

# WRMP19 METHODS – POPULATION, HOUSEHOLD PROPERTY AND OCCUPANCY FORECASTING

## WORKED EXAMPLE





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## UK WATER INDUSTRY RESEARCH LIMITED

### WRMP19 METHODS – POPULATION, HOUSEHOLD PROPERTY AND OCCUPANCY FORECASTING WORKED EXAMPLE

#### Executive Summary

#### Objectives

The primary aims of this project are 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.
- 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.

The purpose of this **Worked Example document and accompanying Worked Example Spreadsheet** is to provide a practical example of how to follow the guidance and undertake the calculations described in the Guidance Manual.

#### Recommendations

It is recommended that this Worked Example is used by water demand forecasting practitioners to assist them in applying the Guidance Manual to calculate population, household property and occupancy forecasts for the 2019 WRMPs. The information presented is intended as an illustration of the decisions and calculations that may need to be taken.

The worked example is NOT provided as a definitive approach to calculating population, household and occupancy forecasts. Equally, the accompanying spreadsheet is provided to help readers check their understanding of how the worked example calculations have been undertaken. The spreadsheet is NOT a calculation tool.

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## Glossary

### Term / Acronym

<b>DCLG</b>	Department for Communities and Local Government
<b>LA</b>	Local authority
<b>Local authority</b>	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.
<b>LDP</b>	Local Development Plan
<b>LSOA</b>	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.
<b>NISRA</b>	Northern Ireland Statistics and Research Agency
<b>NRS</b>	National Records of Scotland
<b>Official statistics</b>	Term used in this report to refer to population and household data published by official national statistics organisations: ONS, DCLG, NISRA, NRS and Welsh Government.
<b>ONS</b>	Office for National Statistics
<b>WRPG</b>	Water Resources Planning Guideline (Environment Agency et al, 2016 in preparation). It is currently being updated to provide guidance to water companies in England and Wales for the preparation of their 2019 WRMPs.
<b>WRMP</b>	Water Resources Management Plan
<b>WRZ</b>	Water resource zone

Note: A more detailed glossary of terms and definitions is provided in the Guidance Manual



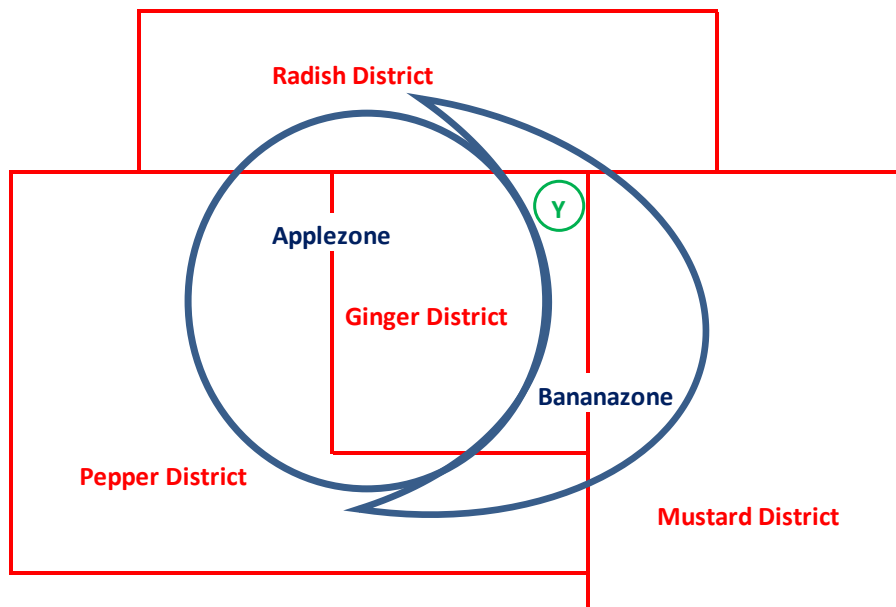
## 1 Aims

The Guidance Manual (separate report) provides practical guidance to water companies on how to carry out population, household property and occupancy forecasting for 2019 WRMPs and beyond. This Worked Example report presents an illustrative example of how to follow the guidance and undertake the calculations.

## 2 Background Information on Worked Example

Imagine that it is now May 2017 and you have been asked to calculate the population, household property and occupancy forecasts for Eggsample Water Company's draft 2019 WRMP. Indicative estimated forecasts are needed by your Director tomorrow, with more detailed forecasts needed by August. You intend to follow the guidance in the Guidance Manual.

The following diagram illustrates the main features of the area served by Eggsample Water Company.



Eggsample Water Company is in England and has two water resource zones:

- Applezone
- Bananazone

These two water resource zones serve all or parts of 4 local authority areas:

- Ginger District
- Mustard District
- Pepper District
- Radish District

You are aware that:

- Ginger and Mustard councils have each produced a Local Development Plan.
- A major new housing development is planned at Yummytown (marked “Y” in the above diagram) in Ginger District - the development will be in Bananazone.
- The base year for Eggsample’s draft 2019 WRMP is 2016/17 and the company has chosen a planning horizon to 2044/45.
- All new households are metered and unmeasured households can opt to be metered, but the company is not planning any compulsory metering of unmeasured households.
- The company also needs to investigate potential investment requirements in its water distribution network.

### **3 Worked Example**

This worked example follows the 6 Tasks described in the Guidance Manual.

The calculation process as presented is lengthy. This is largely because each calculation step is presented in detail. In practice, you would streamline the sequence of calculations and the number of tables involved could be much reduced.

#### **3.1 Task A. Assess needs and make choices**

##### **Assessing needs (see Section 2.1 of Manual)**

You assess:

1. The guidance in the Water Resources Planning Guideline (WRPG):
  - You identify that the current (2015 consultation draft) guidance for water companies in England requires that your WRMP should take account of housing growth set out in local development plans.
2. The company’s needs for population and household forecasts:
  - You identify that population and household forecasts are needed for water distribution network planning as well as for the 2019 WRMP.
  - Forecasts are therefore needed for each district meter area (DMA) as well as for each WRZ.
  - Important investment decisions for DMAs in Bananazone are likely to depend on the location of planned developments. So you anticipate that, for distribution network planning, plan-based forecasts will be required for Bananazone.

3. The size of your WRZs:
  - You identify that your WRZs comprise portions of local authority areas, but your DMAs are very much smaller.
4. 'Problem characterisation' of the supply-demand balance of your WRZs:
  - You use the information in the UKWIR report "WRMP19 Methods – Decision Making Process" (UKWIR 2016, in preparation) to characterise the future supply-demand problems in each zone. You identify that Applezone has few supply-demand balance issues to address but there are more substantial issues to resolve in Bananazone.
5. The availability of digital boundaries:
  - You confirm that digital boundaries are available on your company's geographical information system for your WRZs, DMAs and local authorities, and can be used with the billing system to calculate the number of households in each area.

### **Making choices (see Section 2.2 of Manual)**

You make the following choices:

1. Forecasting method
  - You decide to use plan-based forecasts to comply with WRPG guidance and because the location of planned developments may influence your WRZ and DMA investment decisions.
  - You decide to also prepare trend-based forecasts using LA geography because they provide a useful starting point for calculating plan-based forecasts. In addition, you are interested to see how similar the plan-based and trend-based forecasts are.
  - Econometric modelling is not appropriate to consider because your WRZs are much smaller than a region, and further forecasts are not needed.
2. Operational areas
  - You decide that you need forecasts for WRZs and DMAs, and you prepare a full schedule of them.
3. Census geography
  - Your WRZs comprise parts of local authority areas and so Lower Super Output Area (LSOA) geography may be appropriate.
  - Your DMAs are small areas, typically supplying less than 5000 people and so small area geography (e.g. LSOA, Output Area (OA) or postcode) would be appropriate. You decide that postcode geography should be used as these are smaller than the

smallest DMAs to derive DMA forecasts. You will build-up the DMA values to produce WRZ forecasts.

- You need some early provisional forecasts by tomorrow, so you decide that you will calculate initial forecasts using LA geography, and use the results to cross-check the later forecasts using postcode geography.

4. Which forecast is more important?

- You identify whether you will calculate household consumption forecasts using per capita consumption or per household consumption values, and therefore whether population or household projections are more important to focus attention on to ensure accurate demand forecasting.

5. In-house or external resources

- You decide to use in-house resources to calculate the initial trend-based and plan-based forecasts for WRZs using LA geography.
- Because of the data and analysis complexities involved, you decide that for the more detailed analyses you will employ a specialist population forecasting consultant to undertake the WRZ and DMA forecasts using postcode geography.

In summary, you decide to:

- Undertake **two sets of initial calculations** for your WRZs. You will apply trend-based forecasting using LA geography (Option 1 in Guidance Manual) and plan-based forecasting (Option 4 in Guidance Manual) using LA geography. You will carry out the initial calculations in-house.
- Subsequently, you will employ a specialist consultant to calculate forecasts for each DMA using a **more detailed approach**. You will ask the consultant to use Local Development Plan data, where available, supplemented by official statistics information where necessary. For population forecasting, you expect only official statistics data to be available, and so you will apply trend-based forecasting using postcode geography (Option 3 in Guidance Manual). For household projections, you will ask the consultant to use plan-based forecasting (Option 4 in Guidance Manual) using small area geography as much as possible, but recognise that some local development plan information may be difficult to accurately allocate to postcodes.
- Use the initial forecasts to sense-check the forecasts from the detailed forecasting for DMAs with build-up to WRZs.

The Worked Example in this document will present both sets of initial calculations:

- Trend-based calculations are described in Section 3.3
- Plan-based calculations are described in Section 3.4

### 3.2 Task B. Assess Local Development Plans

#### Step 1. Obtain local development plans from local authority websites (Section 3.1.1 of Manual)

You obtain the latest available Local Development Plans (LDPs) from the websites for Ginger District and Mustard District. You check that adequate data on proposed future housing growth are available so that you can use them. You note that the other two local authorities served by your WRZs, Pepper District and Radish District, have not yet published a LDP.

You record the housing projections in the following table, noting that none of the local authorities have developed their own population projections.

**Table 1 Projections of households from Local Development Plans ('000)**

Local authority	Status of LDP	2014	2015	2016	2017	2018	2019	2020	2029
Ginger District	Final	59.94	60.52	61.28	62.04	62.84	63.74	64.78	70.50
Mustard District	Draft	49.83	50.19	50.74	51.27	51.77	52.28	52.76	56.61
Pepper District	None - use DCLG	33.09	33.34	33.65	33.96	34.27	34.57	34.87	37.63
Radish District	None - use DCLG	23.06	23.32	23.64	23.95	24.25	24.55	24.83	27.43

Note: Projections were available from the LDPs for Ginger and Mustard for each year to 2029. Only selected years are shown here.

Note: The Mustard LDP is currently draft, but you decide to include its projections.

Note: As Pepper and Radish districts have not yet published a LDP, you have used the DCLG projections instead.

#### Step 2. Consider more detailed use of local development plans (Section 3.1.2 of Manual)

You identify from the Ginger District LDP that the Yumyumtown development is planned to take place in Bananzone between 2015 and 2022. The lack of LDPs for significant parts of your WRZs means that it is difficult to make detailed use of the LDPs at the present time in your initial analyses. But you are concerned to ensure that the Yumyumtown development is accurately assigned to appropriate DMAs, and so you will ask your consultant to take special care in their detailed analyses using postcode geography.

#### Step 3. Consider the need for more planning information and/or engagement with local authorities (Section 3.1.3 of Manual)

You decide that you will engage with the local authorities, in particular to gain better understanding of the housing plans in areas served by Bananzone which has been identified as having particular supply-demand challenges.

The additional information will be used by your consultant but will not be ready in time for your initial calculations.

### 3.3 Task C. Calculate trend-based forecasts using LA geography

#### Step 1. Obtain data from official statistics websites (Section 4.1.1 of Manual)

You obtain the most up-to-date official statistics data (at May 2017 – the date for this imaginary worked example) for each local authority:

- a) 2015 mid-year population estimates (from ONS website)
- b) 2014-based population projections (from ONS website)
- c) 2014-based household projections (from DCLG website)
- d) 2011 census data for communal population (from ONS website)

Note: You would obtain data from the NISRA, NRS or Welsh Government website if some or all your local authorities are in one of the other UK nations.

The following table summarises the official statistics data you have obtained.

**Table 2 Summary of official statistics data ('000)**

Item	2011	2014	2015	2016	2017	2018	2019	2020	2039
ONS 2015 mid-year population estimates:									
• Ginger District			134.90						
• Mustard District			121.80						
• Pepper District			78.67						
• Radish District			53.92						
ONS 2014-based population:									
• Ginger District		134.4	134.8	135.4	136.0	136.8	137.5	138.3	153.4
• Mustard District		119.4	119.8	120.4	121.1	121.7	122.3	122.9	134.0
• Pepper District		78.3	78.8	79.3	79.8	80.3	80.9	81.4	89.6
• Radish District		53.9	54.3	54.8	55.4	55.9	56.4	57.0	65.4
DCLG 2014-based household projections:									
• Ginger District		59.94	60.32	60.78	61.24	61.74	62.24	62.78	73.36
• Mustard District		49.83	50.09	50.54	50.97	51.37	51.78	52.16	59.43
• Pepper District		33.09	33.34	33.65	33.96	34.27	34.57	34.87	40.23
• Radish District		23.06	23.32	23.64	23.95	24.25	24.55	24.83	29.67
ONS 2011 census communal population:									
• Ginger District	0.93								
• Mustard District	1.96								
• Pepper District	0.88								
• Radish District	0.64								
Note: Projections were obtained for each year from 2014 to 2039, but are presented here for just selected years.									

#### Step 2. Convert household numbers to financial years (Section 4.1.2 of Manual)

You calculate the financial year equivalent values for official statistics household estimates and projections, as illustrated in the following table.



**Table 3 Official statistics household projections converted to financial years ('000)**

Item	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2038/39
2014-based household projections ('000):							
• Ginger District	60.44	60.90	61.37	61.87	62.38	62.92	73.00
• Mustard District	50.20	50.65	51.07	51.47	51.88	52.26	59.15
• Pepper District	33.42	33.73	34.04	34.35	34.65	34.95	40.04
• Radish District	23.40	23.72	24.03	24.33	24.62	24.91	29.52

Note: Values were calculated for all years to 2038/39, but are presented here for selected years.

Note: The financial year figures have been estimated from calendar year figures: for example 2016/17 values are estimated as weighted averages of 2016 values (75%) and 2017 values (25%).

### Step 3. Calculate base-year water supply households (Section 4.1.3 of Manual)

You obtain billing system counts of household customers in each local authority in each WRZ, as shown in Table 4. Also, although not shown here, you are able to obtain the estimated number of households receiving a private water supply from the company's billing system – you find that they are all in Radish District.

**Table 4 Numbers of households from billing system - 2016/17 average ('000)**

Item	Applezone WRZ	Bananazone WRZ	Total
Total billed households ('000):			
• Ginger District	41.33	19.14	60.47
• Mustard District	0	31.53	31.53
• Pepper District	4.71	0	4.71
• Radish District	4.01	6.31	10.32
• <b>Total</b>	<b>50.05</b>	<b>56.98</b>	<b>107.03</b>

### Step 4. Determine allocations to WRZs (Section 4.1.4 of Manual)

You want to produce a table of the percentage (or proportion) of billed households in each local authority area that are in each WRZ.

This will be based on figures for the base year, 2016/17, using official statistics data (Table 3) and billing system data (Table 4) for each local authority. The 2016/17 household estimates are presented in Table 5 and are used to calculate a table of percentage allocations (Table 6).

**Table 5 Base year (2016/17) household estimates for each WRZ ('000)**

	<b>Total (from official statistics)</b>	<b>Applezone WRZ (from billing system)</b>	<b>Bananazone WRZ (from billing system)</b>	<b>Not allocated to a WRZ</b>
Ginger District	60.90	41.33	19.14	0.43
Mustard District	50.65	0	31.53	19.12
Pepper District	33.73	4.71	0	29.02
Radish District	23.72	4.01	6.31	13.40
WRZ total		50.05	56.98	

Note: Properties that are not allocated to a WRZ include any households that are outside the WRZs served by Eggsample Water Company, or properties within a WRZ but that are not classed as households on the billing system or receive a private water supply.

**Table 6 Percentage allocations of households to each WRZ ('000)**

	<b>Total</b>	<b>Applezone WRZ</b>	<b>Bananazone WRZ</b>	<b>Not allocated to a WRZ</b>
Ginger District	100%	67.87%	31.43%	0.70%
Mustard District	100%	0.00%	62.25%	37.75%
Pepper District	100%	13.96%	0.00%	86.04%
Radish District	100%	16.91%	26.60%	56.49%

Note: Percentage allocations have been calculated from the data in Table 5.  
Note: The Applezone allocation for Ginger District, for example, was calculated as  $41.33/60.90 = 0.6787 = 67.87\%$ .

**Step 5. Calculate forecast water supply households (Section 4.1.5 of Manual)**

You apply the percentage allocations in Table 6 to calculate the numbers of households provided with water services by each WRZ (Table 7).

**Table 7 Household forecasts for each WRZ ('000)**

<b>Item</b>	<b>2016/1 7</b>	<b>2017/1 8</b>	<b>2018/1 9</b>	<b>2019/2 0</b>	<b>2020/2 1</b>	<b>2021/2 2</b>	<b>2038/3 9</b>
Applezone	50.05	50.46	50.90	51.34	51.79	52.27	60.13
Bananazone	56.98	57.47	57.96	58.45	58.94	59.44	67.62

Note: Values were calculated for all years to 2038/39, but are presented here for selected years.  
Note: These values have been calculated from values in Tables 3 and 6. For example: Applezone 2016/17 value was calculated as  $= 0.6787*60.90 + 0.1396*33.73 + 0.1691*23.72 = 50.05$ .  
Note: The calculations for 2016/17 cross-check with the billing system counts in Table 4.

In order to extend the forecasts to the 2044/45 WRMP horizon, you have decided to extrapolate from 2038/39 to 2044/45 by applying the trend for the last 10 years (for example) of the official statistics projections. The values you obtain are presented in Table 8.

**Table 8 Extrapolated household forecasts to 2044/45 ('000)**

	2028/29	2038/39	Av. increase	2039/40	2040/41	2041/42	2044/45
Applezone	55.67	60.13	0.445	60.57	61.02	61.47	62.80
Bananazone	62.90	67.62	0.472	68.10	68.57	69.04	70.45

Note: Forecasts were calculated for each year to 2044/45, but are presented here for just selected years.  
 Note: For Applezone, for example, the average annual increase between 2028/29 and 2038/39 =  $(60.13 - 55.67) / 10 = 0.445$ , so the value for 2039/40 (for example) =  $60.13 + 0.445 = 60.57$ .  
 Note: Values may not sum exactly due to rounding.

**Step 6. Calculate base year and forecast water supply populations (Section 4.1.6 of Manual)**

In order to calculate the population provided with water services in each WRZ, you carry out the following calculations:

- Reconcile population projections to latest mid-year estimates (Table 9)
- Consider exceptional need for adjustment – none required in this example
- Convert adjusted population projections to financial years (Table 10)
- Apply WRZ allocations to calculate WRZ populations (Table 11)
- Extrapolate to WRMP horizon (2044/45) (Table 12)

**Table 9 Reconciliation of population projections with latest mid-year estimates**

Item	2015	2016	2017	2018	2019	2020	2039
Ginger District	134.90	135.50	136.10	136.90	137.60	138.40	153.51
Mustard District	121.80	122.41	123.12	123.73	124.34	124.95	136.24
Pepper District	78.67	79.17	79.67	80.17	80.77	81.27	89.45
Radish District	53.92	54.42	55.01	55.51	56.01	56.60	64.94

Note: Values were calculated for all years to 2039, but are presented here for selected years.  
 Note: The 2015 values are latest mid-year population estimates from the first part of Table 2.  
 Note: The projections for subsequent years (from the second part of Table 2) have been adjusted to reconcile with the latest mid-year estimates. The equation in Section 4.1.6 of the Guidance Manual has been used. For example:  
 Ginger District adjusted population for 2016 = Population projection for 2016 \* Latest mid-year estimate for 2015 / Population projection for 2015 =  $135.4 * 134.9 / 134.8 = 135.50$ .

**Table 10 Reconciled official statistics population projections converted to financial years**

Item	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2038/39
Ginger District	135.05	135.65	136.30	137.08	137.80	138.63	153.06
Mustard District	121.95	122.59	123.27	123.88	124.49	125.08	135.86
Pepper District	78.79	79.29	79.79	80.32	80.89	81.39	89.23
Radish District	54.04	54.57	55.14	55.63	56.15	56.73	64.72

Note: Values were calculated for all years to 2038/39, but are presented here for selected years.  
 Note: The financial year figures have been estimated from calendar year figures: for example 2016/17 values are estimated as weighted averages of 2016 values (75%) and 2017 values (25%).

**Table 11 Population forecasts for each WRZ ('000)**

Item	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2038/39
Applezone	111.80	112.37	112.97	113.66	114.32	115.04	127.29
Bananazone	132.75	133.47	134.25	135.01	135.75	136.53	149.90

Note: Values were calculated for all years to 2038/39, but are presented here for selected years.  
 Note: These population values have been calculated from values in Tables 6 and 10. For example: Applezone 2016/17 value was calculated as = 0.6787\*135.65+0\*122.59 + 0.1396\*79.29 + 0.1691\*54.57 = 112.37.

**Table 12 Extrapolated population forecasts to 2044/45 ('000)**

	2028/29	2038/39	Av. increase	2039/40	2040/41	2041/42	2044/45
Applezone	121.22	127.29	0.607	127.90	128.50	129.11	130.93
Bananazone	142.86	149.90	0.705	150.61	151.31	152.02	154.13

Note: Forecasts were calculated for each year to 2044/45, but are presented here for just selected years.  
 Note: The extrapolation calculation method chosen was the same as for households in Table 8.

**Step 7. Calculate non-household population (Section 4.1.7 of Manual)**

You decide to estimate the non-household population by summing estimates of:

- **Communal population:** You estimate the communal population in each WRZ by applying the % allocations (at Table 6) to the 2011 census communal population in each LA (Table 2). For example, the communal population in Applezone is estimated as:

$$0.6787*930 + 0*1960 + 0.1396*880 + 0.1691*640 = 862$$

- **Population in other non-household properties:** You use your billing system to estimate that there are 500 residences in Applezone that are in properties allocated as non-households (e.g. farms and bulk supply flats) that are likely to have people residing in them. You assume an average occupancy of 2.1 for these residences to obtain an estimated population of 1050.

You therefore estimate the non-household population in Applezone as  $862+1050 = 1912$ .

A similar calculation has identified that the non-household population for Bananazone is **3002**.

You consider that, in the case of these WRZs, the non-household population is unlikely to change significantly over time and so use the same values for forecast non-household populations.

### SUMMARY OF TREND-BASED FORECASTS

The finalised forecasts after following Steps 1 to 7 are summarised in Tables 13 and 14.

**Table 13 Final trend-based household forecasts ('000)**

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2029/30	2038/39	2044/45
Applezone	50.05	50.46	50.90	51.34	51.79	52.27	52.74	56.17	60.13	62.80
Bananazone	56.98	57.47	57.96	58.45	58.94	59.44	59.93	63.42	67.62	70.45

**Table 14 Final trend-based population forecasts for households and non-households ('000)**

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2029/30	2038/39	2044/45
Household forecasts:										
Applezone	112.37	112.97	113.66	114.32	115.04	115.80	116.56	121.94	127.29	130.93
Bananazone	133.47	134.25	135.01	135.75	136.53	137.24	137.92	143.73	149.90	154.13
Non-household population:										
Applezone	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91	1.91
Bananazone	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Total population:										
Applezone	114.28	114.89	115.57	116.23	116.96	117.71	118.47	123.85	129.20	132.84
Bananazone	136.47	137.25	138.01	138.76	139.53	140.25	140.92	146.74	152.91	157.13

### **3.4 Task C. Calculate plan-based forecasts using LA geography**

#### **1. Identify and review local authority housing projections (Section 4.4.1 of Manual)**

You have collated the data available from Local Development Plans (see Table 1), which you will use for your initial plan-based forecasting analyses. You decide that more detailed analysis is not appropriate until after completing the engagement with local authorities.

#### **2. Calculate plan-based household forecasts for WRZs (Section 4.4.2 of Manual)**

As suggested in the Guidance Manual, you decide to adapt the trend-based forecasting approach applied in Section 3.3 to prepare your plan-based household projections. You will use the local authority housing projections (Table 1), where possible, in the place of the official statistics projections.

Therefore, adapting the trend-based method calculation steps, your calculations for household forecasts are as follows:

- **Step 1. Obtain data from official statistics websites and Local Development Plans**

The data are as presented earlier in Tables 1 and 2.

- **Step 2. Convert household numbers to financial years**

See Table 15, below.

- **Step 3. Calculate base-year water supply households**

The data, derived from the billing system, are presented earlier in Table 4.

- **Step 4. Determine allocations to WRZs**

The data, derived from the billing system, are presented earlier in Table 6.

- **Step 5. Calculate forecast water supply households**

Tables 16 and 17, below, show how proportional allocations and extrapolations are used to calculate forecast water supply households. The finalised plan-based forecasts are presented in Table 18.

**Table 15 Projections of households from local development plans, converted to financial years ('000)**

	Calendar years									
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2029
Ginger District (from LDP)	61.28	62.04	62.84	63.74	64.78	65.53	66.29	66.95	67.52	70.50
Mustard District (from LDP)	50.74	51.27	51.77	52.28	52.76	53.26	53.74	54.20	54.65	56.61
Pepper District (from DCLG)	33.65	33.96	34.27	34.57	34.87	35.20	35.51	35.83	36.14	37.63
Radish District (from DCLG)	23.64	23.95	24.25	24.55	24.83	25.14	25.44	25.74	26.03	27.43
	Financial years									
	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2028/29
Ginger District	61.47	62.24	63.07	64.00	64.97	65.72	66.46	67.09	67.67	70.05
Mustard District	50.87	51.40	51.90	52.40	52.89	53.38	53.86	54.31	54.74	56.30
Pepper District	33.73	34.04	34.35	34.65	34.95	35.28	35.59	35.91	36.22	37.41
Radish District	23.72	24.03	24.33	24.62	24.91	25.22	25.52	25.81	26.10	27.23
<p>Note: Numbers for Ginger and Mustard districts are from Local Development Plans (LDP), but from DCLG for Pepper and Radish Districts because they have not yet published a Local Development Plan.</p> <p>Note: 2029 is the last year with household projections in the Local Development Plans. Values were calculated for all years to 2028/29, but are presented here for selected years.</p> <p>Note: The financial year figures have been estimated from calendar year figures: for example 2016/17 values are estimated as weighted averages of 2016 values (75%) and 2017 values (25%).</p>										

**Table 16 Plan-based household forecasts for each WRZ ('000)**

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2028/29
Applezone	50.05	51.06	51.71	52.44	53.19	53.79	54.39	54.91	55.40	57.37
Bananazone	57.30	57.95	58.60	59.29	59.97	60.60	61.20	61.77	62.29	64.31

Note: The base-year (2016/17) values are taken from the billing system - see Table 5.  
 Note: The values for 2017/18 to 2028/29 have been calculated from values in Tables 6 and 15. For example: Applezone 2017/18 value was calculated as = 0.6787\*62.24 + 0\*51.40 + 0.1396\*34.04 + 0.1691\*24.03 = 51.06.  
 Note: Values were calculated for all years to 2028/29, but are presented here for selected years.

**Table 17 Extrapolated plan-based household forecasts to 2044/45 ('000)**

	2028/29 plan- based	2028/29 trend- based	2044/45 trend- based	Av. Increase	2029/30 plan- based	2030/31 plan- based	2031/32 plan- based	2032/33 plan- based	2033/34 plan- based	2044/45 plan- based
Applezone	57.37	55.67	62.80	0.445	57.82	58.26	58.71	59.15	59.60	64.50
Bananazone	64.31	62.90	70.45	0.472	64.78	65.26	65.73	66.20	66.67	71.86

Note: In this case it was decided to extrapolate from 2028/29 using the average trend in household growth from 2028/29 to 2044/45 calculated by the trend-based method from official statistics.  
 Note: Forecasts were calculated for all years to 2044/45, but are presented here for selected years.

### 3. Calculate plan-based population forecasts for WRZs (Section 4.4.3 of Manual)

None of your local authorities have derived evidence-based population projections that differ from official statistics, so your calculation of population forecasts is the same as described above in Section 3.3 using the trend-based method:

- **Step 6. Calculate base year and forecast water supply populations**

The analysis for your trend-based population forecasting using official statistics remains valid. Your results are as in Tables 9 to 12.

- **Step 7. Calculate non-household population**

The analysis for your trend-based forecasting remains valid. Your results are as in Table 14.

#### SUMMARY OF PLAN-BASED FORECASTS

- Your plan-based population forecasts are as calculated previously, and presented in Table 14.
- Your plan-based household forecasts are as presented below in Table 18.
- You recognise that you have not taken account of the specific location of the Yumyumtown (or any other) proposed development in your initial analyses. You will



ask your consultant to pay special attention to this when undertaking the more detailed analyses.

**Table 18 Final plan-based household forecasts ('000)**  
(for selected years, from Tables 16 and 17)

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2028/29	2038/39	2044/45
Applezone	50.05	51.06	51.71	52.44	53.19	53.79	54.39	57.37	61.83	64.50
Bananazone	57.30	57.95	58.60	59.29	59.97	60.60	61.20	64.31	69.03	71.86

### 3.5 Task D. Calculate occupancy forecasts

The example calculations presented here for Task D are based on the trend-based forecasts, as calculated in Section 3.3. Similar calculations would apply for the plan-based forecasts.

#### Step 1. Calculate and check base-year occupancy values (Section 5.1.1 of Manual)

The average household occupancy suggested by your trend-based forecasting for the base-year (2016/17) is calculated from values in Tables 13 and 14:

- Applezone = 112.37 population / 50.05 households = 2.245
- Bananazone = 133.47 population / 56.98 households = 2.342

You compare these with the average company-wide occupancy value obtained from your customer survey in 2016 of 2.305. There seems to be reasonable consistency but you will check further at Step 3.

#### Step 2. Calculate and check forecast occupancy values (Section 5.1.2 of Manual)

You prepare a table (Table 19) of the average household occupancy values inferred by your trend-based forecasting.

You note that there is a gradual downward trend in each WRZ. You then compare this with the local authority occupancy values you have calculated using official statistics in Table 20.

As expected, your occupancy values are slightly different, but they are close and the trends look similar.

**Table 19 Average household occupancy forecasts for WRZs**

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2029/30	2038/39	2044/45
Household forecasts ('000) (trend-based, from Table 13):										
Applezone	50.05	50.46	50.90	51.34	51.79	52.27	52.74	56.17	60.13	62.80
Bananazone	56.98	57.47	57.96	58.45	58.94	59.44	59.93	63.42	67.62	70.45
All zones	107.03	107.94	108.86	109.78	110.73	111.70	112.67	119.59	127.75	133.26
Household population forecasts ('000) (trend-based, from Table 14):										
Applezone	112.37	112.97	113.66	114.32	115.04	115.80	116.56	121.94	127.29	130.93
Bananazone	133.47	134.25	135.01	135.75	136.53	137.24	137.92	143.73	149.90	154.13
All zones	245.84	247.23	248.67	250.07	251.58	253.05	254.48	265.67	277.19	285.06
Inferred average occupancy forecasts:										
Applezone	2.245	2.239	2.233	2.227	2.221	2.216	2.210	2.171	2.117	2.085
Bananazone	2.342	2.336	2.329	2.323	2.317	2.309	2.301	2.266	2.217	2.188
All zones	2.297	2.290	2.284	2.278	2.272	2.265	2.259	2.222	2.170	2.139

**Table 20 Average occupancy forecasts from official statistics for local authorities**

	2016	2017	2018	2019	2020	2021	2022	2023	2029	2039
Household forecasts ('000) (from Table 2):										
Ginger District	60.78	61.24	61.74	62.24	62.78	63.33	63.89	64.45	68.00	73.36
Mustard District	50.54	50.97	51.37	51.78	52.16	52.56	52.94	53.30	55.61	59.43
Pepper District	33.65	33.96	34.27	34.57	34.87	35.20	35.51	35.83	37.63	40.23
Radish District	23.64	23.95	24.25	24.55	24.83	25.14	25.44	25.74	27.43	29.67
Total	168.6 1	170.1 2	171.6 3	173.1 4	174.6 4	176.2 3	177.7 8	179.3 2	188.6 7	202.6 9
Total population forecasts ('000) (from Table 2):										
Ginger District	134.4	134.8	135.4	136.0	136.8	137.5	138.3	139.2	146.4	153.4
Mustard District	119.4	119.8	120.4	121.1	121.7	122.3	122.9	123.4	128.3	134.0
Pepper District	78.3	78.8	79.3	79.8	80.3	80.9	81.4	81.9	86.0	89.6
Radish District	53.9	54.3	54.8	55.4	55.9	56.4	57.0	57.5	61.6	65.4
Total	386.0 0	387.7 0	389.9 0	392.3 0	394.7 0	397.1 0	399.6 0	402.0 0	422.3 0	442.4 0
Inferred average occupancy forecasts:										
Ginger District	2.211	2.201	2.193	2.185	2.179	2.171	2.165	2.160	2.153	2.091
Mustard District	2.362	2.350	2.344	2.339	2.333	2.327	2.321	2.315	2.307	2.255
Pepper District	2.327	2.320	2.314	2.308	2.303	2.298	2.292	2.286	2.285	2.227
Radish District	2.280	2.267	2.260	2.257	2.251	2.243	2.241	2.234	2.246	2.204
Total	2.289	2.279	2.272	2.266	2.260	2.253	2.248	2.242	2.238	2.183

### **Step 3. Consider uncertainty in occupancy values (Section 5.1.3 of Manual)**

Your 2016 customer survey of 500 households indicated an average company-wide occupancy of 2.305 with a standard deviation of 0.841.

You use the formula in Section 5.1.3 of the Guidance Manual to calculate an approximate 90% confidence range for the survey results:

- Lower value =  $2.305 - (1.65 * 0.841 / \sqrt{500}) = 2.243$
- Upper value =  $2.305 + (1.65 * 0.841 / \sqrt{500}) = 2.367$

So, if your customer survey is representative of the household customers, you have 90% confidence that the true average occupancy lies within this range. In practice, your customer survey is unlikely to be fully representative and so the confidence range values are approximate.

You note that the base-year average occupancies for your two WRZs are 2.245 and 2.342 and so lie within this range.

You have read the IMPORTANT NOTE in the manual for this step and decide that, at Task E, your primary assessment of uncertainty in demographic data will be based on population forecasts (rather than on household or occupancy forecasts).

### **Step 4. Modify population or household forecasts if necessary (Section 5.1.4 of Manual)**

You conclude that the base year and forecast average occupancy values look reasonable and there is no need to make any modification to your forecasts.

### **Step 5. Consider customer segmentation (Section 5.1.5 of Manual)**

You are interested in the various options for customer segmentation, but at present you decide to use just meter status. You define four meter status segments:

- Existing metered households
- Unmetered households
- Future new homes
- Future meter optants

### **Step 6. Calculate occupancy and population forecasts for customer segments (Section 5.1.6 of Manual)**

You obtain forecasts of the numbers of new homes from your trend-based household growth forecast and of the numbers opting for metering based on your company's optional metering programme.

You obtain estimates of the average occupancy in the base-year (2016/17) for each meter status type from your company’s customer survey of water use.

Next, you check the consistency of your base-year average occupancy values and carry out reconciliations as appropriate, as summarised for Applezone WRZ in Table 21.

You note from Table 19 that average occupancy (across all households) in Applezone is expected to gradually reduce by 7.1% across the planning period from 2.245 at 2016/17 to 2.085 at 2044/45. You make initial assumptions, as shown in Table 22, about trends in average occupancy values for Applezone WRZ.

These initial assumptions infer that the total household population ('000) in Applezone will be 128.17 at 2044/45, which is less than the 130.93 value from your trend-based forecast (Table 14). So you need to adjust your assumption for one or more segments to ensure a match with the 130.93 value. You also need to check values for other years in the planning period and apply reconciliations. The easiest way is to adjust the average occupancy for one segment to ensure population reconciliation in each year. Table 23 shows that, for example, by adjusting the optant household average occupancy at 2044/45 to 2.002 the total WRZ population matches the 130.93 value.

**Table 21 Base year occupancy assessment for Applezone**

Item of information (for base year, 2016/17)	Source	Value	Calculation
Total household population from official statistics ('000)	Trend-based population forecast	112.37	
Number of metered households ('000)	Billing system	19.86	
Number of unmetered households ('000)	Billing system	30.19	
Total households ('000)	Billing system	50.05	
Initial average occupancy of metered households	Customer survey	2.111	
Initial average occupancy of unmetered households	Customer survey	2.433	
Initial metered household population using customer survey average occupancy ('000)	Calculated	41.92	=19.86*2.111
Initial unmetered household population using customer survey average occupancy ('000)	Calculated	73.45	=30.19*2.433
Initial total population inferred by using customer survey occupancy values ('000)	Calculated	115.38	=41.92+73.45

**Note:** Reconciliation of average occupancy values is required to ensure that inferred total population matches that derived using official statistics (112.37). Example calculations given

below:			
Estimated average occupancy of all households based on customer survey	Calculated	2.305	=115.38/50.05
Estimated average occupancy of all households based on trend-based forecast using official statistics	Calculated	2.245	=112.37/50.05
Adjustment needed to survey occupancies	Calculated	-0.060	=2.245-2.305
Revised average occupancy of metered households	Calculated	2.051	=2.111-0.060
Revised average occupancy of unmetered households	Calculated	2.373	=2.433-0.060
Revised metered household population ('000)	Calculated	40.73	=2.051*19.86
Revised unmetered household population ('000)	Calculated	71.64	=2.373*30.19
Revised total household population ('000)	Calculated	112.37 (match ok)	=40.74+71.62

**Table 22 Initial assumptions for (trend-based) forecast occupancy values and household numbers by meter status in Applezone**

	2016/17 occupancy value	Basis	Initial 2044/45 occupancy value	Basis	Forecast 2044/45 household number ('000)	Basis	Inferred household population at 2044/45 ('000)
Existing metered households	2.051	Table 21	1.905	7.1% reduction	19.86	Same as 2016/17	37.84
Unmetered households	2.373	Table 21	2.373	Unchanged	15.19	Reduction due to optants	36.04
Future new homes	2.281	Customer survey	2.119	7.1% reduction	12.75	Forecast growth in households	27.02
Future meter optants	1.818	Customer survey	1.818	Unchanged	15.00	Company forecast	27.27
<b>Total</b>					<b>62.80</b>		<b>128.17</b>

**Table 23 Revised assumptions for (trend-based) forecast occupancy values and household numbers by meter status in Applezone**

	2016/17 occupancy value	Basis	Revised 2044/45 occupancy value	Basis	Forecast 2044/45 household number ('000)	Basis	Inferred household population at 2044/45 ('000)
Existing metered households	2.051	Table 21	1.905	7.1% reduction	19.86	Same as 2016/17	37.84
Unmetered households	2.373	Table 21	2.373	Unchanged	15.19	Reduction due to optants	36.04
Future new homes	2.281	Customer survey	2.119	7.1% reduction	12.75	Forecast growth in households	27.02
Future meter optants	1.818	Customer survey	2.002	Revised to achieve reconciliation	15.00	Company forecast	30.03
<b>Total</b>					<b>62.80</b>		<b>130.93</b>

### 3.6 Task E. Analyse uncertainty

The example calculations presented for Task E are based on the trend-based forecasts, as calculated in Section 3.3. Similar calculations would apply for the plan-based forecasts (Section 3.4).

#### Step 1. Identify the size category of your WRZ(s) (Section 6.1.1 of Manual)

You decide that the size of your WRZs is more like local authorities than regions or counties. So the look-up values in Table 10 of the Guidance Manual can be applied.

#### Step 2. Use look-up tables to quantify uncertainty (Section 6.1.2 of Manual)

You decide to calculate an approximate 90% confidence range around the population forecasts for your WRZs. The 5 and 95 percentile values for each year are taken from Table 10 of the Guidance Manual, as summarised below in Table 24.

**Table 24 Approximate 90% confidence range values from look-up table**

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2044/45
95 %ile	2.61%	3.85%	5.09%	6.33%	7.57%	8.63%	9.13%	9.63%	10.13%	16.95%
5 %ile	-2.61%	-3.85%	-5.09%	-6.33%	-7.57%	-8.63%	-9.13%	-9.63%	-10.13%	-16.95%

Note: Values were calculated for all years but are presented here for selected years.

You have read the IMPORTANT NOTE in the front page of Task E in Section 6 of the Guidance Manual. You decide that you will calculate uncertainty ranges for just population.

Table 25 shows the approximate upper and lower 90% confidence range population forecasts for Applezone (for example) and the principal forecast. You are therefore 90% confident that the actual population in a particular year will be between the upper and lower forecast values.

**Table 25 Approximate 90% confidence range for Applezone total population forecasts ('000)**

	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2044/45
Principal forecast	112.37	112.97	113.66	114.32	115.04	115.80	116.56	117.39	118.17	130.93
Upper forecast	115.30	117.32	119.44	121.55	123.75	125.79	127.19	128.69	130.13	153.12
Lower forecast	109.43	108.62	107.87	107.08	106.34	105.81	105.92	106.09	106.20	108.74

Note: Values were calculated for all years but are presented here for selected years.  
 Note: Principal forecast values taken from Table 14.  
 Note: The upper and lower 90% confidence range forecasts are calculated by applying the percentile values in Table 24 to the principal forecast. For example, the upper forecast for 2016/17 = 112.373 + 2.61%\*112.37 = 115.30.

**Step 3. Consider alternative forecasts and scenarios (Section 6.1.3 of Guidance Manual)**

You decide to wait until you have the results from the more detailed population and household forecasting before deciding what (if any) other forecasts or scenarios should be calculated.

**3.7 Task F. Review and finalise forecasts**

You have completed your initial calculations. You have prepared trend-based and plan-based population and household forecasts for Applezone and Bananazone WRZs using LA geography. You have also calculated upper and lower 90% confidence range population forecasts.

You carry out the checks that are listed for Task F in Section 7 of the Guidance Manual, and undertake any changes that are needed to your forecasts.

You now await the results from the more detailed analyses to be carried out by your specialist population forecasting consultant. In order to comply with regulatory guidance that applies (in this example) for your WRZs, you expect to you use their plan-based WRZ forecasts as the principal forecasts in your WRMP.