trend-based methods, and particularly cohort-survival methods, are the most widely used approach to population forecasting. This section firstly describes the official UK population projections produced by ONS, NISRA, NRS and Welsh Government, and secondly forecasts produced by other suppliers which may also be taken into consideration, particularly in areas of higher risk.

Official projections use a trend-based (cohort survival) methodology that has been developed and evaluated over a long period of time and which has been extensively used for a range of service planning purposes. They therefore have the advantages of using an established methodology that commands wide acceptance, along with broadly known levels of uncertainty.

In the UK, official population projections are produced using trend-based methods by the various government statistical agencies: ONS in England, NRS in Scotland, NISRA in Northern Ireland and Welsh Government in Wales.

- ONS produce *National Population Projections* for England, Wales, Scotland and Northern Ireland. These usually give projections extending 35-40 years into the future – enough for water resources planning – but they do not geographically subdivide the four countries.
- The statistical agencies also produce *Subnational Population Projections* for local authorities in their respective countries. These typically give projections that extend around 25 years from the base year of the projections, and require some extrapolation to cover the full time horizon to be analysed for WRMPs. The population projections are used by DCLG, NISRA, NRS and Welsh Government to develop household projections for each local authority.

It is widely recommended by government, across a number of application areas, (e.g. DCLG, 2014), that public service organisations use these official (trend-based) projections for planning. Official forecasts are in this sense a natural source of ***original forecasts*** for all public service and utilities sector planning. The government recommends, for example, that when assessing future housing need 'household projections are produced by applying projected household representative rates to the population projections published by the Office for National Statistics' (DCLG, 2014). The NHS recommends that 'population change will be based on the latest available ONS population projections.' (NHS England, 2013).

These recommendations are, however, sometimes tempered by the need to recognise the limitations of official projections and to gain a better understanding of factors specific to local areas:

- The housing assessment advice (DCLG, 2014), for example, goes on to say 'The household projection-based estimate of housing need may require adjustment to reflect factors affecting local demography and household formation rates which are not captured in past trends'.
- In at least one recent case, public service planners have been criticised for over-reliance on official projections. As mentioned in Section 3.5.3 above, the House of

Commons Public Accounts Committee (2013) commented that 'The Department [for Education] was slow to respond to the rising demand for school places […].Despite the birth rate beginning to increase in 2001, it was not until 2008 that the ONS reflected the rising birth rate in its population projections'.

- There have also been other cases in which official projections seem implausible, such as recent ONS projections of decline in the population of Cambridge, a city currently experiencing strong economic growth. (Cambridgeshire County Council, 2013).

Official trend-based projections furthermore do not deliver all water industry requirements in the form they are published. In particular they are not produced for WRZ areas, they do not calculate non-household population in the way required by the water industry, and the Subnational Projections may not extend far enough into the future. There is, therefore, an unavoidable need for water companies to create ***derived statistics*** based upon the statistical agencies' original projections. A methodology guide for creation of derived statistics is therefore required for water companies. This will be included in the guidance manual.

Some other bodies also produce or commission their own trend-based population projections. These include the Greater London Authority (GLA 2015) and other local government bodies (e.g. Cambridgeshire County Council, 2013). These also will generally not meet water industry requirements for geographical units or for extension into the future; consequently, their use still requires the creation of derived statistics.

Alternative sources of trend-based projections may be considered if water companies consider there is sufficient risk associated with using projections based on official statistics only. The acceptability of other sources must be evaluated on a case-by-case basis, and it is recognised that this evaluation is likely to be at least partly based upon an assessment of the credibility of the supplier, since a full comparative evaluation of methodologies is likely to be very difficult or impossible.

While, therefore, official projections are the natural starting point for any public service or utilities planning, it is recommended that planners be aware of the uncertainties in the forecasts, to evaluate the implications associated with these uncertainties.

4.4 Plan-based methods

Use of plan-based methods was considered to be the primary approach to water resources planning in England and Wales in the 2012 Water Planning Guidance (Environment Agency *et al*, 2012), which stated 'The approach to forecasting future population, households and occupancy is focussed on using information produced by local authorities'.

Population and housing projections based upon local authority plans have, however, a number of disadvantages, which include:

- Difficulty in obtaining, collating, quantifying and geographically referencing information from local authorities.

- The risk of "double counting" development if there is overlap of projections between neighbouring local planning authorities.

- The lack of an accepted methodological basis as a method of projecting population.
- Possible inconsistency in planning targets of adjacent local authorities.
- Plans may themselves be based upon either official statistics or some other population projections. If they are, then it may be more logical to consider the projections upon which the plans are based.
- Delivery of housing, or lack of delivery, does not necessarily significantly affect population growth, particularly over relatively large areas. It could simply mean that the projected population live in the houses available, however many that is.
- The exact location of developments identified in local development plans is likely to be deferred to Neighbourhood Plans, particularly in local authorities with significant rural areas. This can be difficult to take account of in the plan-based approach.

Weighed against these disadvantages there are the following benefits:

- Local authority plans may give information not derivable from any other source, particularly relating to the likely location of significant residential developments in the next 5-10 years.
- In exceptional cases, there may be identifiable errors in the official projections for a local authority, for which there is adequate supporting evidence and are of sufficient magnitude that the revised forecasts presented in the local development plans are more reliable.
- DCLG have advised that WRMPs should take account of housing growth set out in local development plans in England, to ensure that the availability of water supplies can support housing or economic development.

4.5 Econometric methods

An alternative approach to population projection is to use methods based upon econometric models. Such models forecast economic growth and changes in employment as part of a model of the national or regional economy, and then forecast changes in population as a derived variable based upon these. These models generally work for large geographical areas, usually not smaller than regions. Some economic forecasting organisations can produce population forecasts based upon these methods, for example as commissioned by Cambridgeshire County Council (2013).

This type of model is less widely used than cohort survival methods as a method of population projection, but is sometimes used at least as a component of a population projection model. For example, Statistics Norway forecasts gross immigration to Norway using an econometric model based on standard migration theories (Cappelen *et al*, 2014). However, econometric models for population and household forecasts currently lack the depth of use and scrutiny that has been applied to trend-based methods. In view of this relative lack of documented use for population projections, it is not currently recommended that they are used to develop “core” projections. Such models can, however, be included to

provide an alternative view of the future, and may give extended indications of the range of uncertainty of future models. Econometric models are, to a significant degree, explanatory rather than extrapolative, and so may be considered suitable particularly if scenario analysis is considered to be required, or if the future is considered particularly uncertain.

Although some indicative projections of economic-related factors are published for the UK (e.g. Office for Budget Responsibility, 2015), it is likely that a specialist consultant would be required to produce the economic and employment forecasts and to develop the econometric model.

4.6 Hybrid approach

When two or more forecasts are derived, a decision needs to be taken on what forecast values to use. This could be to choose:

- One of the forecasts to provide the principal values in preference to the other forecasts. The range of available forecasts may be used as part of the uncertainty assessment.
- Or a combination of the forecasts, referred to as a "hybrid approach" in this report.

The "hybrid approach" could involve calculating a weighted-average of the forecasts (not necessarily using the same weight for each forecast), or could involve using different forecast trends for different periods in the future. There is no established method for a hybrid approach, although the work of Cambridge County Council (2013) provides a good example of using alternative methods to examine the range and validity of potential forecasts, and applying judgement to decide how to use the results.

4.7 Evaluation of alternative methods

A comparative evaluation of the relative merits of each forecasting method has been undertaken using specific criteria, as shown in Table 9 (the derivation of the evaluation criteria is described in Appendix 3).

The green/amber/red colour scheme denotes an indicative assessment of whether the method has strong/moderate/weak characteristics. The evaluation highlights the strengths of the trend-based forecasting method, but identifies that the other methods have merits in particular circumstances.

Table 9 Evaluation of the strengths and weaknesses of forecasting methods (Green = strong characteristics; Amber = moderate; Red = weak)

Criterion	Trend-based method	Econometric modelling method	Plan-based method
1. The forecast gives estimates for all future years required for water planning, typically 25 or more years into the future	Official national projections: yes. Official sub-national projections: typically extend 25 years ahead, and may need to be extended a few more years.	In principle yes. These forecasts are not in general freely available online and must be either purchased or commissioned from a supplier.	Typically local plans project up to 15 years into the future – and may not plan-based population data.
2. The forecast gives estimates for required geographical areas (WRZs)	Generally down to LA level, and need to be remapped onto WRZs, e.g. using LSOA data.	Generally national or regional, but some such as the East of England Forecasting Model (EEFM) give LA figures (Oxford Economics, 2013).	Generally to LA level, with some scope for identifying and quantifying planned locations of future growth in more detail.
3. The methodology is widely accepted and well-documented	Yes. However it may not fully take account of housing growth in local development plans.	Not as much as trend-based methods. Government primary advice is normally for use of trend-based methods, but economic models can give insight into their likely accuracy.	Plan-based methods are largely confined to the water company and energy sectors. Their use for core forecasts has attracted some criticism in that context. A documented methodology was developed for 2014 WRMPs. However, DCLG has advised that WRMPs in England should take account of housing growth forecasts in local development plans.
4. Original forecasts produced by a credible organisation	Official forecasts: yes. Others, if commissioned, will need to be evaluated on a case-by-case basis.	Yes: economic forecasts are generally made by established economic forecasting organisations.	Yes: plans are created by local authorities. There may be some question about whether they are forecasts or are likely to be delivered.

Criterion	Trend-based method	Econometric modelling method	Plan-based method
5. The methodology used for the original forecasts is clearly and fully documented	Official forecasts: yes.	Yes in at least some cases: for example the EEFM has considerable documentation.	Individual local authorities give background information to their local plans, but methodology may vary to some degree from one authority to the next.
6. The creation of derived statistics takes place by clearly defined and documented steps	Yes. This is under the control of water companies regardless of the method.		
7. The methodology has an established track record	Yes. These methods have been extensively used across the world for decades.	These methods have not been as widely used as trend-based methods.	Largely confined to the water and energy sectors in UK.
8. The methodology has been assessed for accuracy over a period of time.	Yes: see, for example the ONS (2008) review of accuracy of historical statistics.	Not aware of any assessment of historical accuracy. The EEFM documentation does show how forecasts have varied from one version to the next (Oxford Economics, 2013).	Not aware of any assessment for accuracy over time.
9. Original forecasts should quantify uncertainty	Can be assessed by either measures of historical accuracy or use of variant projections.	Can be assessed by creation of different scenario forecasts.	Individual local authorities may or may not address uncertainty in their plans.
10. Takes account of the location of local development	Trend-based forecasts can be modified to take account of specific developments.	Generally these models are used at a regional or large county level.	Yes. Enables location of anticipated local development to be identified and used.
11. Flexible use of assumptions and scenarios	Scenarios using alternative assumptions or uncertainty ranges can be applied .	Alternative economic scenarios can be used in the models.	Some individual plans may provide alternative scenarios.
12. Cost effective and easy to obtain data and apply method	Yes. Low cost to obtain official statistics and the analysis requirements are relatively modest.	Economic data are relatively expensive to obtain, and the modelling involved is complex requiring specialist input.	The LA plans are freely available but extensive effort may be required to obtain and analyse the data.

4.8 Occupancy forecasts

Most water companies carry out questionnaire surveys of large number of customers during preparation of their WRMP to obtain information on occupancy, water use characteristics and possibly other information. The results can be used to estimate the current average occupancy of their households, or particular segments (i.e. groups with specific characteristics) of households. They can also be used to determine a confidence range around the average.

There is no established method within the water industry for directly forecasting average occupancy. The main methods available to water companies to forecast the average occupancy of their households are:

a) **By dividing the forecast population by the forecast number of households.** In this case, the population and household forecasts are calculated for the particular group(s) of household customers under consideration, and the occupancy values derived from them. This is the most common approach used by water companies to derive the average occupancy for all households in a WRZ. The occupancy values can provide a very useful sense-check by comparing them with the published official statistics values and/or expert judgement of the expected approximate values. If the occupancy values seem to be too high or too low, the company should check the derivation of the population and household forecasts and may need to adjust some of the calculations.

b) **By using judgement.** When a water company is assessing how to allocate the total population in a WRZ across the different groups of customers (e.g. different meter status types, or other customer segments) assumptions will need to be made concerning the future occupancy trends for each group, which will often differ from group to group. These assumptions are derived by professional judgement taking account of: the current average occupancy of each group in the customer survey; the trend in published official forecasts; the characteristics of each household group; and the expected movement of people between groups over time. Often, some reconciliation adjustments are needed to ensure that the sum of inferred populations for each customer group sum to the total WRZ population.

More details on the importance of occupancy in calculating household consumption rates and how to choose customer segmentation are provided in “WRMP Methods – Household Consumption Forecasting” (UKWIR 2015, in preparation).

4.9 Uncertainty assessment

Inevitably there are errors and uncertainties in the official statistics estimates and projections of population and households, due to uncertainties in the most recent mid-year estimates, and the assumptions used in deriving projections. Census results are also subject to a degree of uncertainty, and ONS give confidence intervals for 2011 Census population estimates (ONS 2014). These indicate a 95% confidence of +/- 0.15% in the total 2011 Census population of England and Wales. The 95% confidence limits for individual local authorities average at +/- 1.4% of the population of each authority, suggesting a root mean square error

(RMSE)[8] of around +/- 0.7% in census population estimates for these areas. Since this level of error is small compared to the level of uncertainty in projections over several years, this report applies the usual working assumption that census estimates are accurate, for the purposes of assessing the accuracy of mid-year estimates and population projections. Little assessment has been made of the uncertainty in household projections other than to apply variant population projections to derive alternative scenarios. The uncertainty topic that has been most studied concerns uncertainty in population forecasts, as discussed below.

4.9.1 Uncertainty in population forecasts

Sources of uncertainty in population forecasts are discussed by Wilson and Rees (2005). Traditional cohort survival models, such as trend-based models, have three explicit sources of uncertainty: in fertility rates, mortality and migration. The largest error generally arises from uncertainty in migration. The Greater London Authority has observed, for example, that migration patterns into and away from London changed significantly after the financial crisis in 2008 and during the subsequent recovery (GLA 2015).

Trend-based models may either use extrapolation of past trends in projecting patterns of fertility, mortality and migration, or they may use models that attempt to explain these trends. Most current methods, including UK official projections, use extrapolation, and this approach has generally been shown to perform better than explanatory methods. Measurement has generally been made in times of relative stability, however, within which extrapolative methods are expected to perform well (Wilson and Rees, 2005).

Two broad approaches have traditionally been used to estimate the level of uncertainty associated with projections:

- Use of **variant projections**, based upon alternative assumptions about future fertility, mortality and migration. ONS publish variant projections at a national level – an example is illustrated in Figure 4, which shows a recently published range of possible population projections from 2012 to 2037 using a variety of assumptions. The highest variant gives a 2037 population figure (a 25 year projection period) for the UK that is 6% higher than the principal projection, while the lowest variant gives a figure 6% lower than the principal projection.

- Use of **post-hoc assessment** of the accuracy of past projections as a guide to future accuracy. ONS have published two post-hoc assessments of the accuracy of subnational projections for local authorities, counties and regions (ONS 2008, 2015). The more recent assessment compares projections dating from 2004 onwards with, essentially, the results of the 2011 census.

Figure 5 shows the typical percentage error, expressed as root mean square error (RMSE), of past projections of the mid-year population in 2011 for a variety of geographical area types in England. It shows that:

[8] Root mean square error (RMSE) is a measure of the typical magnitude of the difference between predicted and measured values.

- For example, there is typically 5.3% difference between the 2004-based population projections for Unitary Authorities at 2011 and the 2011 Mid-Year Estimates, which are closely based on the 2011 Census results.

- The forecasting errors are generally smaller for larger areas (e.g. regions) than for smaller areas (e.g. local authorities).

- The forecasting errors are smaller for shorter projection periods than for longer projections. For example, the errors in 2010-based projections are consistently lower than those in earlier projections.

- Errors for London boroughs are considerably larger than for any other area type.

A further alternative for consideration of uncertainty is the use of scenarios, in which a range of alternative assumptions about the future are developed and described in wide-ranging detail. These alternative assumptions are linked to numerical projections of fertility, mortality and migration and hence to variant population projections. The extra development and explanation present in a scenario analysis, in comparison to the usual use of variant projections, may be considered to give more confidence that the range being considered does encompass the range of likely outcomes. Scenarios can alternatively be viewed as a move towards explanatory methods rather than extrapolation. It is not suggested that scenario development should be a specific requirement, but it is another option available to individual water companies that can be utilised dependent on the level of risk faced (and may be linked to other scenario activities for other elements of the supply-demand balance assessment).

It should be noted that Wilson and Rees (2005) identify limitations of these approaches, and suggest alternative stochastic modelling methods for assessing uncertainty that run multiple projections based upon a simulation of statistical distribution of the uncertain parameters. However, these methods have not as yet been developed or verified to a level that makes then usable in practice for water industry planning purposes at this stage.

The work of Cambridgeshire County Council (2013) shows an example of deriving population and household forecasts using a variety of methods (trend-based, plan-based and econometric) and a range of scenarios using a variety of assumptions for fertility, mortality, migration and economic development.

Figure 4 Estimated and variant population projections for the UK (million), mid-2001 to mid-2037 (from ONS, 2013)

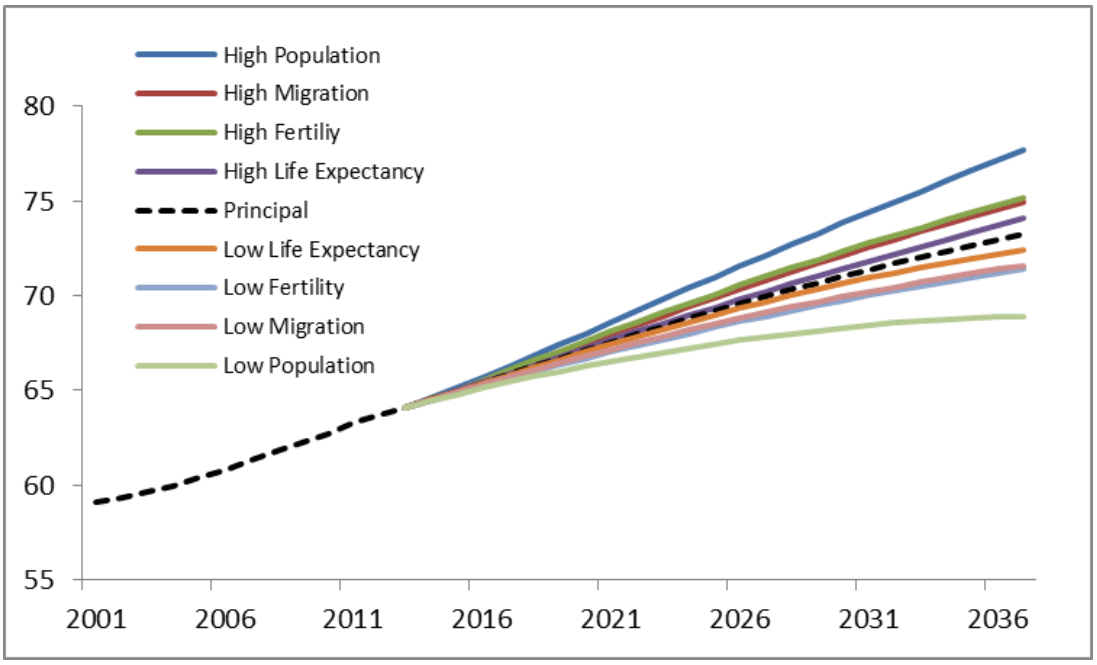
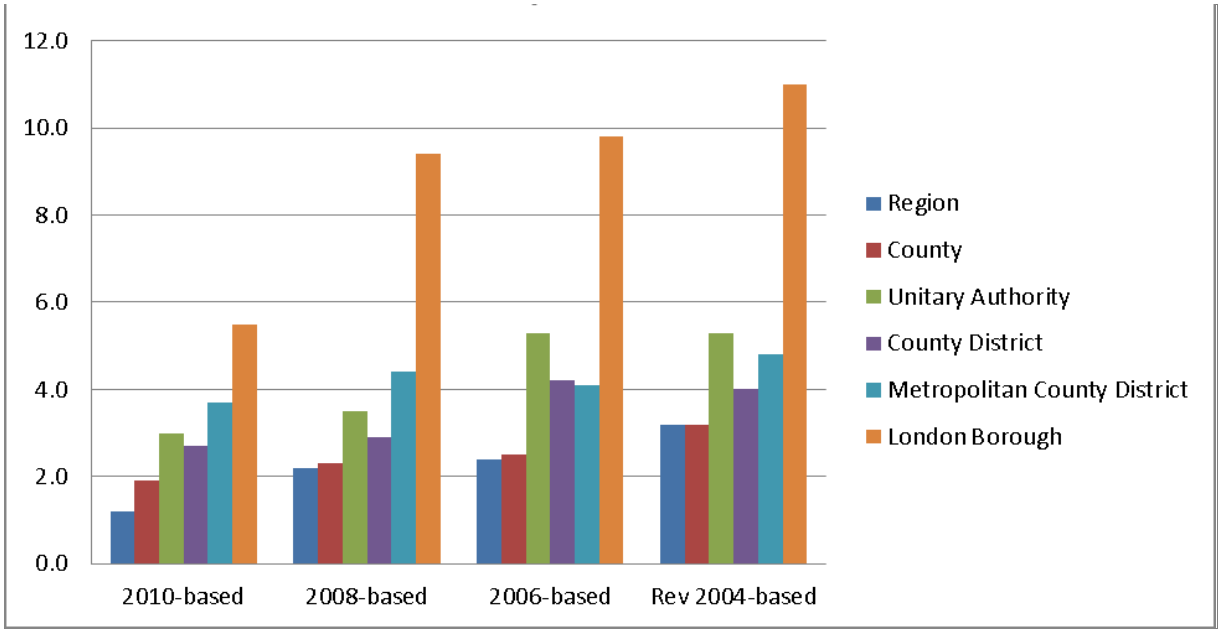


Figure 5 Comparison of typical % difference between predicted and actual 2011 mid-year population estimates, for different periods of projection and different sizes of geographical area

(derived using data in Tables 4 and 7 of ONS, 2015 – as presented later in Table 10 of this report)



4.9.2 Post-hoc accuracy of Projections and Mid-Year Estimates (ONS 2008)

It is considered that a straightforward approach based on post-hoc assessment could be used in an initial evaluation of the likely errors in core projections. This will use "look-up" tables based on the data in (ONS 2015) and other sources, as described below. If this initial evaluation of uncertainty indicates an above-threshold level of risk in a WRZ, then more thorough analysis can be undertaken looking at other sources and methods of making projections, and also examining variant projections.

The typical percentage error (RMSE) for regions, counties and local authorities is shown in Table 10.

Table 10 Typical percentage difference (RMSE) between predicted and report Mid-Year Estimate populations for 2011 – for different sizes of geographical area and different periods of projection (from Tables 4 and 7 of ONS, 2015)

Total projection % RMSE compared to 2011 Mid-Year Estimates	**2010-based projections**	**2008-based projections**	**2006-based projections**	**Revised 2004-based projections**
Regions	1.2	2.2	2.4	3.2
Counties	1.9	2.3	2.5	3.2
All Local Authorities	4.2	5.9	6.6	7.2
Local authorities by type:				
Unitary Authorities (UAs)	3.0	3.5	5.3	5.3
County Districts	2.7	2.9	4.2	4.0
Metropolitan County Districts	3.7	4.4	4.1	4.8
London Boroughs	5.5	9.4	9.8	11.0
Population-weighted average for UAs and County Districts	2.8	3.1	4.6	4.4

These figures provide the basis for the indicative estimates of future errors given below. It is, however, important to note the following:

- The *total projection* RMSE as given above include both errors in the Mid-Year Estimates (*MYE error*) upon which the projections were based, and errors in the forward projections themselves (*forward projection error*). The errors in Mid-Year

Estimates are expected to be higher in the later versions of projections (highest in the 2010-based projections), while the errors in the forward projection process are expected to be higher in the earlier versions of projections.

- In order to make estimates of likely typical error across longer time periods, it is desirable to separate out the MYE error from the forward projection error. The ONS document is of only limited assistance in this, since it gives MYE error for regions (ONS 2015, Table 4) but not for smaller areas.

- It can be seen from the table above that errors have been much larger in London boroughs than in other kinds of local authority. The aim of this study is to give an indication of likely error for Water Resource Zones (WRZs) of various indicative sizes. WRZs of roughly the size of a local authority are however generally outside London and other metropolitan areas. The RMSE values for Unitary Authorities and County Districts can therefore be considered as indicative of the likely forecasting errors for WRZs of similar size to local authorities.

The following table gives estimates of RMSE in Mid-Year Estimates for areas of various sizes, derived by comparing the original population estimate with revised estimates to reflect methodological improvements. Values for Regions are taken from ONS (2015, table 4). Values for Unitary Authorities and County Districts (combined) are derived from an independent comparison of ONS original and revised (after the 2011 census) Mid-Year estimates. Values for counties are approximate estimates interpolated from these figures following the broad pattern for errors in projections given above.

Mid-Year Estimates % RMSE	**2010 MYE**	**2008 MYE**	**2006 MYE**	**2004 MYE**
Regions	1.1	1.2	0.7	0.3
Counties	1.7	1.2	0.8	0.3
UA / County Districts	2.5	2.0	1.4	0.9

Detailed analysis of errors in MYE and projections can in principle determine forward projection error and MYE error accurately. ONS have not published this analysis however and it is beyond the scope of the production of this document. Instead, as an approximation, if it is assumed that MYE error and forward projection errors are correlated, i.e. across geographical areas, the level of over or under-estimation in Mid-Year Estimates corresponds to the level of over or under-estimation in forward projections. This seems a reasonable assumption since the main cause of error in both is migration estimates, and errors in estimating migration in a local authority are likely to be largely shared by both MYE and projections.

Under this assumption:

Total projection RMSE = Forward projection RMSE + MYE RMSE

This gives the following estimates of forward projection RMSE:

Forward projection % RMSE to 2011	2010-based projections	2008-based projections	2006-based projections	Revised 2004-based projections
Regions	0.1	1.0	1.7	2.9
Counties	0.2	1.1	1.7	2.9
UAs / County Districts	0.3	1.1	3.2	3.5

These can be extrapolated to obtain an indication of expected forward projection RMSE over a 10-year period:

Forward projection % RMSE	10-year period
Regions	3.8
Counties	3.8
UAs / County Districts	5.3

These baseline estimates for forward projection RMSE over a ten-year period can be extrapolated and combined with MYE error as described below.

4.9.3 Post-hoc accuracy of Projections and Mid-Year Estimates (Post 2011)

These figures give a basis for a broad estimate of likely levels of error in future projections. The 10-year figures can be multiplied up to give error estimates 20 and 30 years into the future, and applied to areas of roughly the size of regions, counties or local authorities.

The approach used assumes that:

- Errors are distributed normally. This assumption is unlikely to be true in practice and is discussed further below.

- Percentile points will be given relating to the distribution of individual areas. It may be expected, for example, that 5% of areas may lie below to 5th percentile, 10% below the 10th percentile etc.

- The figures given for 20 and 30 years in the future are based upon the assumption that errors in successive decades are uncorrelated with each other. So, if an area grows more rapidly than expected over the next 10 years, this is not taken to imply

that the growth over the subsequent 10-year period will also be an underestimate. Under this assumption, squares of errors, rather than RMSE errors, accumulate over time. This assumption is arguably optimistic, in that it leads to rather smaller estimates of likely errors over a 20 or 30 year period than would an assumption of positive correlation between projection errors in consecutive decades.

- The next round of WRMP forecasts are to take place around 2018, and will therefore use 2016 Mid-Year Estimates and 2016-based projections. The 2016 MYE are assumed to have the same RMSEs as the 2006 MYE had.

The estimated error distributions are summarised in Tables 11 to 13, and are presented in Section 6 of the Guidance Manual in the form of "look-up" tables. The RMSE values are equivalent to standard deviations and were used to derive the presented percentile values assuming the errors are normally distributed.

Table 11 Region expected percentile error distribution for future years based on 2016 (%)

Region	**Year**						
Percentile	**2016**	**2021**	**2026**	**2031**	**2036**	**2041**	**2046**
97.5	1.4	6.6	8.8	10.5	11.9	13.1	14.3
95	1.2	5.6	7.4	8.8	10.0	11.0	12.0
90	0.9	4.3	5.8	6.9	7.8	8.6	9.3
75	0.5	2.3	3.0	3.6	4.1	4.5	4.9
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	-0.5	-2.3	-3.0	-3.6	-4.1	-4.5	-4.9
10	-0.9	-4.3	-5.8	-6.9	-7.8	-8.6	-9.3
5	-1.2	-5.6	-7.4	-8.8	-10.0	-11.0	-12.0
2.5	-1.4	-6.6	-8.8	-10.5	-11.9	-13.1	-14.3
RMSE	0.7	3.4	4.5	5.4	6.1	6.7	7.3

Table 12 County expected percentile error distribution for future years based on 2016 (%)

County	Year						
Percentile	**2016**	**2021**	**2026**	**2031**	**2036**	**2041**	**2046**
97.5	1.6	6.8	9.0	10.7	12.1	13.3	14.5
95	1.3	5.7	7.6	9.0	10.2	11.2	12.1
90	1.0	4.5	5.9	7.0	7.9	8.7	9.5
75	0.5	2.4	3.1	3.7	4.2	4.6	5.0
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	-0.5	-2.4	-3.1	-3.7	-4.2	-4.6	-5.0
10	-1.0	-4.5	-5.9	-7.0	-7.9	-8.7	-9.5
5	-1.3	-5.7	-7.6	-9.0	-10.2	-11.2	-12.1
2.5	-1.6	-6.8	-9.0	-10.7	-12.1	-13.3	-14.5
RMSE	0.8	3.5	4.6	5.5	6.2	6.8	7.4

Table 13. Local authority (Unitary Authority/County District) expected percentile error distribution for future years based on 2016 (%)

Local Authority	Year						
Percentile	**2016**	**2021**	**2026**	**2031**	**2036**	**2041**	**2046**
97.5	2.7	10.1	13.1	15.5	17.4	19.2	20.7
95	2.3	8.5	11.0	13.0	14.6	16.1	17.4
90	1.8	6.6	8.6	10.1	11.4	12.5	13.6
75	0.9	3.5	4.5	5.3	6.0	6.6	7.1
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	-0.9	-3.5	-4.5	-5.3	-6.0	-6.6	-7.1
10	-1.8	-6.6	-8.6	-10.1	-11.4	-12.5	-13.6
5	-2.3	-8.5	-11.0	-13.0	-14.6	-16.1	-17.4
2.5	-2.7	-10.1	-13.1	-15.5	-17.4	-19.2	-20.7
RMSE	1.4	5.1	6.7	7.9	8.9	9.8	10.6

In these tables the error shown for 2016 is the expected error in Mid-Year Estimates only, since this round of forecasts is expected to use 2016-based projections.

One caveat with this guideline is that there are indications that errors are not normally distributed. This is suggested by the GLA (2012) data, which shows that three local authorities had, according to the 2011 census, populations more than 20% higher than indicated in the 2010 mid-year estimates. Had the above assumptions about normality been true, there would have been expected to be none, or at most one. These local authorities are Manchester (+22.1%), Newham (+26.7%), and Tower Hamlets (+24.4%), with Hackney (+19.8%) nearly 20% higher. The informal implication here seems to be that there may be a higher than usual risk of large unanticipated growth in authorities in large urban areas.

It can also be observed that growth of population in some London Boroughs defied all expectations in the period 2001-2011. This fact suggests that the straightforward approach given above may be inadequate for use in London.

4.10 Using uncertainty estimates

The main approaches that have been used by water companies for quantifying the extent of uncertainty in components of water demand forecasts are:

- Deterministic ranges
- Probability density functions (pdf)
- Scenarios

The **deterministic ranges** approach involves the derivation of an upper and a lower forecast for to establish a range within which it is very likely that the actual value will lie. For example (for illustrative purposes) the percentage values in Tables 11, 12 or 13 could be assumed to estimate the range of upper and lower values for forecast populations.

The **probability density functions** approach involves identifying a probability density functions (pdf), for each input value in the analysis that represents the range and shape of distribution of feasible values. There are many different distributions that can be used, for example the distribution may be described by a normal curve ("bell-shaped") using the approximate values in Tables 11, 12 or 13.

The **scenarios** approach involves identifying a range of "what if?" scenarios for each input variable in the analysis which are used to calculate alternative demand forecasts. The input variables could include, for example, population (or contributory factors such as birth rate, mortality rate or migration rate), households, or per capita consumption. The variability in forecasts across the scenarios is examined to identify the potential uncertainty.

The Guidance Manual provides outline guidance for the estimation of uncertainty in population and household forecasts. But it does not cover the incorporation of assessed uncertainties in the calculation of the supply-demand balance as this is addressed by the UKWIR projects "WRMP19 Methods – Risk Based Planning" (UKWIR 2016, in preparation).

5 Proposed approach for 2019 WRMPs

5.1 Core methods

Trend-based forecasting using official population and household estimates and projections (e.g. from ONS, DCLG, Welsh Government, NRS and NISRA) has been identified as a method that could be widely used, for the reasons described in the preceding sections:

- The data sources are trustworthy.
- The statistical analyses used are well-established, having been used over many years, validated and incrementally improved.
- They are widely used across all sectors.
- The water industry is familiar with using them.
- Official statistics are often the only readily available source of population projections, unless the local authority has developed its own plan-based projections.
- Trend-based forecasts can be adapted to use local authority plan-based projections.

Plan-based forecasting has the important merit of taking explicit account of housing growth projections in local authority plans, which DCLG has advised as being required to ensure that WRMPs can support planned housing and economic growth in England. The development of a plan-based forecast may often use parts of the trend-based forecast as a starting point, in particular:

- The approach to establishing base-year values would be the same.
- The reconciliation of household or population projections to the base-year values would follow the same approach.
- The trend-based population forecasts may need to be used, unless the local authority has calculated population projections that differ from official statistics.
- Official statistics used to develop trend-based forecasts extend further into the future than local authority plans.

5.2 Proportionate approach

The UK water industry has adopted a proportionate approach to the preparation of WRMPs, as reinforced by the water resources planning framework methodologies currently being developed for “WRMP19 Methods – Risk Based Planning” (UKWIR 2016, in preparation) and “WRMP19 Methods – Decision Making Process” (UKWIR, 2016, in preparation). These allow water companies to choose appropriate methods for the demand forecast according to the assessed supply-demand balance issues (“problem characterisation”) of each WRZ.

Therefore, for WRZs with few or no supply-demand issues, or where the population and household forecasts have small impact on the supply-demand issues, a simple application of planning information may often be adequate, to ensure that there is sufficient availability of water supplies to support housing and population growth. It will however be important for companies in to comply with government policy and any specific requirements set out in the Water Resources Planning Guideline (and any equivalent guidance issued in Scotland and Northern Ireland).

For WRZs with a more significant supply-demand balance issues, there is likely to be a need to obtain a more detailed understanding of the planning information and/or engage with the local authorities. There may also be a need to calculate supplementary forecasts to better understand potential uncertainty, for example by developing alternative trend-based or plan-based scenarios and/or using other methods such as econometric or hybrid forecasts and associated scenarios.

5.3 Engaging with local authorities

Local authorities are an important source of local information on anticipated housing needs. Local development plans in final or draft form, as published on local authority websites, provide housing growth projections which can be used.

The extent to which a water company makes use of other local authority information (in addition to that in local development plans) or engages with its local authorities in determining household and population forecasts is likely to vary according to the WRZ characteristics and supply-demand issues faced, and the extent to which housing growth could affect WRMP forecasts.

For WRZs with few or no supply-demand issues, the local development plans should provide adequate information.

For WRZs with more substantial supply-demand issues to address, the further methods of engagement or use of local authority information that could be considered include:

- Meetings with some or all local authorities.
- Written, or telephone, requests for information not on their websites, or for details of specific developments or issues.
- Review of other planning documents for some or all local authorities available on their websites. For example Objectively Assessed Need (OAN), Strategic Housing Land Availability Assessment (SHLAA), or Strategic Housing Market Assessment (SHMA) documents that each local authority produces to establish evidence for its housing growth projections.
- Review of information available through operational or planning personnel within the water company who have contact with the local authorities on development matters.
- Targeted “planning forum” with all or a selection of local authorities which may also enable wider dialogue on asset planning as well as for WRMP purposes.

- Or any combination of some of the above.

5.4 Framework methodology

The proposed framework methodology for forecasting population and households in 2019 WRMPs is illustrated in Figure 6. It is based on the findings from engagement with stakeholders and the technical review of methods, as described above and the preceding sections.

The methodology comprises six primary Tasks:

- **Task A. Assess needs and make choices** – involves considering the requirements of the population and household forecasts and the WRZ supply-demand "problem characterisation", to help choose how to calculate the forecasts. Choices will need to take account of regulatory guidance and policy.

- **Task B. Assess Local Development Plans** – involves collating and assessing the housing growth forecasts set out in local authority development plans, and engaging with local authorities as appropriate to obtain further information and understanding about the housing plans.

- **Task C. Calculate population and household forecasts** – involves applying the chosen forecasting method(s): trend-based and/or plan-based and/or econometric and/or a "hybrid" approach using a combination of methods.

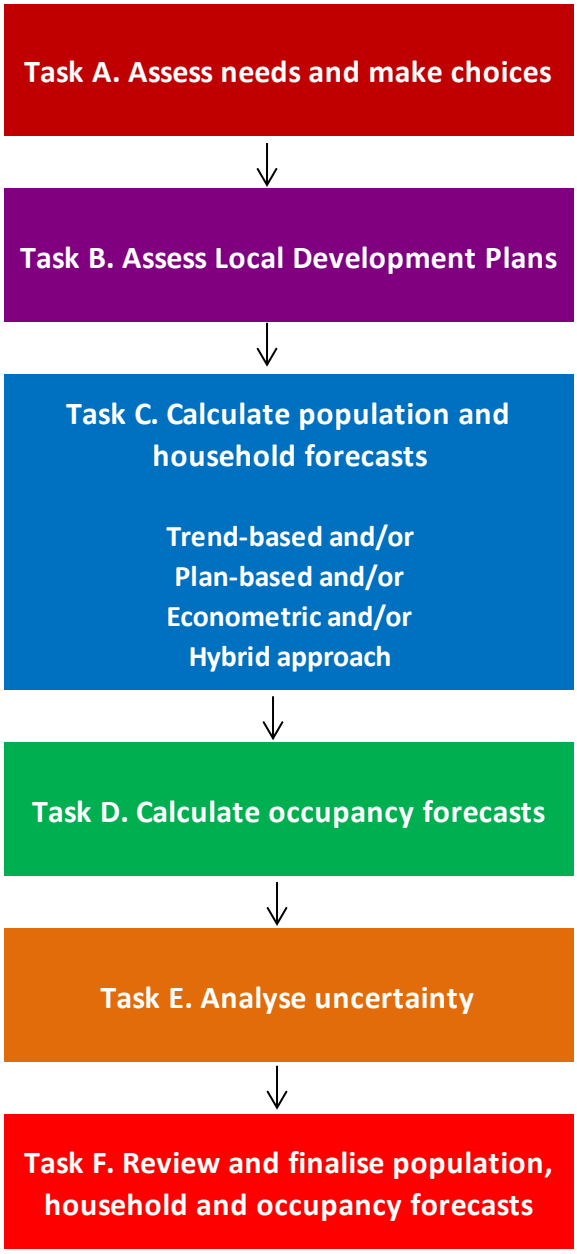
- **Task D. Calculate occupancy forecasts** – involves checking the occupancy values implied by the population and household forecasts and making modifications if necessary to ensure consistency between the values derived.

- **Task E. Analyse uncertainty** – involves quantifying potential uncertainty in the population, household or occupancy forecasts. Look-up tables that provide approximate confidence ranges are presented for companies to use in their uncertainty analyses (links to the UKWIR WRMP19 Risk Based Planning project).

- **Task F. Review and finalise population, household and occupancy forecasts** – involves carrying out appropriate checks and identification of preferred forecasts.

Detailed guidance on how to undertake each of these tasks is provided in the accompanying Guidance Manual.

Figure 6 Flowchart for the recommended process for 2019 WRMPs



6 Conclusions and recommendations

6.1 Conclusions

The stakeholder engagement (Section 3) found that:

- Trend-based population and household projections, from official statistics, are widely used as the starting point or the sole basis for forecasting by the majority of UK public sector bodies and utilities.

- Finalised, evidence-based Local Development Plans in England should be available for most local authorities for use in the development of the 2019 WRMPs.

- As advised by DCLG, WRMPs for water companies in England should take account of the housing growth set out in Local Development Plans, and ensure that the availability of water supplies can support housing and economic development. The Water Resources Planning Guideline for 2019 WRMPs (currently in preparation) is likely to provide policy guidance on this.

- The new methodology should be flexible, enabling each water company to choose the level of analysis that is appropriate for the supply-demand issues faced in its WRZs. For some WRZs a simple approach is appropriate. There should be improved flexibility for companies with WRZs where there are greater supply-demand challenges, with options to apply more sophisticated methods.

- Improved understanding of how to assess the uncertainty of population, household property and occupancy forecasts is needed.

The review of alternative forecasting methods used in the UK and elsewhere (Section 4) found that:

- There are three population and household forecasting approaches suitable for consideration: trend-based, plan-based and econometric.

- Trend-based forecasts use official statistics that are derived from assumed rates for fertility, mortality and migration. Trend-based forecasts are widely used in the UK because they are derived by well-established and reliable statistical methods, and the assumptions have been subject to expert panel review. The data collation and analysis can be relatively straightforward. Therefore, trend-based forecasting is suitable for widespread use by water companies, especially for population forecasting.

- Plan-based forecasts use local authority household projections and have been used within the water and energy sectors to take account of local authority development plans. The forecasts of local development tend to be of variable quality and completeness. However, local authority plans provide local information that is not derivable from any other source relating to the potential size and location of significant housing developments over the next 5 to 10 years.

- Econometric modelling applies assumptions about how future economic growth may affect employment, housing development and population movements. These models generally work for large geographical areas (usually not smaller than regions), but can provide alternative forecasts for consideration.

- The potential uncertainty in trend-based forecasts can be estimated by applying the typical variations in past projections. Alternatively, a scenario approach can be applied to any of the above forecasting methods to derive ranges of forecasts for different assumptions.

6.2 Recommendations

The stakeholder engagement (Section 3) and the evaluation of alternative forecasting methods (Section 4) have been used to form the proposed approach for 2019 WRMPs (Section 5). These have identified that the following principles should be applied by water companies and be incorporated within the Guidance Manual:

1. The approach used by each water company to forecast population, household properties and occupancy should be consistent with:

    - The policy guidance in the Water Resources Planning Guideline (or equivalent), and

    - The supply-demand balance "problem characterisation" of its WRZs (as developed in a parallel UKWIR project (WRMP19 Decision-Making Process)).

2. Water companies in England should ensure their WRMPs take account of housing growth set out in Local Development Plans. Guidance is also provided on the approach taken to local housing growth projections in Wales, Scotland and Northern Ireland.

3. The extent to which a water company makes use of other local authority information (in addition to that in Local Development Plans) or engages with its local authorities in determining household and population forecasts is likely to vary according to the WRZ characteristics and problem characterisation, and the extent to which housing growth could affect WRMP forecasts or be constrained by supply-demand considerations.

4. Trend-based population, household and occupancy forecasts using official statistics may be developed to provide a useful starting point. The forecasts can be used or, if required, adapted to derive plan-based forecasts that take explicit account of local authority housing projections.

5. Water companies should recognise that some local authority projections may be in draft form. Companies may need to consider the extent to which proposed housing developments will occur and whether the location or timing of the developments may change.

6. Uncertainty assessment should be carried out on population and household forecasts by deriving appropriate evidence-based ranges or scenarios, and using deterministic or stochastic approaches to explore and quantify the potential uncertainty.

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Appendix 1 Acknowledgements and list of stakeholders consulted

Acknowledgements

The Project Team is very grateful to everyone in the stakeholder organisations that we spoke to or met with, and for the information they provided, which was invaluable in developing this report and the Guidance Manual.

Stakeholders

The stakeholders that were consulted in the project are listed below.

Water regulatory bodies and government agencies:		
Defra	Local Government Association	Welsh Government
Department for Communities and Local Government (DCLG)	Natural Resources Wales	
Environment Agency	Ofwat	
Water companies:		
Affinity Water	Northern Ireland Water	Southern Water
Anglian Water	Northumbrian Water	Sutton and East Surrey Water
Bournemouth Water	Portsmouth Water	Thames Water
Bristol Water	Scottish Water	United Utilities
Cambridge Water	Severn Trent Water	Wessex Water
Dee Valley Water	South East Water	Yorkshire Water
Dŵr Cymru - Welsh Water	South Staffs Water	Also: Water Resources in South East project (WRSE)
Essex and Suffolk Water	South West Water	

Other stakeholders:		
Local authorities	**Energy Sector**	**Others**
AGMA (Association of Greater Manchester Authorities)	Electricity North West	Department for Education
Cambridgeshire County Council	Energy Networks Association	Department for Transport
Conwy County Borough Council	Energy UK	NHS England
East Sussex County Council	GDF Suez	
GLA (Greater London Authority)	National Grid	
Liverpool City Council	UK Power Networks	
Oxfordshire County Council		
Vale of White Horse District Council		
Wealden District Council		

Appendix 2 Water company structured survey questionnaire

This Appendix presents a copy of the structured survey questionnaire issued to water companies. The answers were obtained by telephone or face-to-face interviews, as described in Section 3.3.

Objective of survey:

The purpose of the survey is to identify:

- The methods that are currently in use in the UK to forecast population, households and occupancy for water resource zones.
- The issues and needs that should be addressed by the new forecasting methodology (being developed by this project).
- Suggestions for improvements to the existing methods or alternative new methods.

Contact details:

Name of water company:	
Name of person completing the questionnaire:	
Contact telephone number:	

Questions:

1. **Population and household forecasting** (delete choices where appropriate)

Question	Answer - population	Answer - households
a) Which types of water resource zone population/household forecasts were developed for your 2014 WRMP?	• Trend-based • Plan-based • Most likely • Other (please specify)	• Trend-based • Plan-based • Most likely • Other (please specify)
b) Which forecast did you choose as your central estimate?		
c) Why was this forecast chosen?		
d) What were the pros and cons of developing more than one type of forecast (if applicable)?		
e) How would you describe the effort and level of analysis required to develop your population and household forecast(s)?	• Too little • Reasonable • Too complex • Other comments?	

Question	Answer - population	Answer - households
f) Who produced your water resource zone population and household forecasts?	• In-house • Consultant • Specialist census agent • Mix of the above • Other (please specify)	
g) What were the reasons for your choice of resource?		
h) To what extent did you check that you and neighbouring water companies were developing consistent forecasts?		
i) What geography level was used in deriving water resource zone population/household data and forecasts?	• Local authority • Lower Super Output Area (LSOA) • Postcode • Other (please specify)	• Local authority • Lower Super Output Area (LSOA) • Postcode • Other (please specify)
j) Why was this geography-level chosen?		
k) How did you reconcile values obtained with those on your company billing system?		
l) How did you allocate values obtained for your chosen geography-level to each WRZ?		
m) In hindsight, would a different geography-level have been more appropriate, if so what?		
n) What were your main data sources for *base year* population/ household estimates?	• ONS • Local authorities • Billing system • Other (please specify)	• DCLG • ONS • Local authorities • Billing system • Other (please specify)
o) What were your main data sources for population/ household *projections*?	• ONS • Local authorities • Other (please specify)	• DCLG • ONS • Local authorities • Other (please specify)
p) How did you calculate the uncertainty around your central population/household base year and forecast values?		
q) What (if any) major problems did you or your	Obtaining population data:	Obtaining household data:

Question	Answer - population	Answer - households
consultant/agent encounter in … (Note: Question 2 asks about your engagement with local authorities.)	Reconciling population data:	Reconciling household data:
	Producing population forecasts:	Producing household forecasts:
	Choosing preferred forecast:	Choosing preferred forecast:
	Assessing uncertainty:	Assessing uncertainty:
r) How were these problems addressed?	Obtaining population data:	Obtaining household data:
	Reconciling population data:	Reconciling household data:
	Producing population forecasts:	Producing household forecasts:
	Choosing preferred forecast:	Choosing preferred forecast:
	Assessing uncertainty:	Assessing uncertainty:
s) What (if any) improvements would you like to see in the new methodology regarding …	Obtaining population data:	Obtaining household data:
	Reconciling population data:	Reconciling household data:
	Producing population forecasts:	Producing household forecasts:
	Choosing preferred forecast:	Choosing preferred forecast:
	Assessing uncertainty:	Assessing uncertainty:

2. Engagement with local authorities

Question	Answer
a) How many local authorities did you contact to request plan-based forecasts?	
b) How many local authorities provided the information you needed?	
c) What benefits to the WRMP were achieved by producing plan-based forecasts?	
d) What other benefits to the WRMP were obtained by engaging with local authorities?	
e) What were the drawbacks of engaging with local authorities?	
f) What extent and types of engagement with local authorities should the new forecasting methodology recommend?	
g) How did you use the information that local authorities provided?	
h) What influence did the data provided by local authorities have on the projections and base data you produced?	

3. Occupancy

Question	Answer
a) How did you forecast average occupancy for each water resource zone? (delete choices as appropriate)	• From household and population forecasts • From published occupancy forecasts • Other (please specify)
b) How did you *forecast* average occupancy for each customer grouping/segment?	
c) How did you check for consistency between population, household and average occupancy forecasts for each water resource zone?	
d) What adjustments or other actions were needed to achieve consistency between population, household and average occupancy forecasts?	
e) How did you calculate uncertainty around your central occupancy estimates?	

4. Suggestions for the new methodology

Question	Answer
a) Do you have any other suggestions for	

improvements to the new methodology for forecasting population, households and occupancy?	
b) What other forecasting methods should this project investigate?	
c) How should the forecasts be baselined in WRMP19 in the absence of a recent national census?	

Thank you very much for your time and help.

Appendix 3 Development of evaluation criteria

This Appendix summarises how the criteria for evaluating the alternative forecasting methods were identified.

The Project Team initially identified the following items as important criteria against which to assess a method for forecasting population and households, based on the stated UKWIR and Environment Agency requirements for the project:-

a) Costs (data acquisition, level of resource input required, software and hardware requirements)
b) Benefits (including accuracy, transparency, ease of use by practitioners, time requirements)
c) Data requirements: volume of data needed; data quality; availability (including its maintenance over the longer-term); spatial and temporal coverage and depth of coverage; licensing and/or cost implications
d) Levels of uncertainty associated with the data inputs and projection outputs (and how those uncertainties can be determined and assessed by practitioners)
e) Level of usage of data and/or method across the UK
f) Flexibility of assumptions and/or scenarios
g) Acceptability (to both companies, government and regulators)
h) Implementation issues and risks
i) Level of complexity of analysis
j) Suitability for application to water resources planning and associated activities in relation to delivering resilient water supplies
k) Ability to check/test the validity of the data and forecast
l) Ability for the forecasts to take account of localised development may be important.

Although derived for a different purpose, the requirements for household consumption forecasting methods identified by the current UKWIR project: "WRMP 2019 Methods – Household Consumption Forecasting" were also considered:-

A. Acceptance by the regulator, industry and external stakeholders
B. Transparency and clarity
C. Logical/theoretical appeal
D. Explicit treatment of factors that affect consumption (not directly applicable to the current project)
E. Empirical validation
F. Appropriate to the level of risk being addressed
G. Explicitly address uncertainty
H. Be underpinned by valid data

However, population and household statistics and forecasting methods have specific characteristics. As the project developed, it was decided to adopt criteria that are more relevant and could be more definitively evaluated, as listed in the table below. There are many links with the criteria identified above.

Criteria for evaluation of forecasting methods
1. The forecast gives estimates for all future years required for water planning, typically 25 or more years into the future
2. The forecast gives estimates for required geographical areas (WRZs)
3. The methodology is widely accepted and well-documented
4. Original forecasts are made by a credible organisation
5. The methodology of original forecasts is clearly and fully documented
6. The creation of derived statistics takes place by clearly defined and documented steps
7. The methodology has an established track record
8. The methodology has been assessed for accuracy over a period of time.
9. Original forecasts should quantify uncertainty
10. Takes account of the location of local development
11. Flexible use of assumptions and scenarios
12. Cost effective, and easy to obtain data and apply method