Water Resources Management Plan

Appendix B – How much water do we need?

Water Resource Strategy team

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APPENDIX B – How much water do we need?

B1. Forecasting demand for water in our region

To estimate future distribution input, we produce projections of each component of demand separately, and sum them to derive customers' consumption and total demand inclusive of total leakage. In brief, the methodology for forecasting household customers' consumption uses year on year forecasts of population and the number properties to be served, along with year on year forecasts of the annual average unit consumption in each of those property types. We then multiply the property and unit consumption forecasts for each property type.

For each of our water resource zones, we have generated household property and population projections which have been used to generate a forecast of household water consumption in measured and unmeasured properties to 2045.

Our baseline distribution input scenario assumes that, as a minimum, our 2019/20 leakage target is maintained with no decline to 2044/45. It is important to note that simply maintaining this level of leakage over time will require significant investment to offset the underlying leakage breakout rate (LBR) in leakage which results from mains deterioration over time.

These assumptions are consistent with the NRW/EA's guidance in respect of the baseline scenario.

B2. Forecasting household demand for water

We forecast the demand for water from households in each of our water resource zones. The key components used in forecasting household demand are:

- Population and household numbers
- Consumption in unmeasured households (i.e. those who do not have a metered supply)
- Consumption in measured households (i.e. those who have a metered supply)

In each case, we determine the current position in a base year, and then forecast changes in each component from that starting year over the following 25 years.

The current Water Resources Planning Guideline[1] identifies the need for water companies to use methods for supply and demand analysis that are appropriate to the level of planning concern in their water resources zones (WRZs). Section 5 of the Final Water Resources Planning Guideline (Environment Agency, 2016) describes how Water Resources Management Plans (WRMPs) should demonstrate the demand for water in the base year, and how this is likely to vary over the planning period.

The problem characterisation assessment, which assesses a company's vulnerability to various strategic issues, risks and uncertainties, varies across the Hafren Dyfrdwy (HD) region – the assessment is 'low' for the Wrexham and Saltney WRZ's and high for the Llandinam &

[1] Water Resources Planning Guideline: Interim Update April 2017

Llanwrin and Llanfylin WRZ's. Therefore, the forecasting methodology has been developed using the appropriate level of concern and follows best practice guidelines (detailed in Figure B2.1) and recent guidance developed by UKWIR on household consumption forecasting (UKWIR, 2016).

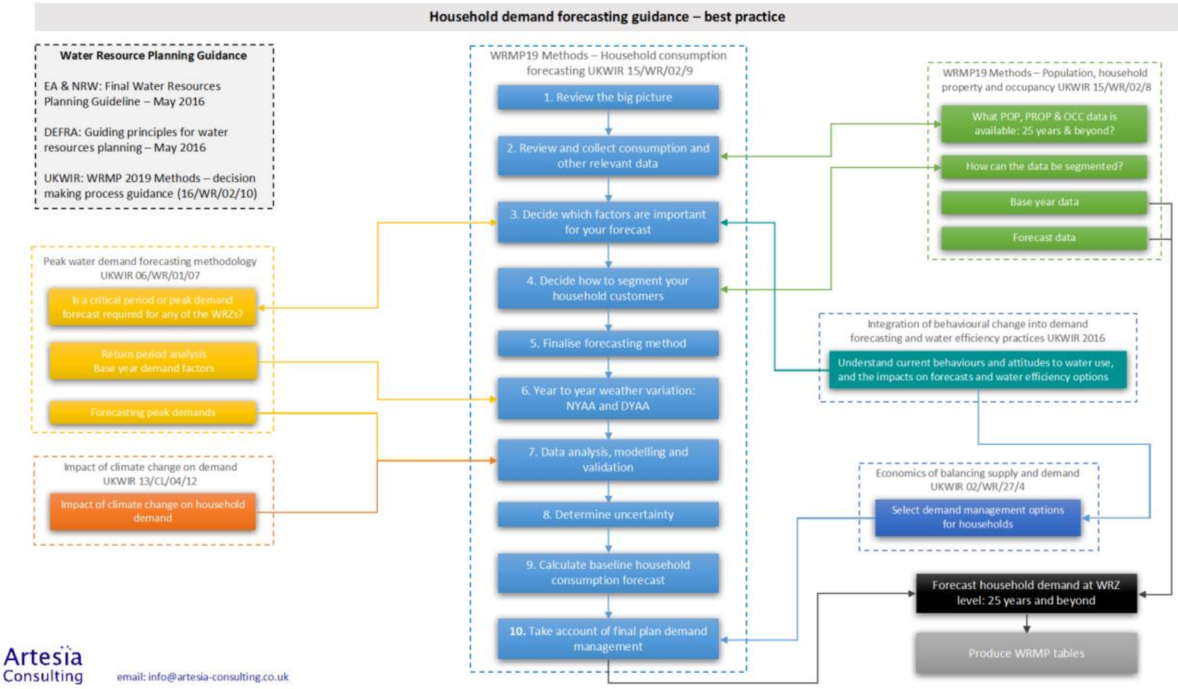


Figure B2.1 - Best practice guidelines for household demand forecasting

The best practice guidelines include a number of household consumption forecasting methods, ranging from quantitative to semi-quantitative analysis and methods that use outputs from other studies. The choice of the forecasting method is based on the assessment of a series of factors, such as:

- Review of factors that influence consumption
- Review of available data and information about those factors
- Assessment of the appropriate level of analysis for the region

Methods such as regression analysis, micro-simulation and micro-component forecasting are data intensive techniques that require in depth analysis and quality data at a suitable resolution. These methods are more appropriate, and likely to be chosen, in water resource zones that are expected to have a supply-demand deficit in the planning period, and where the problem characterisation is high. For WRZs where a deficit is not expected and the problem characterisation is low, the use of a simpler forecast approach might be appropriate.

For the Llanfyllin and Llandinam & Llanwrin WRZs, the problem characterisation was high and we have therefore adopted a microcomponent forecasting methodology as detailed in *Micro-component forecasting* on page 19.

For Saltney and Wrexham WRZs the problem characterisation assessment is 'low', and the use of a less data intensive forecasting method has been considered.

The Hafren Dyfrdwy baseline forecast trend is from a micro-component model using best available data from local and national datasets. The model is segmented by property type using unmetered, new build, metered and free optant metered households. The model is based on per household consumption (PHC), and includes linear modelling of key micro-components against occupancy to reflect the variation of PHC by occupancy within each household type. The model forecasts are developed from historic industry and UKWIR micro-component datasets and Market Transformation Programme predictions. We take account of demographic, social, economic, lifestyle, environmental and such other factors as are likely to influence how consumption patterns may change over the next 25 years. We break consumption in measured and unmeasured household down into micro-components which together sum to give the overall consumption total. The micro-components we use are:

- toilet flushing;
- personal washing;
- clothes washing;
- dish washing;
- miscellaneous internal use;
- external use.

Forecasts of the property, population and occupancy are established by household segment via a model to allow for various assumptions and mathematical calculations as the company trends towards 100% meter penetration

Household customers were segmented based on meter status (measured/unmeasured), with sub-divisions for meter type (existing metered, free meter optants, new property). Normal year and dry year adjustments were made to the base year consumption and the consumption forecast.

We have produced household annual average demand forecasts for each of the following scenarios:

- baseline dry year;
- final planning dry year;

B2.1 Base year population and properties

For the base year 2016/17, we use the numbers of properties and the population as reported in the 2016/17 Annual Return. For each resource zone the total number of properties is broken down into the required categories of measured/unmeasured, household/non-household and voids. These data form the base year numbers from which we forecast property numbers and population for each future year to 2045.

Forecasting population

For estimates of future total population we have used trends from the Welsh Government Local Authority population projections and applied forecast percentage rates of change to our base year data. This gives the underlying change in population due to births, deaths and migration in the region. The LA population projections do not extend to 2045, ending 5 to 10 years earlier. To extrapolate to 2045 the rate of change in the last year of data is assumed for remaining years.

Using the overall population trend for our region, we allocate future population changes across different property categories (unmeasured and measured households) and take account of population movement between these categories.

It is necessary to allocate the population forecast between property types as this defines the property occupancies which influence the level of water use in each household. The following section details the population forecast allocation methodology.

Unmeasured household population forecast

For each resource zone, our starting point is the reported 2016/17 unmeasured household population from the Ofwat Annual Return 2017 (AR17). The impact of our assumptions for ONS rates of growth, future rates of metering and new property population generates the unmeasured household population forecast for each resource zone. At the company level, base year and forecast year population of unmeasured households are calculated as the sum of the population of unmeasured households in the fifteen resource zones. Figure B2.2 shows how unmeasured property population is forecast.

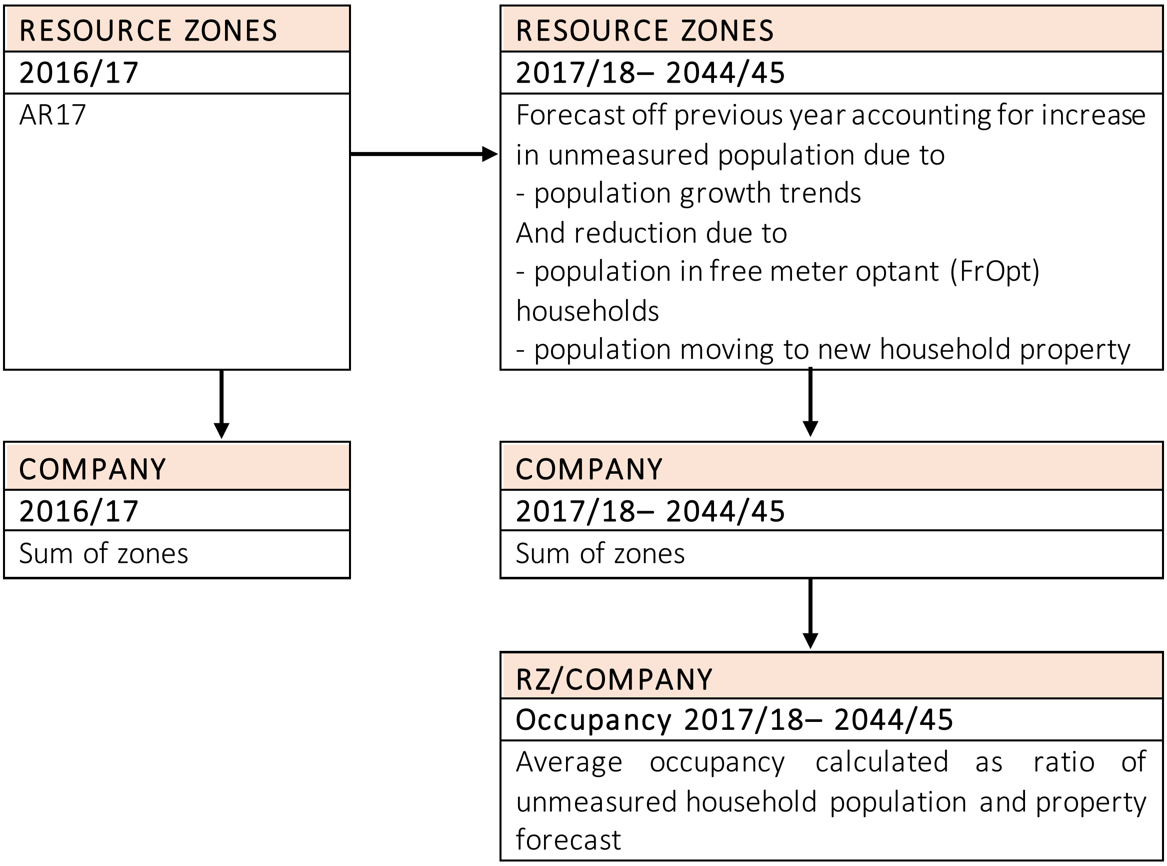


Figure B2.2: Flow chart showing derivation of unmeasured household population forecast

Measured household population forecast

For each resource zone, our starting point is reported 2016/17 number of measured households from AR17. The impact of our assumptions around future metering uptake, new property builds and demolitions generates the net measured household numbers forecast for each resource zone. Figure B2.3 shows how measured household population is forecast.

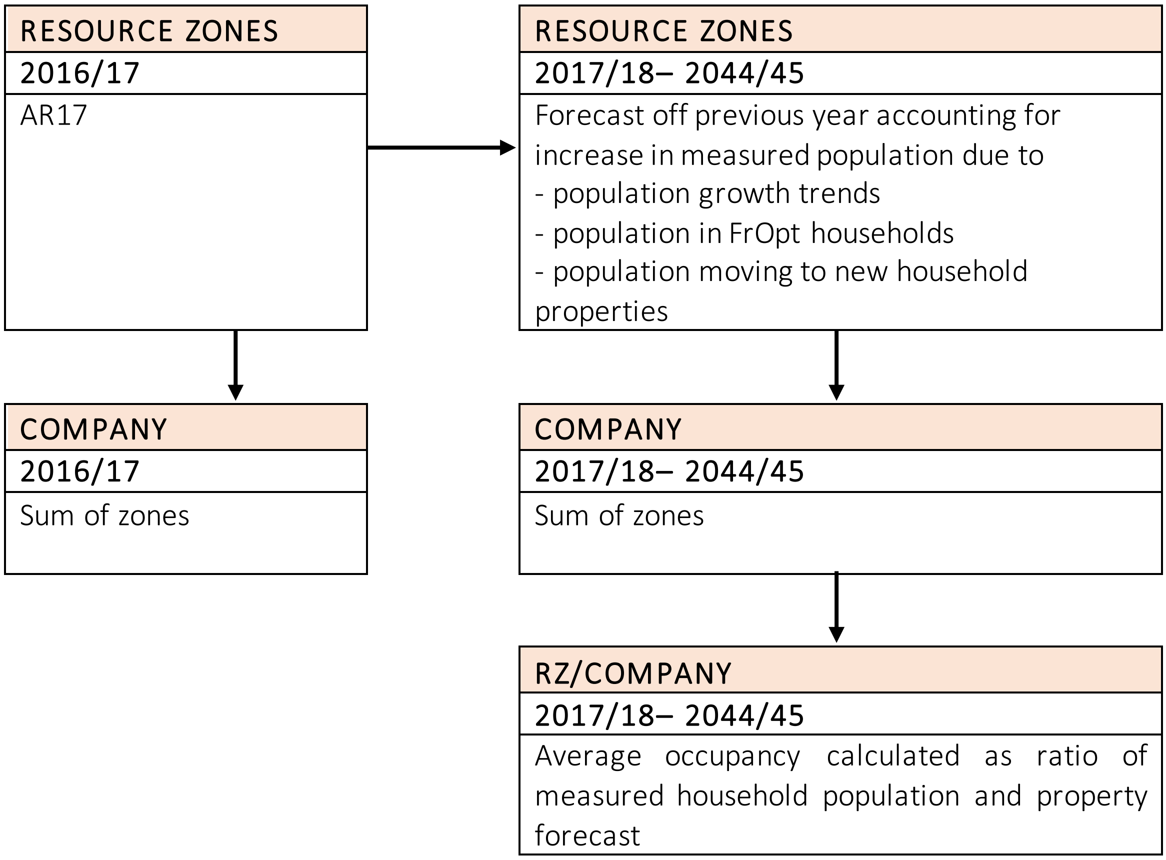


Figure B2.3 Flow chart showing derivation of measured household population forecast

Meter optants population

Customers who opt for a meter do so to reduce their water bills, and they tend to be low occupancy properties with an average household consumption below the average unmeasured household consumption.

For our forecast, we have maintained a constant ratio between meter optant average occupancy rate and unmeasured average occupancy rate. As lower than average occupancy unmeasured properties opt for a meter, the average occupancy of the remaining unmeasured customer base will rise. Year on year, the average occupancy rate of unmeasured customers that opt for a meter will also rise (since lower occupancy properties would have opted in earlier years). This ratio approach to forecasting meter optant average occupancy rate captures the changing profile of the unmeasured occupancy rate over time. Figure B2.4 shows how unmeasured property population is forecast.

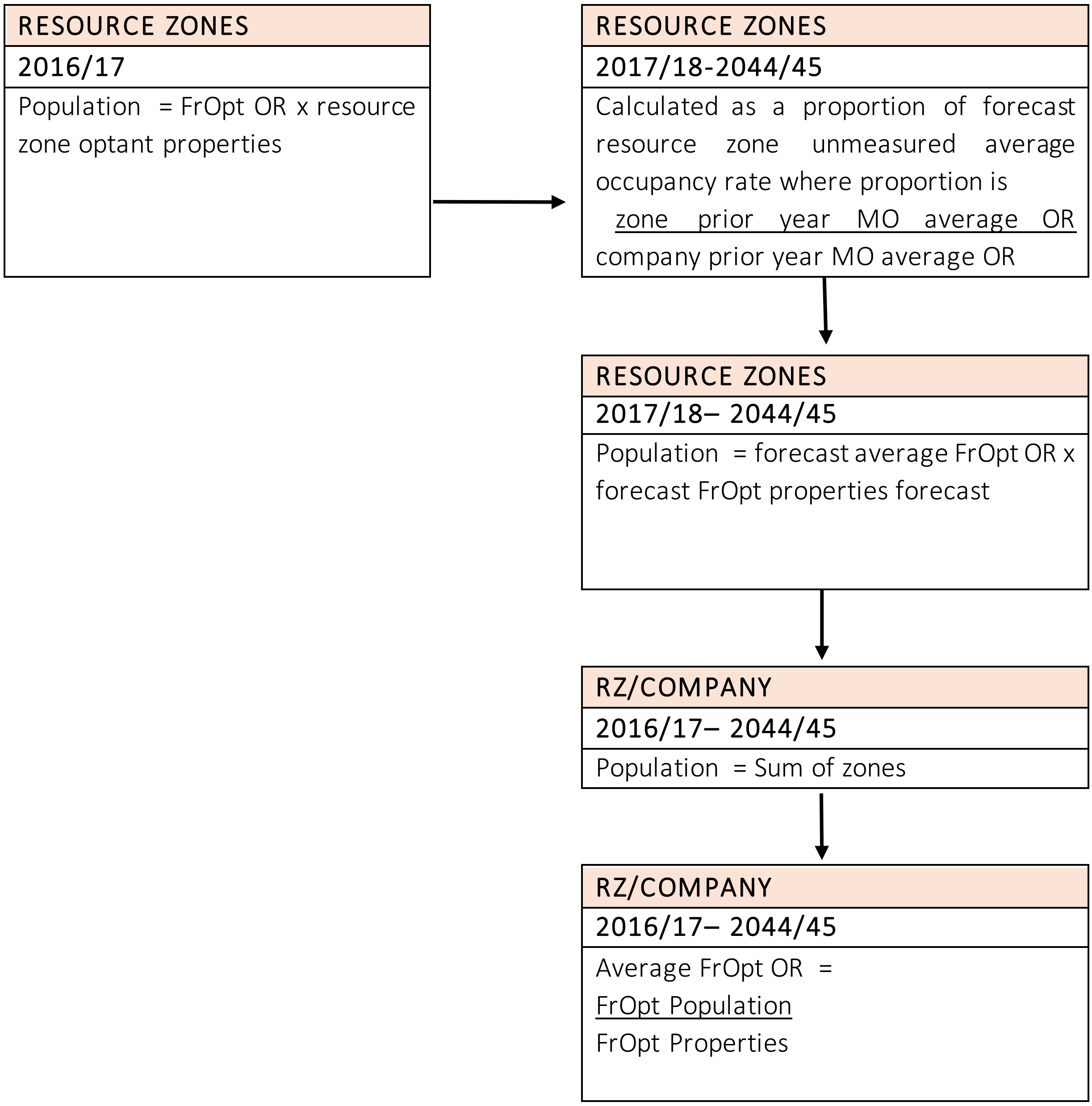
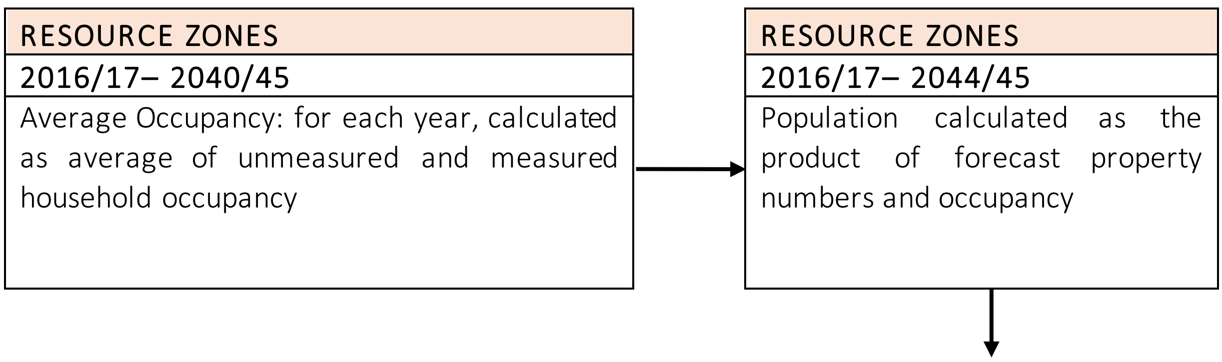


Figure B2.4: Flow chart showing derivation of free meter optant household population forecast

New household property population

Population in new household properties is the product of our forecast of the number of new households, and an assumption for occupancy. The new household property occupancy is calculated each year as the average occupancy of all households (unmeasured and measured) in our region. Figure B2.5 shows how new household property population is forecast.



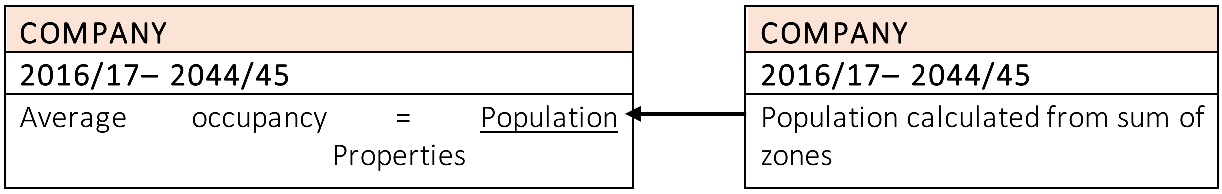


Figure B2.5: Flow chart showing derivation of new household population forecast

Non-household population forecast is the base year population held constant over the planning period.

Property forecasts

We forecast household property numbers for two property categories; unmeasured household, that is properties that do not have a water meter fitted and pay for their water on the basis of property rateable value, and measured households that have a water meter fitted. Measured properties include:

- New properties
- Meter optant properties i.e. properties that were previously unmetered and opt to have water meter installed

Within the measured category, we forecast new household property (all such properties are metered) numbers and newly metered properties i.e. properties that were previously unmetered and opt to have water meter installed.

The following section details the property forecast methodology.

Unmeasured household property forecast

For each resource zone, our starting point is the reported 2016/17 unmeasured households from the Ofwat Annual Return 2017 (AR17). The impact of our assumptions around future rates of metering and demolitions then generates the unmeasured household numbers forecast for each resource zone as shown in Figure B2.6.

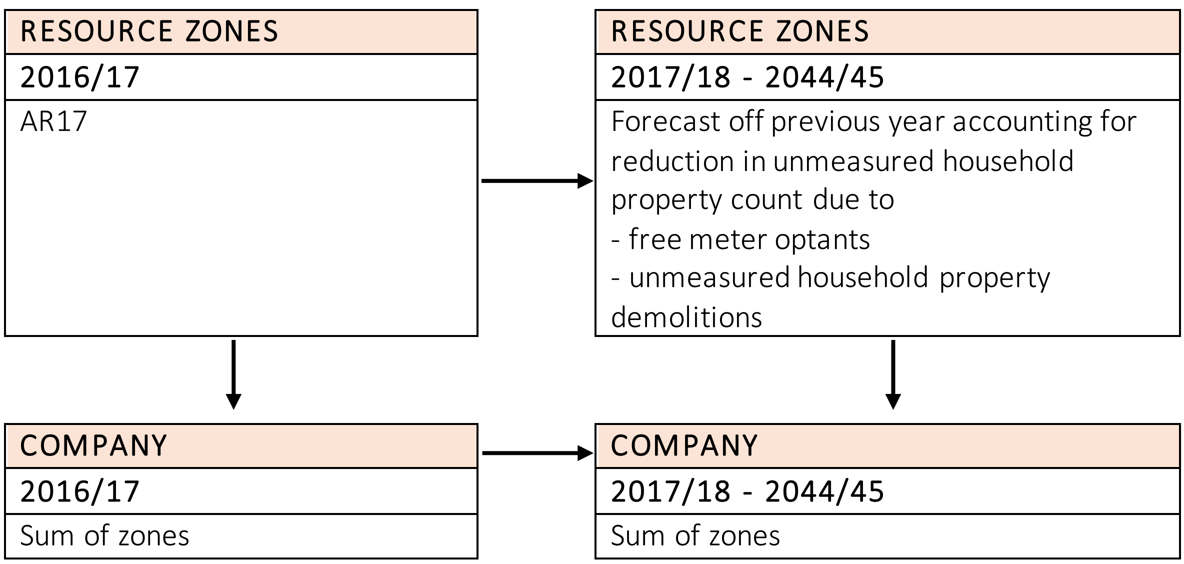


Figure B2.6: Flow chart showing derivation of unmeasured property forecast

Measured household properties forecast

For each resource zone, our starting point is reported 2016/17 number of measured households from AR17. The impact of our assumptions around future metering uptake, new property builds and demolitions then generates the measured household numbers forecast for each resource zone. Figure B2.7 below shows how measured property numbers are forecast:

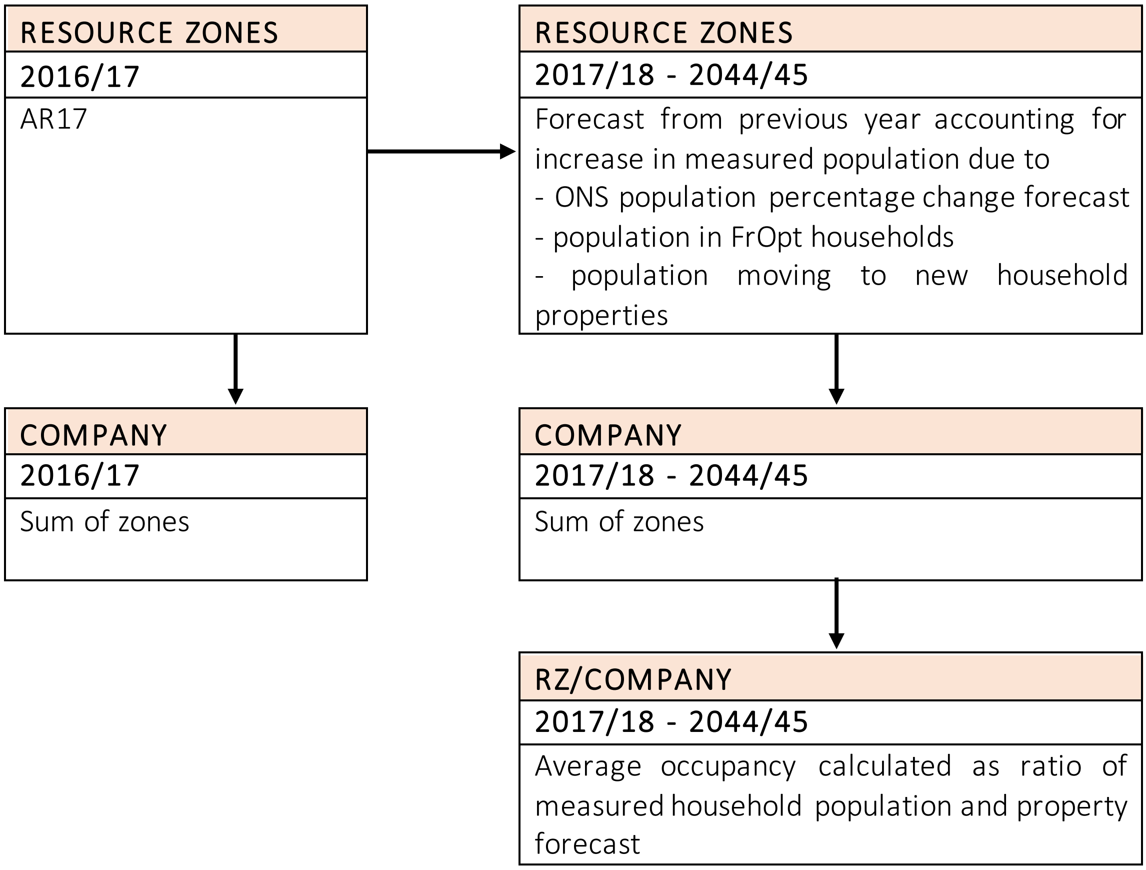


Figure B2.7: Flow chart showing derivation of measured household population forecast

Property forecast assumptions

In arriving at our property forecast for unmeasured and measured households we make a number of assumptions to derive each profile. The following section sets out the basis for our baseline forecast assumptions for household properties.

Baseline metering - Free meter option

Our baseline demand forecasts assume a continuation of current percentage rates of optional metering of unmeasured households.

	AMP 7	AMP 8	AMP 9	AMP 10	AMP 11
	2020/21 - 24/25	2025/26 - 29/30	2031/32 - 34/35	2035/36 - 39/40	2041/42 - 44/45
Free Meter Optant forecast	5,067	4,354	3,745	3,224	2,779

Table B2.1- Meter optants

New household property forecast

The WRMP19 guidance, explicitly instructs water companies to account for the local council projections of household growth for supply capacity planning purposes. In light of this, we are adopting Local Council levels of growth from AMP7 onwards for the WRMP19. In developing our WRMP we have actively consulted with Local Authorities to gain an understanding of the projected future growth in our region. We have also followed the regulatory guidance that requires use of Local Authority growth forecasts when planning for future demand. However, planning horizons for Local Authorities do not reach 2045, and are only projected up to 15 years ahead. Within the planning horizon councils specify a cumulative housing need and present a yearly profile to meet this need. Beyond each council's specified planning horizon, we have extrapolated assuming the annual average housing need from the planning horizon continues to 2045.

We have prepared the new property forecast using the Welsh Governments Local Authority Households Projections data set published March 2017.

This included a search for all relevant housing policy documents. This was done by reviewing the planning department's published documents:

- Assessment of Housing Needs and Objectively Assessed Housing Need
- Core Strategy
- Local Development Plan
- Annual Monitoring Report
- Site Allocation Reports
- Strategic Housing Market Assessment
- Residential Land Availability
- Land Supply Statement
- Strategic Housing Land Availability Assessment
- Housing Trajectories

Table B2.2 below shows the HD Company level growth data gathered during this process and assumed in our dWRMP18.

	2024-25	2029-30	2034-35	2039-40	2044-45
WRMP19 forecast household growth	694	637	578	509	509

Table B2.2 - Company level growth data

B2.2 Forecasting household water consumption

Method selection

The Water Resources Planning Guideline identifies the need for water companies to use methods for supply and demand analysis that are appropriate to the level of planning concern in their water resources zones (WRZs).

The problem characterisation assessment, which assess a company's vulnerability to various strategic issues, risks and uncertainties, is low for the Saltney and WrexhamWRZs. The forecasting methodology has been developed considering this low level of concern for these zones. For the Llanfyllin and Llandinam & Llanwrin WRZs the problem characterisation was high and we have therefore adopted a microcomponent forecasting methodology as detailed in *Micro-component forecasting* on page 19.

Demand forecasts for HD WRZs are derived using a mapping of historic Dee Valley Water and Severn Trent Water WRZs projections.

The newly formed HD WRZs are Saltney, Wrexham and Llanfyllin, with Llandinam & Llanwrin moving wholly to Hafren Dyfrdwy from Severn Trent Water. Table B2.3 below shows the mapping of the old WRZ forecasts to the new WRZs. Property, population and consumption forecasts for the new WRZs have been derived from the old Severn Trent Water and Dee Valley Water WRZs via apportionment on the basis of Annual Return property data mapped to the England and Wales border.

Old WRZ (dWRMP 2018)	Border split	New WRZ (fWRMP 2019)
Shelton (STW)	Shelton Wales	Llanfyllin (HD)
	Shelton England	Shelton (in Severn Trent Water Region)
Chester (DVW)	Chester Wales	Saltney (HD)
	Chester England	Chester (in Severn Trent Water Region)
Wrexham (DVW)	Wrexham England	
	Wrexham Wales	Wrexham (HD)
Llandinam and Llanwrin (STW)	N/A	Llandinal and Llanwrin (STW)

Table B2.3 - Changes to WRZs following formation of Hafren Dyfrdwy

Below we describe the methodology followed for Hafren Dyfrdwy Saltney and Wrexham WRZs with a low level of problem characterisation concern.

The method is based on analysis metrics which are known to affect the HHCF such as occupancy and meter penetration and correspondence in PHC (per household consumption) and PCC (per capita consumption).

The examination of the results indicated that trends in occupancy for total, measured and unmeasured households were the most significant metrics for the identification of a Severn Trent Water zone baseline. This resulted in the identification of an appropriate Severn Trent Water WRZ for each of Saltney WRZ and Wrexham WRZ as the baseline PHC, PCC and micro-component trend. This was validated by testing the model against a bottom up micro-component model that has been developed for Severn Trent Water and used for the household demand forecast. The following sections set out the analysis in selecting the appropriate Severn Trent Water WRZ for Saltney and Wrexham WRZs.

Ranking of metrics

The selection of the most appropriate metric for use in identifying comparable Severn Trent Water WRZs has been studied by addressing the variance (absolute percentage difference) amongst Severn Trent Water and Hafren Dyfrdwy WRZs using static annual reported figures for base year 2016/17 for: PCC (per capita consumption), PHC (per household consumption), occupancy for measured and unmeasured households, and meter penetration.

Meter Optant rate (proportion of unmeasured switching to metered) is similar amongst all Severn Trent Water zones and also differs from the Dee Valley Water areas. Therefore, this metric has not been used for comparison. This is shown in Figure B2.8.

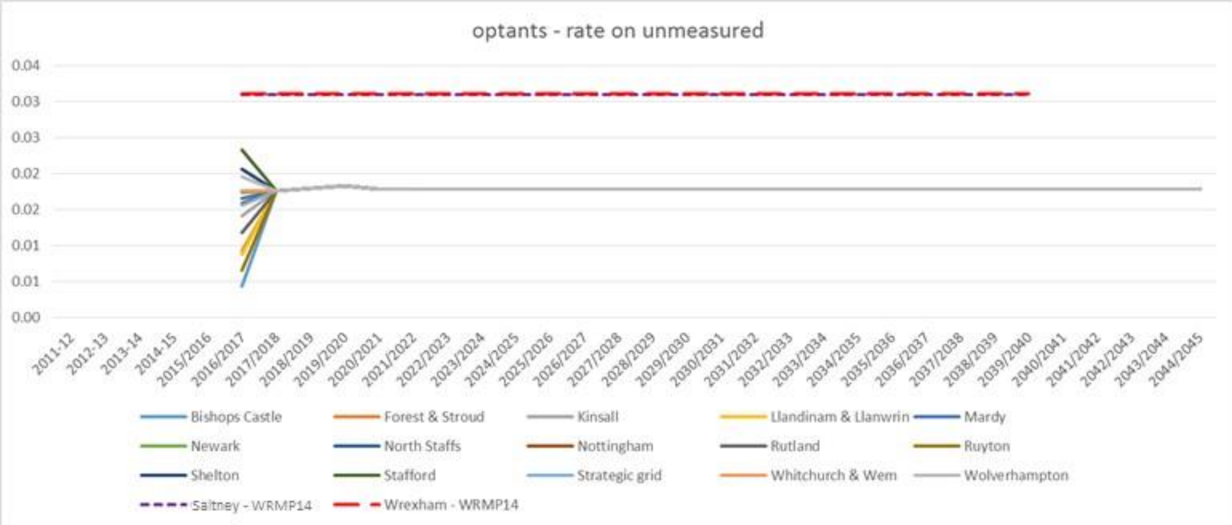


Figure B2.8 Optant rate for Severn Trent Water and Hafren Dyfyrdwy Water zones

For both Hafren Dyfrdwy WRZs, the selection shows a complexity of results that does not indicate clearly the most appropriate Severn Trent Water WRZs to use as baselines (Table B2.3).

	% absolute difference							% absolute difference						
	mPCC	umPCC	mOcc	umOcc	mPHC	umPHC	mp	mPCC	umPCC	mOcc	umOcc	mPHC	umPHC	mp
	Chester							Wrexham						
Bishops Castle	3.01%	11.05%	10.01%	11.60%	13.32%	21.37%	33.27%	9.96%	14.38%	2.78%	12.64%	13.02%	25.21%	29.52%
Forest & Stroud	3.29%	12.58%	11.46%	0.89%	7.80%	13.36%	43.92%	3.24%	15.85%	4.14%	2.06%	7.51%	17.59%	40.77%
Kinsall	4.13%	11.63%	16.49%	5.12%	21.30%	16.15%	21.80%	11.16%	14.93%	8.83%	6.24%	20.97%	20.24%	17.41%
Llandinam & Llanwrin	8.70%	9.73%	13.53%	8.47%	3.65%	17.38%	31.56%	2.54%	13.11%	6.07%	9.55%	3.37%	21.41%	27.72%
Mardy	0.80%	11.43%	15.51%	1.87%	14.59%	9.78%	21.28%	5.90%	14.74%	7.91%	0.66%	14.28%	14.18%	16.86%
Newark	3.08%	12.87%	5.11%	5.78%	1.87%	17.90%	20.55%	3.46%	16.13%	1.80%	6.89%	1.60%	21.91%	16.09%
North Staffs	9.71%	12.72%	10.02%	0.94%	0.65%	13.54%	28.68%	3.61%	15.98%	2.79%	2.11%	0.92%	17.76%	24.67%
Nottingham	2.21%	10.82%	7.83%	1.84%	5.45%	12.46%	34.28%	4.39%	14.16%	0.74%	3.00%	5.16%	16.73%	30.59%
Rutland	5.18%	12.05%	15.75%	0.24%	9.76%	11.84%	11.83%	1.22%	15.34%	8.15%	0.95%	9.47%	16.14%	6.87%
Ruyton	4.10%	15.02%	38.05%	0.54%	43.71%	14.56%	11.33%	11.13%	18.20%	28.97%	0.64%	43.32%	18.73%	6.35%
Shelton	6.22%	10.03%	12.11%	0.31%	5.14%	10.31%	25.56%	0.11%	13.40%	4.74%	1.49%	4.85%	14.69%	21.38%
Stafford	7.63%	12.91%	13.68%	1.41%	5.01%	11.68%	5.48%	1.40%	16.17%	6.21%	0.21%	4.72%	15.99%	0.17%
Strategic grid	2.79%	9.73%	11.52%	1.45%	8.41%	8.42%	30.38%	3.77%	13.11%	4.19%	0.25%	8.11%	12.89%	26.47%
Whitchurch & Wem	0.37%	13.60%	10.90%	1.43%	10.49%	14.83%	12.87%	6.35%	16.83%	3.61%	2.60%	10.20%	18.99%	7.98%
Wolverhampton	3.37%	11.76%	7.00%	3.96%	3.39%	8.27%	34.26%	3.15%	15.06%	0.03%	2.73%	3.12%	12.74%	30.57%

	Chester							Wrexham						
	RANK							RANK						
	mPCC	umPCC	mOcc	umOcc	mPHC	umPHC	mp	mPCC	umPCC	mOcc	umOcc	mPHC	umPHC	mp
Bishops Castle	5	5	4	15	12	15	12	13	5	4	15	12	15	12
Forest & Stroud	7	10	7	4	8	8	15	6	10	7	7	8	8	15
Kinsall	10	7	14	12	14	12	7	15	7	14	12	14	12	7
Llandinam & Llanwrin	14	2	10	14	4	13	11	4	2	10	14	4	13	11
Mardy	2	6	12	10	13	3	6	11	6	12	4	13	3	6
Newark	6	12	1	13	2	14	5	7	12	3	13	2	14	5
North Staffs	15	11	5	5	1	9	9	8	11	5	8	1	9	9
Nottingham	3	4	3	9	7	7	14	10	4	2	11	7	7	14
Rutland	11	9	13	1	10	6	3	2	9	13	5	10	6	3
Ruyton	9	15	15	3	15	10	2	14	15	15	3	15	10	2
Shelton	12	3	9	2	6	4	8	1	3	9	6	6	4	8
Stafford	13	13	11	6	5	5	1	3	13	11	1	5	5	1
Strategic grid	4	1	8	8	9	2	10	9	1	8	2	9	2	10
Whitchurch & Wem	1	14	6	7	11	11	4	12	14	6	9	11	11	4
Wolverhampton	8	8	2	11	3	1	13	5	8	1	10	3	1	13

Table B2.3 Metric Ranking System

B2.3. Forecasting Demand

Due to the complexity of the results, all the Severn Trent Water zones that are ranked first or second in each metric have been used to produce forecasts and assess the range of results.

Appendix B – How much water do we need?

Each of the Severn Trent Water WRZs selected by the ranking system is calibrated to the Dee Valley Water PHC in the base year. The trend in measured and unmeasured PHC for each Severn Trent Water zone is then used to project future consumption for the Saltney and Wrexham WRZs. Forecasts are produced for both normal year annual average (NYAA) and dry year annual average (DYAA) for PHC, PCC, total demand for measured, unmeasured and total households. Consumption is calculated by using the PHC trends and the updated POPROC numbers.

This approach produces an array of forecasts that give a view of potential uncertainty. The trends in total household PHC for each ranked metric, and correspondent Severn Trent Water WRZ, is shown in the following figures. An average trend is highlighted in red. It is worth noting that some Severn Trent Water zones appear twice because they are within the first two ranked for two metrics. This is weighted in the average calculation.

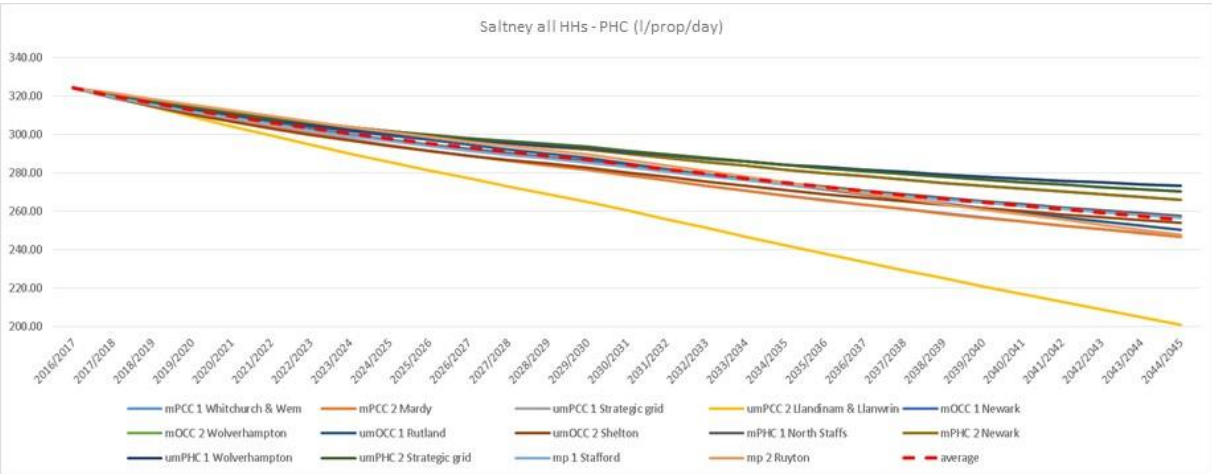


Figure B2.9 Saltney PHC (DYAA) forecasts based on ranked metrics

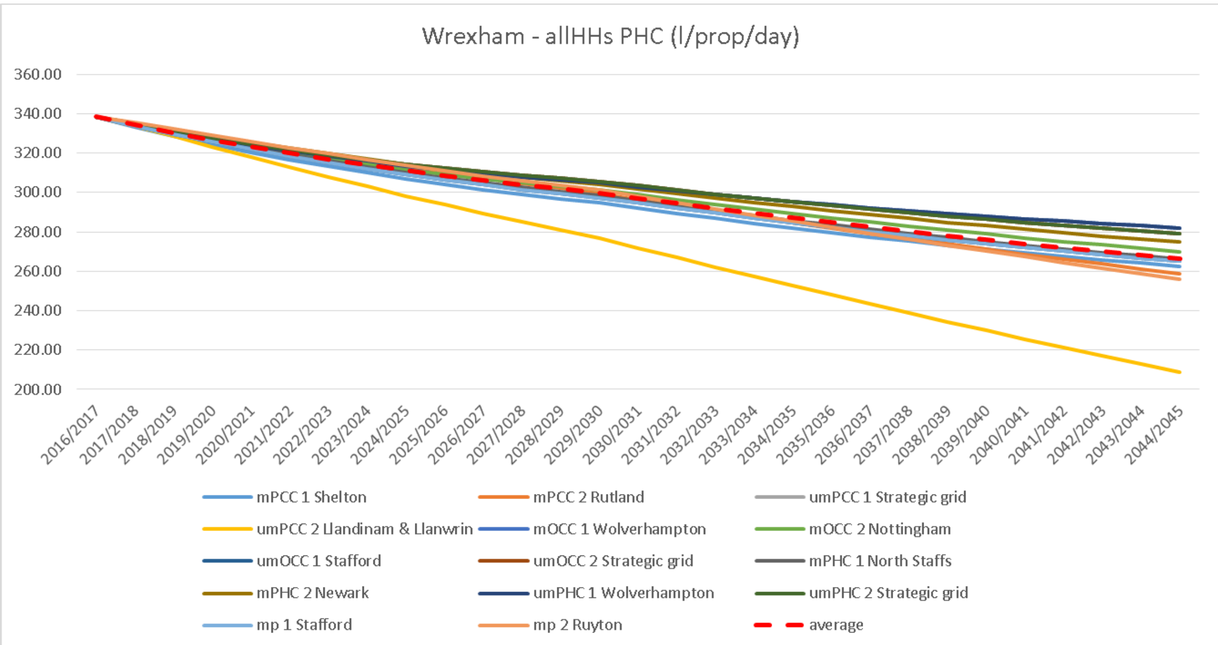


Figure B2.10 Wrexham PHC (DYAA) forecasts based on ranked metrics

Total demand is also calculated. Table B2.4 shows that, for the baselines selected, consumption trends in the final year are within a 1.6 Ml/d range (not considering Llandinam & Llanwrin, and Bishop Castle which have the steeper decline in PHC) for Saltney, but with slightly increasing demand for Wolverhampton) and decreasing for all the others. For Wrexham, all the forecasts produce a decreasing demand but with different rate, with a maximum reduction of 4.02 Ml/d (again not considering Llandinam & Llanwrin and Bishop Castle), as shown in Table B2.5.

IF the following RZ is selected	2016/17 Ml/d – DYAA	2044/45 Total Ml/d - DYAA	difference in Ml/d between BY and FY
Bishops Castle	15.76	13.54	-2.21
Forest & Stroud	15.76	14.96	-0.80
Kinsall	15.76	14.32	-1.43
Llandinam & Llanwrin	15.76	11.64	-4.11
Mardy	15.76	14.30	-1.46
Newark	15.76	15.42	-0.33
North Staffs	15.76	14.92	-0.84
Nottingham	15.76	15.14	-0.62
Rutland	15.76	14.51	-1.25
Ruyton	15.76	14.36	-1.40
Shelton	15.76	14.72	-1.03
Stafford	15.76	14.87	-0.89
Strategic grid	15.76	15.66	-0.10
Whitchurch & Wem	15.76	14.30	-1.45
Wolverhampton	15.76	15.83	0.07

Table B2.4 Saltney total demand (DYAA) using baseline selected by the metric ranking

IF the following RZ is selected	2016/17 Ml/d – DYAA	2044/45 Total Ml/d - DYAA	difference in Ml/d between BY and FY
Bishops Castle	22.54	17.55	-5.00
Forest & Stroud	22.54	19.39	-3.15
Kinsall	22.54	18.55	-3.99
Llandinam & Llanwrin	22.54	15.16	-7.38
Mardy	22.54	18.53	-4.02
Newark	22.54	19.96	-2.59
North Staffs	22.54	19.33	-3.22
Nottingham	22.54	19.60	-2.94
Rutland	22.54	18.80	-3.74
Ruyton	22.54	18.60	-3.95
Shelton	22.54	19.07	-3.47
Stafford	22.54	19.26	-3.29
Strategic grid	22.54	20.26	-2.29
Whitchurch & Wem	22.54	18.53	-4.02

Wolverhampton	22.54	20.49	-2.06

Table B2.5 Wrexham total demand (DYAA) using baseline selected by the metric ranking

At this point, it is still not evident which metrics are the most important for the selection of the best Severn Trent Water WRZ baseline.

In order to further assess this, the reported figures in the base year for the Hafren Dyfrdwy zones are utilised within the micro-component model developed for the Severn Trent Water region and results are compared against all the forecast produced. This is described in the following section.

B2.4. Assessing uncertainty with the micro-component model

Using reported figures for each Dee Valley Water zone, the micro-component model reported an increase of 0.3 Ml/d for Chester and a decrease of 1.14 Ml/d for Wrexham in the final year of the forecast (2044/45) compared to the base year figures as shown in Table B2.6:

Model	2016/17 Ml/d – DYAA	2044/45 Total Ml/d - DYAA	difference in Ml/d between BY and FY
MC model - Saltney	15.76	15.83	0.08
MC model - Wrexham	22.54	21.52	-1.02

Table B2.6 Micro-component forecast results for Hafren Dyfyrdwy

The result for Saltney appears to not match most of the forecast produced, while the result for Wrexham is more in-line. As the micro-component model is heavily dependent on the occupancy trends for the calculation of consumption (in particular PHC, on which the micro-component model is based and calibrated), a new ranking system has been developed to compare trends in occupancy between Dee Valley Water and Severn Trent Water zones.

Occupancy trend ranking

The comparison is made mathematically on the slope of occupancy trends for total, measured and unmeasured households between Hafren Dyfrdwy and Severn Trent Water WRZs. An additional sum of all rankings for each occupancy trends is used to check the most similar Severn Trent Water zone for all occupancy trends. This is shown in Table B2.7 and Table B2.8.

	Chester							
	total OCC slope	rank	measured OCC slope	rank	unmeasured OCC slope	rank	sum of scores	rank
Bishops Castle	-0.016	13	-0.018	13	-0.005	8	34	14
Forest & Stroud	-0.007	2	-0.009	5	0.012	12	19	4
Kinsall	-0.013	10	-0.016	12	0.002	2	24	10
Llandinam & Llanwrin	-0.024	15	-0.027	15	-0.013	14	44	15
Mardy	-0.014	12	-0.016	11	0.003	4	27	12
Newark	-0.006	4	-0.007	2	0.010	10	16	1
North Staffs	-0.009	3	-0.011	6	0.009	9	18	3
Nottingham	-0.007	1	-0.009	4	0.010	11	16	1
Rutland	-0.012	8	-0.013	9	0.006	5	22	7

Ruyton	-0.017	14	-0.023	14	0.001	3	31	13
Shelton	-0.010	5	-0.012	8	0.007	6	19	4
Stafford	-0.010	7	-0.012	7	0.008	7	21	6
Strategic grid	-0.005	6	-0.008	3	0.014	13	22	7
Whitchurch & Wem	-0.014	11	-0.015	10	0.002	1	22	7
Wolverhampton	-0.004	9	-0.005	1	0.018	15	25	11
Saltney	-0.008		-0.004		0.002			

Table B2.7 - Saltney occupancy trend ranking

	Wrexham							
	total OCC slope	rank	measured OCC slope	rank	unmeasured OCC slope	rank	sum of scores	rank
Bishops Castle	-0.016	13	-0.018	13	-0.005	14	40	13
Forest & Stroud	-0.007	4	-0.009	5	0.012	2	11	4
Kinsall	-0.013	10	-0.016	12	0.002	11	33	10
Llandinam & Llanwrin	-0.024	15	-0.027	15	-0.013	15	45	15
Mardy	-0.014	12	-0.016	11	0.003	10	33	10
Newark	-0.006	3	-0.007	2	0.010	5	10	3
North Staffs	-0.009	6	-0.011	6	0.009	6	18	6
Nottingham	-0.007	5	-0.009	4	0.010	4	13	5
Rutland	-0.012	9	-0.013	9	0.006	9	27	9
Ruyton	-0.017	14	-0.023	14	0.001	13	41	14
Shelton	-0.010	7	-0.012	8	0.007	8	23	8
Stafford	-0.010	8	-0.012	7	0.008	7	22	7
Strategic grid	-0.005	2	-0.008	3	0.014	1	6	2
Whitchurch & Wem	-0.014	11	-0.015	10	0.002	12	33	10
Wolverhampton	-0.004	1	-0.005	1	0.018	3	5	1
Wrexham	-0.001		0.001		0.014			

Table B2.8 Wrexham occupancy trend ranking

The results produce a more obvious ranking than the annual return metrics. In particular, Wolverhampton is the highest for Wrexham for most of trends (measured and total occupancy. Newark and Nottingham are the highest ranked for Chester when considering all trends. However when looking at the trends, Newark's trends appear more similar to the micro-component results; with Newark being second for measured occupancy trend, while Nottingham being fourth.

Validation of occupancy trend ranking system

At this point, the micro-component results are compared with the forecasts using all the Severn Trent Water zones. The results of the comparison are shown in Table B2.9.

Baseline RZ	Saltney		Wrexham	
	% diff of ***Hafren Dyfrdwy (Saltney/Wrexham)*** model on MC model	rank	% diff of ***Hafren Dyfrdwy (Saltney/Wrexham)*** model on MC model	rank
Bishops Castle	-14.48%	14	-18.47%	14
Forest & Stroud	-5.53%	5	-9.90%	5
Kinsall	-9.55%	11	-13.80%	11
Llandinam & Llanwrin	-26.46%	15	-29.56%	15
Mardy	-9.71%	13	-13.91%	13
Newark	-2.61%	3	-7.28%	3
North Staffs	-5.78%	6	-10.20%	6
Nottingham	-4.41%	4	-8.94%	4
Rutland	-8.36%	9	-12.64%	9
Ruyton	-9.32%	10	-13.60%	10
Shelton	-7.01%	8	-11.38%	8
Stafford	-6.08%	7	-10.54%	7
Strategic grid	-1.11%	2	-5.88%	2
Whitchurch & Wem	-9.67%	12	-13.91%	12
Wolverhampton	-0.02%	1	-4.82%	1

Table B2.9 Comparison between Micro-component and Hafren Dyfrdwy (Saltney/Wrexham) model results

It appears clear that the similarity in occupancy is somewhat reflected in the total demand forecasts. For Wrexham, Wolverhampton is first again with around 4.8% difference in the total Ml/d forecast. For Saltney, Newark is the third closest with only around 2.6% difference between models. Nottingham, which was also considered for Chester, is fourth in the comparison.

When looking at the PHC trends for measured and unmeasured households, the trends corroborate the selection of Newark and Wolverhampton as baseline. These are shown in the Figures B2.11 and B2.12 below.

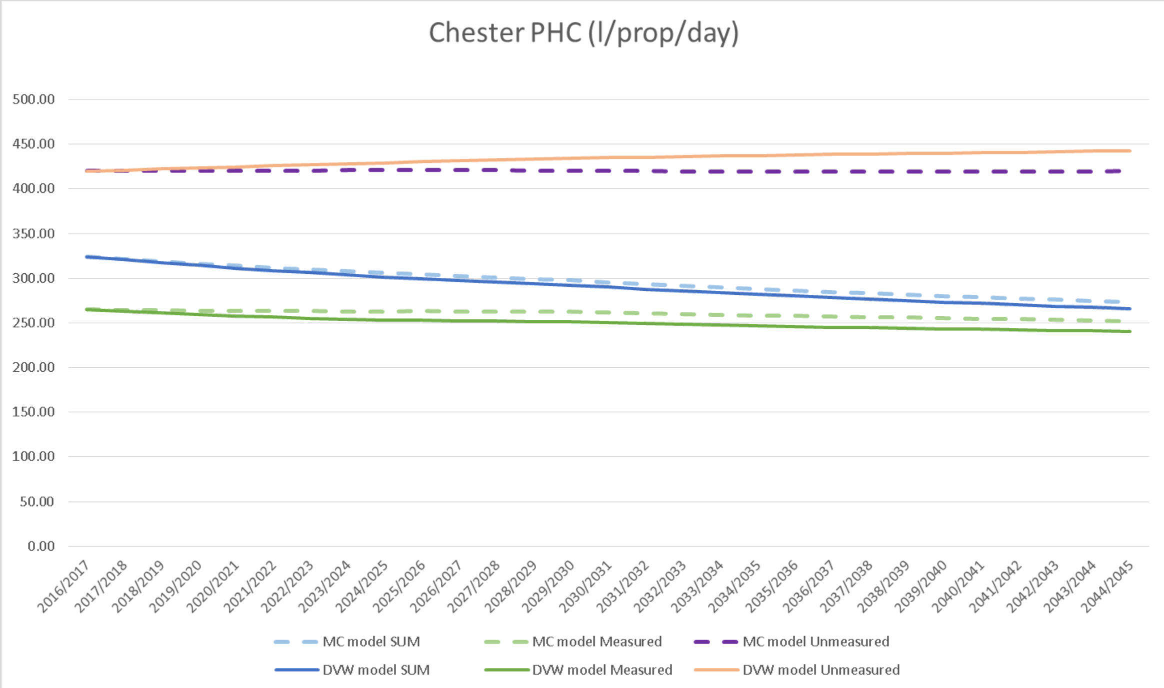


Figure B2.11 Saltney micro-component and Hafren Dyfrdwy model comparison

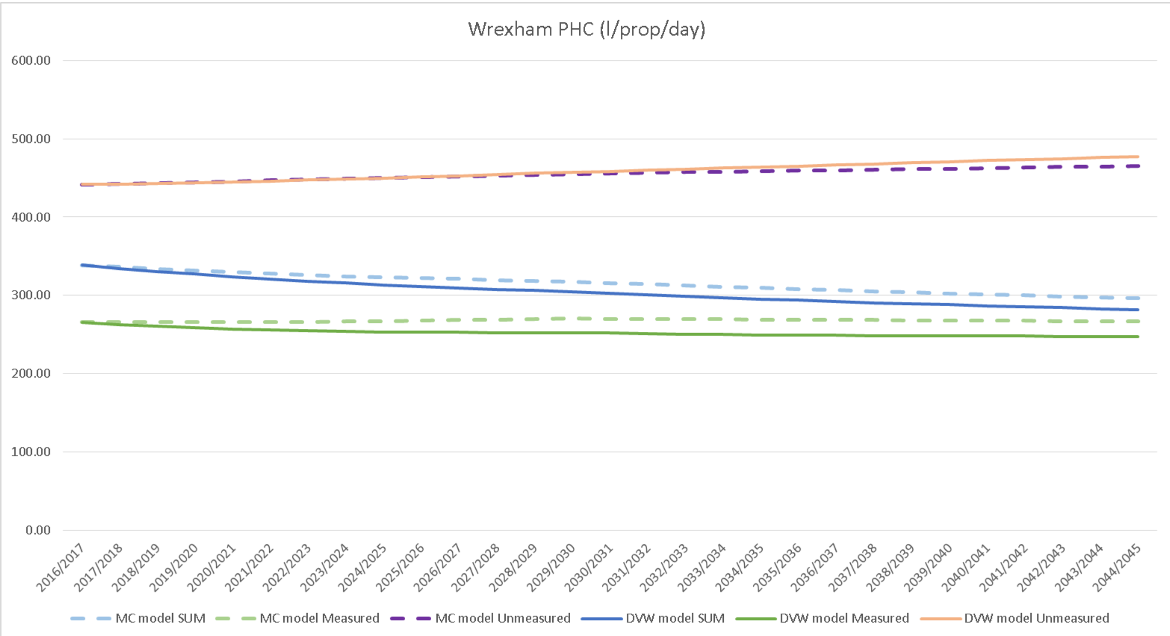


Figure B2.12 Wrexham micro-component and Hafren Dyfyrdwy model comparison

The differences amongst trends are likely to be due to the higher occupancy of optants populations for Dee Valley Water WRZs, which reflect the higher meter penetration of these two zones. In detail, the micro-component model estimates a higher PHC for optant, which results in higher measured PHC and a less pronounced decrease of the PHC trend. The Dee Valley Water model cannot capture this as the Severn Trent Water baseline WRZs have a sensible lower occupancy for optants, therefore a steeper decrease in measured PHC.

The difference in optant occupancy is shown in Figure B2.13.

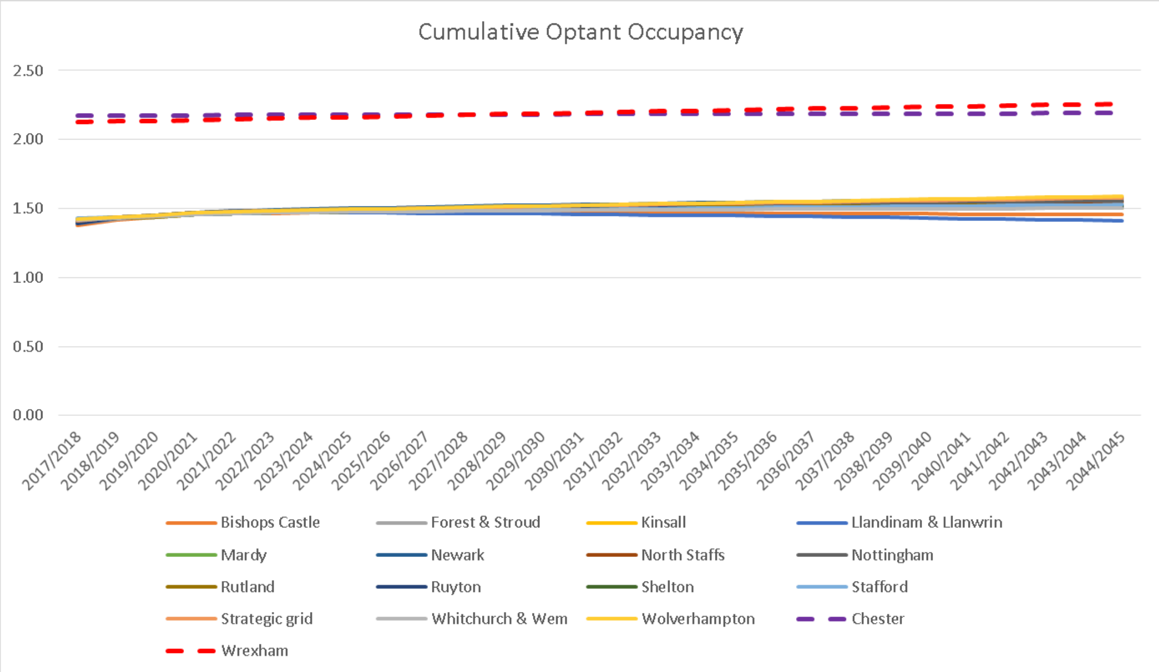


Figure B2.13 Difference in optant occupancy

Nevertheless, these results confirm that occupancy trends play an important role in selecting the baseline resource zone.

The selected comparison zones are thus:

- Newark WRZ for Saltney WRZ
- Wolverhampton WRZ for Wrexham WRZ.

Micro-component Forecast

The WRMP Guidance requires that consumption is also assessed at a micro-component resolution. In or micro-component model, the trend per micro-component are a function of ownership (O), volume per use (V) and frequency of use (F). Per-capita (PCC) or per household consumption (PHC) can be modelled as:

PCC or PHC = ∑i(Oi x Vi x Fi) + pcr

Where

> ‘O’ is the proportion of household occupants or households using the appliance or activity for micro-component ‘i’,
>
> ‘V’ is the volume per use for ‘i’,
>
> ‘F’ is the frequency per use by household occupants or households for ‘i’,
>
> ‘pcr’ is per capita residual demand.

In particular, occupancy is used as an important metric to define and forecast changes in volume and frequency per micro-component. The Severn Trent Water micro-component model also estimates changes in these variables, to reflect future changes in technology, policy, regulation, and behaviour (more detail follows table 7 below)

Since occupancy is an important factor in micro-component trends and Severn Trent Water WRZs are selected based on occupancy trends, it is expected that micro-component trends for Dee Valley Water water resources zone will reflect the trends of the Severn Trent Water baseline WRZs.

In the Dee Valley Water model, for each micro-component, the proportional PCC/PHC volume in the baseline water resource zone is used to derive the micro-component consumption and trends for Wrexham and Saltney for every year of the planning period. The base year micro-component volumes for each Dee Valley Water WRZs are detailed in Table B2.10.

	Saltney	Wrexham
Measured Household – PCC (l/head/day)	133.3	124.8
Measured toilet flushing	30.7	28.6
Measured personal washing	55.5	52.2
Measured clothes washing	16.5	15.5
Measured dish washing	13.0	12.2
Measured miscellaneous internal use	15.9	14.8
Measured external use	1.6	1.5
Unmeasured Household – PCC (l/head/day)	167.3	173.8
Unmeasured toilet flushing	38.1	38.8
Unmeasured personal washing	69.2	73.3
Unmeasured clothes washing	20.1	21.0
Unmeasured dish washing	15.9	16.6
Unmeasured miscellaneous internal use	22.2	22.4
Unmeasured external use	1.8	1.8

Table B2.10 Base year 2016/17 micro-component PCC for Hafren Dyfyrdwy Saltney and Wrexham water resource zones

The following section details the micro-component modelling methodology for the selected Severn Trent Water comparison zones.

Data availability

The base year selected for the development of the initial dWRMP18 micro-component model is 2015/16.

We have used a number of data which are either used in the forecast, or for validation of the model. This data includes daily consumption data from the Company's domestic consumption monitor (DCM), historic trends from the June Returns, the WRMP14 forecast, the Company's forecast for population and properties, historic weather data and historic distribution input (DI) data.

In addition to Company data, several national datasets are used to increase the understanding of historic, present and future micro-component consumption. Historic micro-components are extracted from the WRc CP187 report, current micro-components are extracted from UKWIR 16/WR/01/15 Integration of Behaviour Change and future projections are extracted from the Market Transformation Programme (MTP).

Measured micro-component data

By 'measured' we mean micro-component data that has been collected by measuring the different micro-components used within the household (as opposed from survey questions and assumptions). This allows ownership (O), volume per use (V) and frequency of use (F), to be calculated for each micro-component. There are two main sources of data for this:

2015-16 data collected using the Siloette system:

a sample of measured billed households, which has associated occupancies and demographic information on the households, collated during an UKWIR Study[2] (this contains 62 households from around England and Wales):

- a sample of RV billed households, which does not have associated demographics (collated from other anonymous Siloette studies carried out by Artesia Consulting, from England and Wales).
- 2002 – 2004 O, V, and F data collected using the Identiflow system (a sample of RV billed households, reporting in WRc Report CP187[3]).

Both the Siloette and Identiflow systems measure the flow into a property and compute the individual micro-components through pattern recognition (although the detailed methodology of the two systems is different). The Siloette system uses a Siloette logger that is connected to the pulsed output from a meter via a pulse unit, as illustrated in Figure B2.14.

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[2] Integration of behavioural change into demand forecasting and water efficiency practices, UKWIR 16/WR/01/15, 2016

[3] Increasing the Value of Domestic Water use Data for Demand Management, WRc, March 2005

Figure B2.14 Siloette logger installed in a boundary box

The logger records the flow through the meter at sub 1-second resolution. Once downloaded an algorithm is applied to the data to create a high-resolution flow trace of the flow into the property, as illustrated in Figure B2.15.

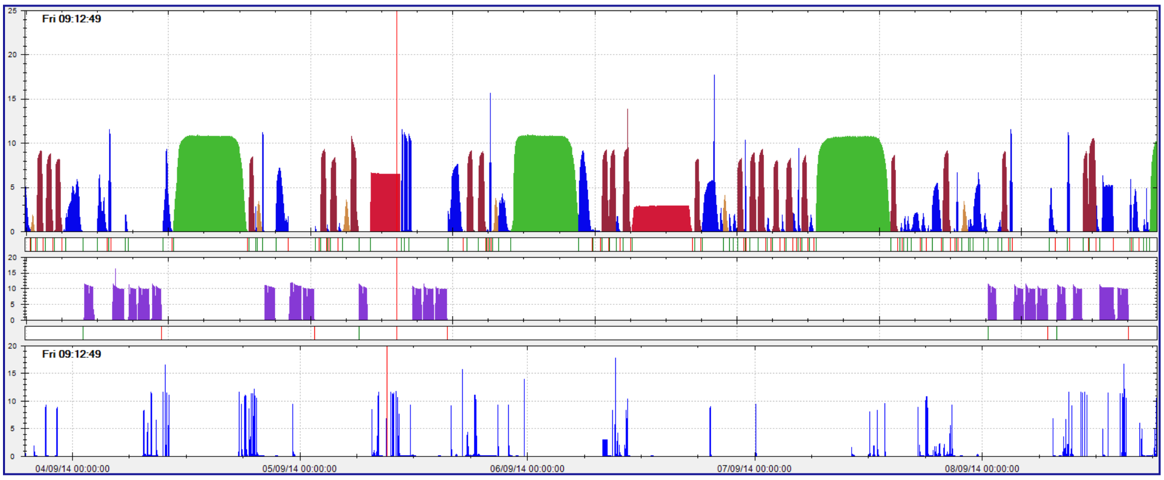

Figure B2.15 Illustration of Siloette logger output

Each water-using event in the house has a flow-rate profile characterised by the time, duration and volume of water per use. Siloette takes the data from the logger and uses pattern-recognition software to disaggregate and quantify the individual micro-component events and provide information on time of event, flow rates and volumes. In Figure B2.15 the bottom trace shows the time-series of the flow profile, and the top row shows the resulting events that have been characterised, with each event type shown in a different colour (for example, baths are coloured green in Figure B2.15).

B2.5. Market transformation data

Defra's Market Transformation Programme produced product summaries for various water using appliances in 2014. These provide predictions of water use for appliances and devices in 2030 for three scenarios:

- Reference scenario (equivalent to baseline forecast)
- Policy scenario (assuming more effective implementation and accelerated take-up of more sustainable products)
- EBP or early best practice (which assumes a more positive impact than the policy scenario and an early take up of innovative water efficient products).

Approach to micro-component forecasting

Micro-component models have been used for water demand forecasting in England and Wales from the late 1990s. They quantify the water used for specific activities (e.g. showering, bathing, toilet flushing, dishwashing, garden watering, etc.) by combining values for ownership (O), volume per use (V) and frequency of use (F).

By applying this together with the population or property data, a water demand model can be formed. By forecasting changes in each of the variables (O, V, F or daily water use for each micro-component) over time, a water demand forecast can be created. Hence the micro-component forecast model requires estimates of changes in these variables, to reflect future changes in technology, policy, regulation, and behaviour.

Basic inputs required

To build the micro-component forecast model, we need the following inputs:

- Base year household consumption broken down into micro-components.
- Reported base year household consumption (from water company annual return data).
- Rates of change in micro-components across the planning period.

Selection of the basic unit of consumption

Two commonly used methods of consumption forecasts are based on Per Capita Consumption (PCC) and Per Household Consumption (PHC). Linear modelling can use either approach.

In the case of PHC modelling, occupancy needs to be included as an explanatory variable, and PHC is composed of a consumption allotted to the house on the basis of its characteristics, and an additional consumption assigned to each occupant.

PCC modelling assigns a different consumption value per person on the basis of the characteristics of the property they inhabit.

In the former case, the model is property driven, which aligns with the data collection based on household meter reads. The latter case introduces all the error associated with the household occupancy figure into the model at the very first step. If the model is based on PCC,

[4] http://efficient-products.ghkint.eu/cms/product-strategies/subsector/domestic-water-using-products.html#viewlist

the PCC is calculated from estimated occupancy (for which there is an error), so there is no part of the consumption modelling that is independent of occupancy error; all the error in population forecasting is propagated through the zonal forecast if it is based on PCC.

Modelling by PHC makes occupancy-driven household consumption components implicit in the model whereas PCC-driven modelling would need to incorporate a correction for changing occupancy rates in PCC forecasting. For these reasons PHC is used as the basis for aggregating up to a zonal consumption forecast.

NRW and the EA require that the micro-components are reported in the WRMP tables in units of occupancy, i.e. per capita consumption; and the model converts the PHC micro-component values at the zonal level to PCC by dividing through by occupancy.

Micro-component occupancy model

Whilst we carry out the forecast model at household level, there is an influence on a selection of the micro-components from occupancy. Therefore, in calculating the base year and final year PHC values, we use a set of linear models that relate either daily use or frequency of use to occupancy in each year. The model is also used to provide the base and final year values for different metered property types: existing metered, optant metered, new property metered and selective metered.

The UKWIR 2015/16 micro-component data for measured billed households was used for the modelling because this dataset had a complete set of occupancy data for each household over the logging period. The total number of households in the sample was 62.

Figure B2.16 shows the daily use (or contribution to per household consumption) for each of the following micro-components:

- WC flushing,
- Shower use,
- Bath use,
- Tap use,
- Dish washer use,
- Washing machine use,
- Water softener use,
- External use, and
- Miscellaneous use (including internal plumbing losses).

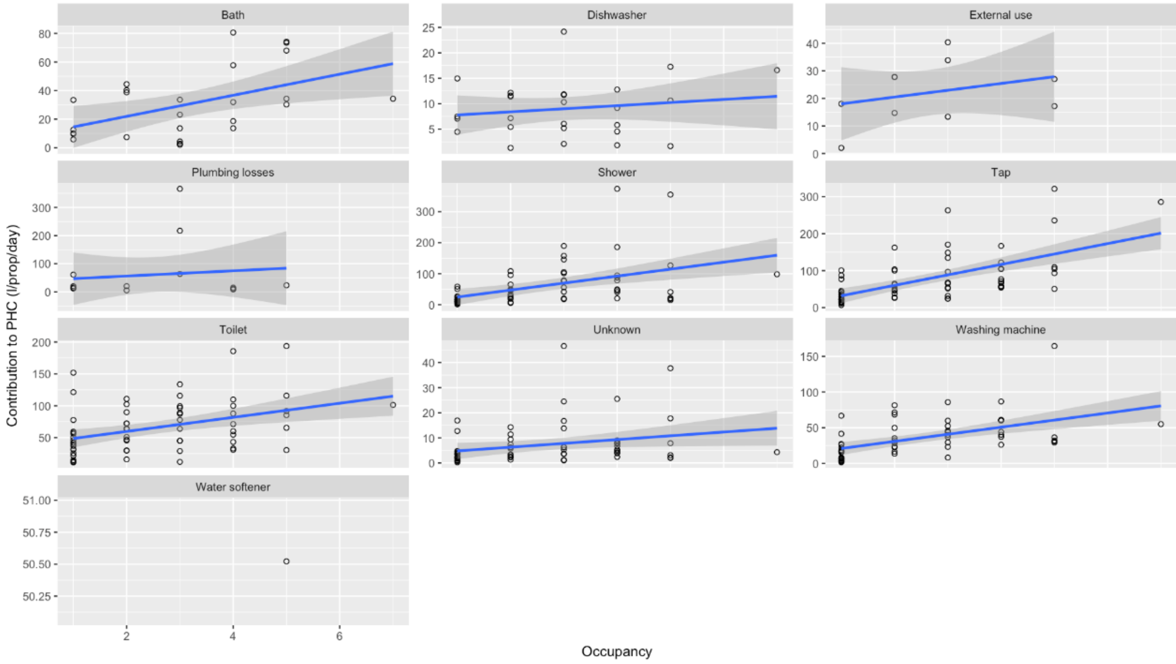

Figure B2.16 Each micro-component daily use plotted against occupancy

Each of the micro-components were investigated to determine whether the daily volume per use, frequency of use or ownership varied significantly with occupancy. The following micro-components showed relationships where occupancy was a significant factor:

- WC flushing,
- Shower use,
- Bath use,
- Tap use,
- Washing machine use.

For each of these micro-components (WC, Shower, Bath, WM and Taps) we developed a linear model using occupancy as the predictive factor.

Figure B2.17 shows the variation of WC flushing frequency per day with occupancy, with the mean frequency of use per day plotted against occupancy. The model is a log relationship of frequency of use against occupancy with the following equation:

Frequency of use (uses/day) = 6.143 + 3.744 * ln(occupancy) *Equation 1*

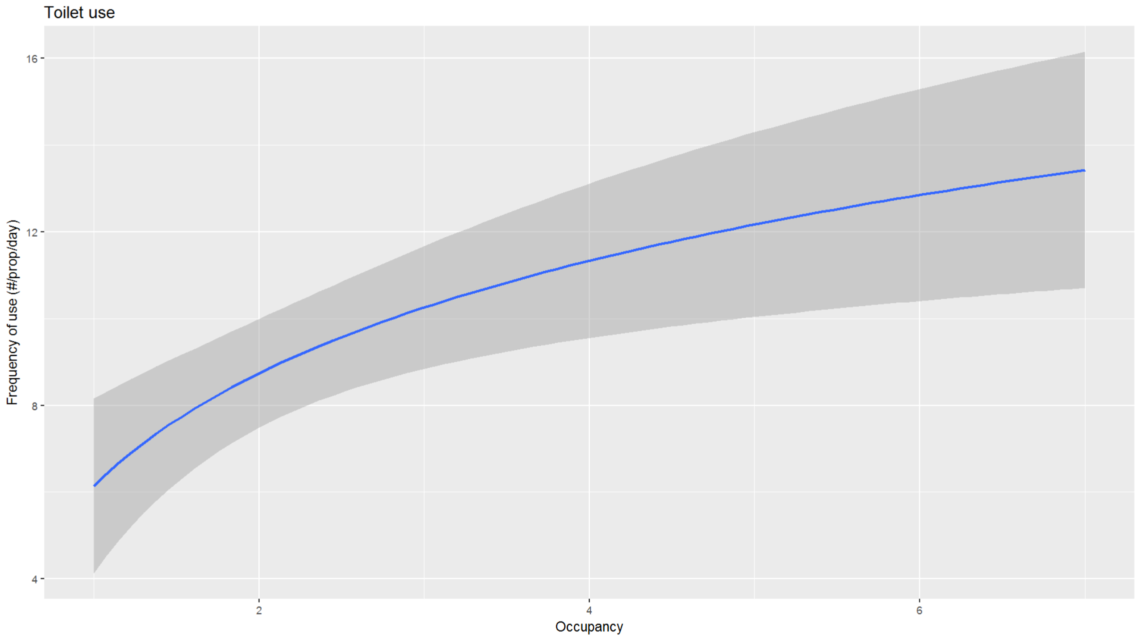

Figure B2.17 Variation of WC flushing frequency (uses per day) with occupancy

Figure B2.18 shows the variation of the water used for showering each day with occupancy, with the mean water use per day plotted against occupancy. Shower use was also explored in terms of frequency of use per day, but a more robust model could be built with volume used per day. This is probably because with increased occupancy there is increased variation in length of showering. The model is a log relationship of volume used per day against occupancy with the following equation:

Shower volume used per day = 15. 47 + 57.47 * ln(occupancy) *Equation 2*

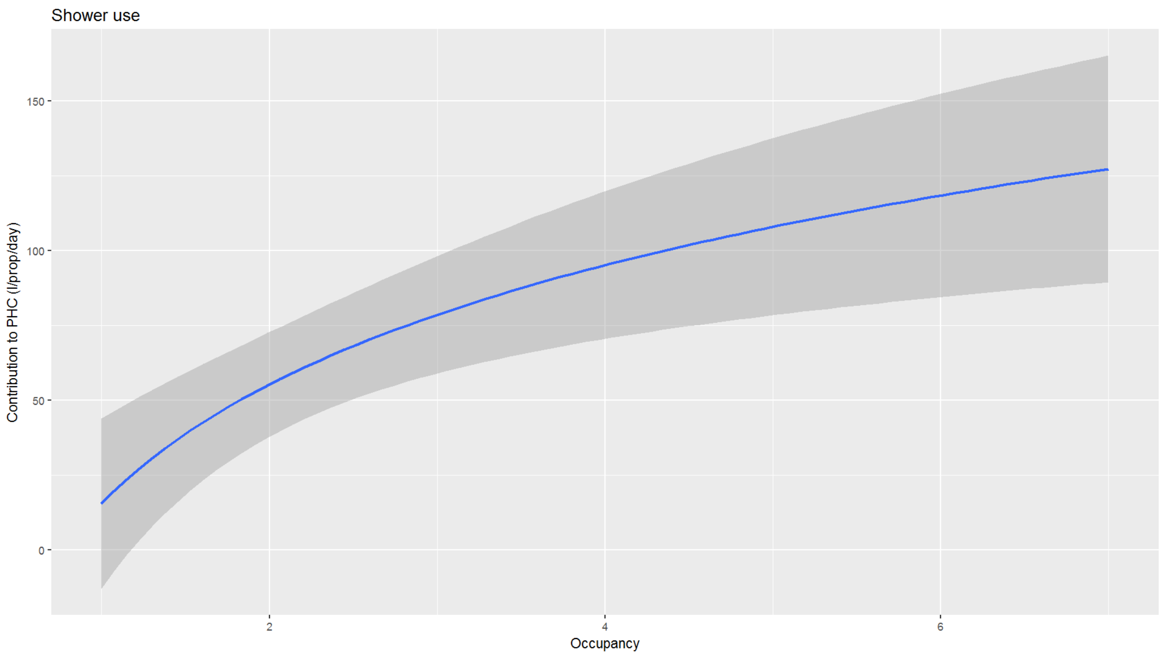

Figure B2.18 Variation of shower volume used per day with occupancy

Figure B2.19 shows the variation of the water used for bath use each day with occupancy, with the mean water use per day plotted against occupancy. The model is a log relationship of volume used per day against occupancy with the following equation:

Bath volume used per day = 7.181 + 7.378 * ln(occupancy) *Equation 3*

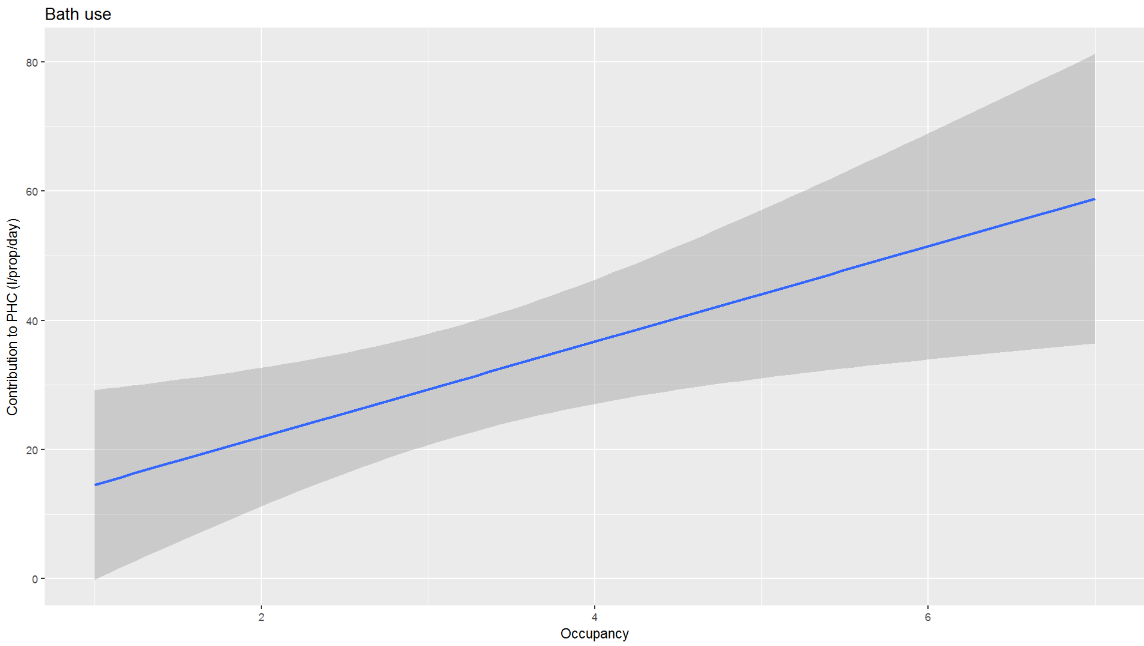

Figure B2.19 Variation of bath volume used per day with occupancy

Figure B2.20 shows the variation of the water used for tap use each day with occupancy, with the mean water use per day plotted against occupancy. The model is a log relationship of volume used per day against occupancy with the following equation:

Tap volume used per day = 27.92 + 62.89 * ln(occupancy) *Equation 4*

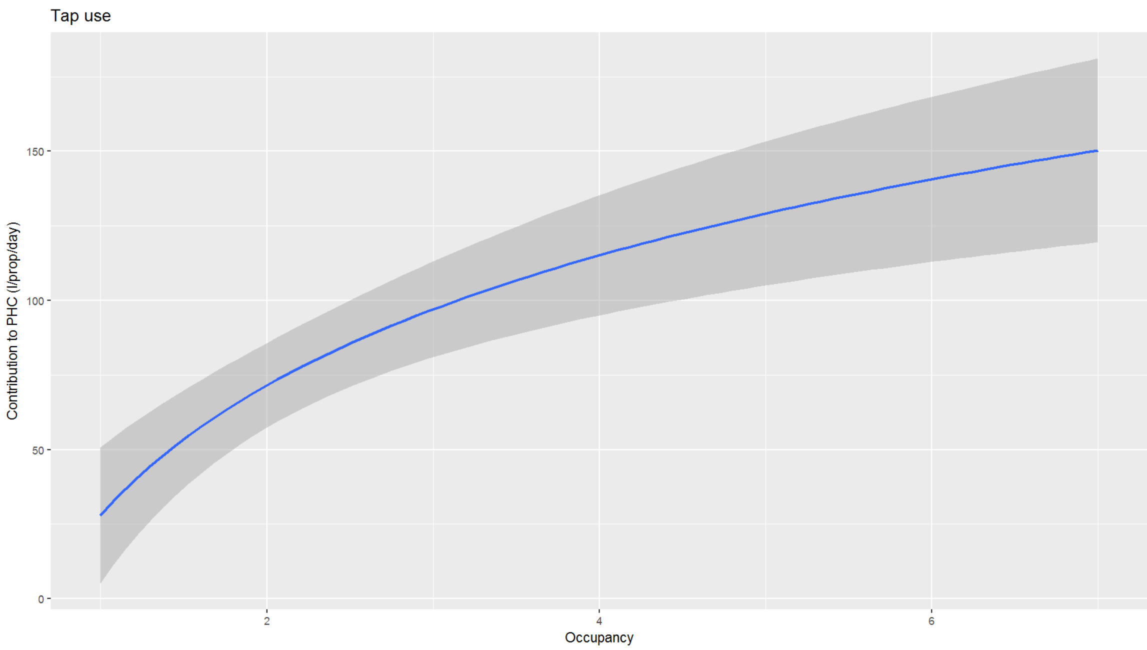

Figure B2.20 Variation of tap volume used per day with occupancy

Figure B2.21 shows the variation of the water used for washing machine use each day with occupancy, with the mean frequency of use per day plotted against occupancy. The model is a log relationship of frequency of use per day against occupancy with the following equation:

Frequency of use (uses/day) = 0.3242+ 0.43705 * ln(occupancy) *Equation 5*

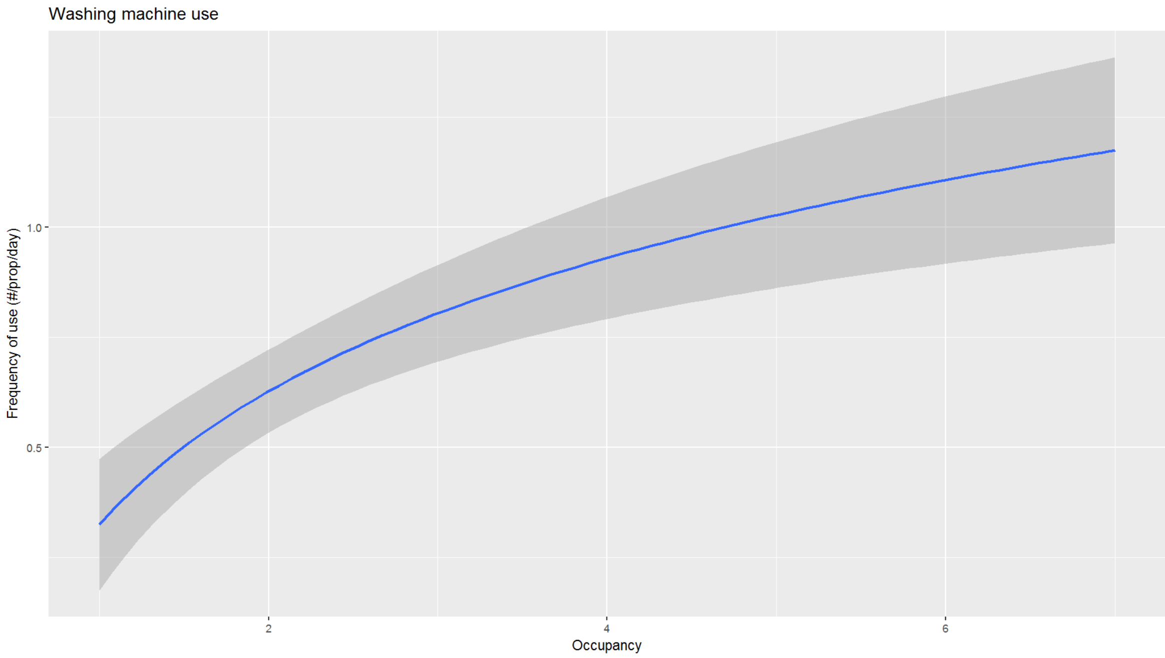

Figure B2.21 Variation of washing machine frequency of use with occupancy

For each property type the model variables shown in Table B2.11 are also changed depending on the meter status of the property.

Property type	**WC flush volume (mean l/flush)**	**Washing machine volume/use (mean l/use)**	**Dish washer volume/use (mean l/use)**	**Wastage / plumbing losses (frequency of occurrence)**
RV billed household (HH)	7.58	54.19	16.7	1.5*1.55
Existing measured HH	7.29	54.19	16.7	1.55
Optant measured HH	6.0	54.19	16.7	0.5*1.55
New build measured HH	5.5	50.0	15.0	0.5*1.55
Selective metered HH	7.58	54.19	16.7	0.5*1.55

Table B2.11 Micro-component variables that change with meter status

Combining all the relationships and variables, the micro-component occupancy model is defined in Table B2.12.

Micro-component	Weighted Ownership 'O'	Volume per use 'V' (l/use)	Frequency of use 'F' (uses/day)	Daily use (l/prop/day)
WC flushing	1	See Table 4	See Equation 1	O*V*F
Shower use				See Equation 2
Bath use				See Equation 3
Tap use				See Equation 4
Dish washer	0.42	See Table 4	0.5	O*V*F
Washing machine	0.95	See Table 4	See Equation 5	O*V*F
Water softener	0.02	52.06	0.97	O*V*F
External use	0.18	285.18	0.07	O*V*F
Plumbing losses	0.22	37.2	See Table 4	O*V*F
Miscellaneous	0.95	1.63	3.74	O*V*F

Table B2.12 Micro-component occupancy model parameters

The model can then be used to calculate the micro-component daily use (and hence the per household consumption 'PHC') for the following property types based on the occupancy of assigned to each property type, in the base year and in the final year of the forecast:

- RV billed households
- Existing metered billed households
- Optant metered billed households
- New build metered households
- Selective (or compulsory) metered billed households.

B2.6. Micro-component trend model - baseline scenario

To investigate trends in individual micro-components due to technology change, policies and regulation, and behaviour change, we have used the data set from 2002/04 and the 2015/16 datasets. For future projections of trends we have generally used the forecast water use values from Defra's Market Transformation Programme.

WC Flushing

For the trend we assume that ownership and frequency of use for WC flushing remains constant, with the volume per use changing due to market transformation.

Using data from the WRc micro-component report CP187 and data from the UKWIR 2016 study, we can create a histogram of the volumes per flush from 2002/04 and 2015/16. These are shown in Figure B2.22. This shows that for 2002/04 the mean flush volume was 9.4 l/flush, with a range of flush volumes from 5 litres to > 15 litres. In 2015/16 the mean flush volume had reduced to around 7.3 litres with a range from 3 litres to about 13 litres per flush.

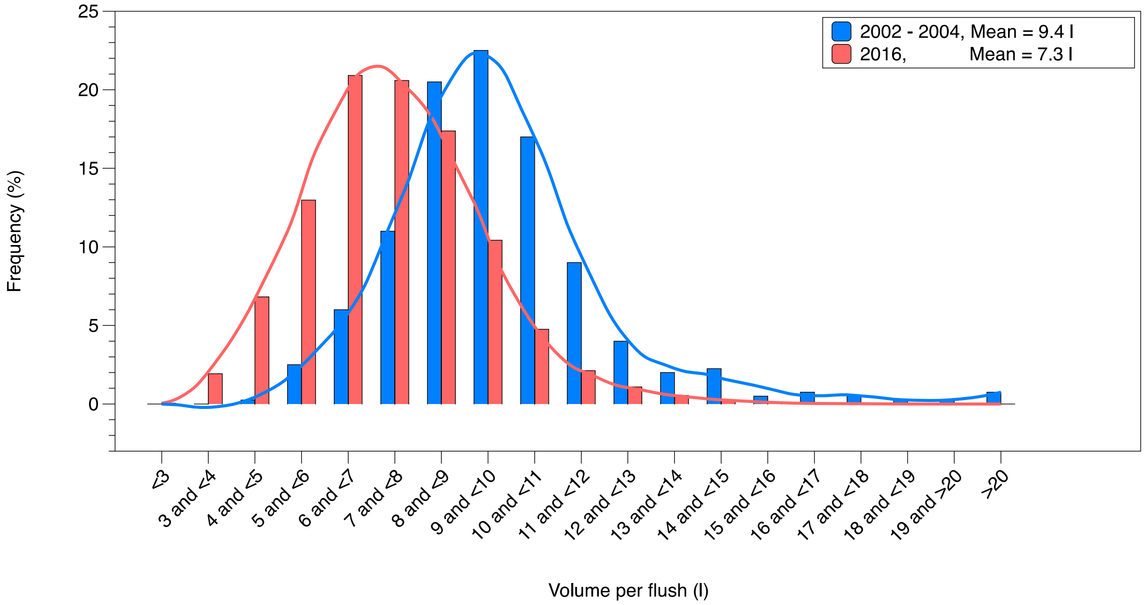

Figure B2.22 Histogram of WC flush volumes from 2002/04 and 2015/16

The reason for the reduction in flush volumes from 2002/04 to 2015/16 is due to the replacement of larger volume WC cisterns with smaller volume cisterns, due to market transformation based on regulatory policies. The schematic in Figure B2.23 shows the change in maximum flush volumes over time due to changes in regulation. From 12 litres in 1910 to 6 litre single flush or 6/4 or 6/3 litre dual flush in 2000 to date. The reason why we see larger flush volumes in the histogram is due to incorrect setting up of the fill height or over filling during the flush period.

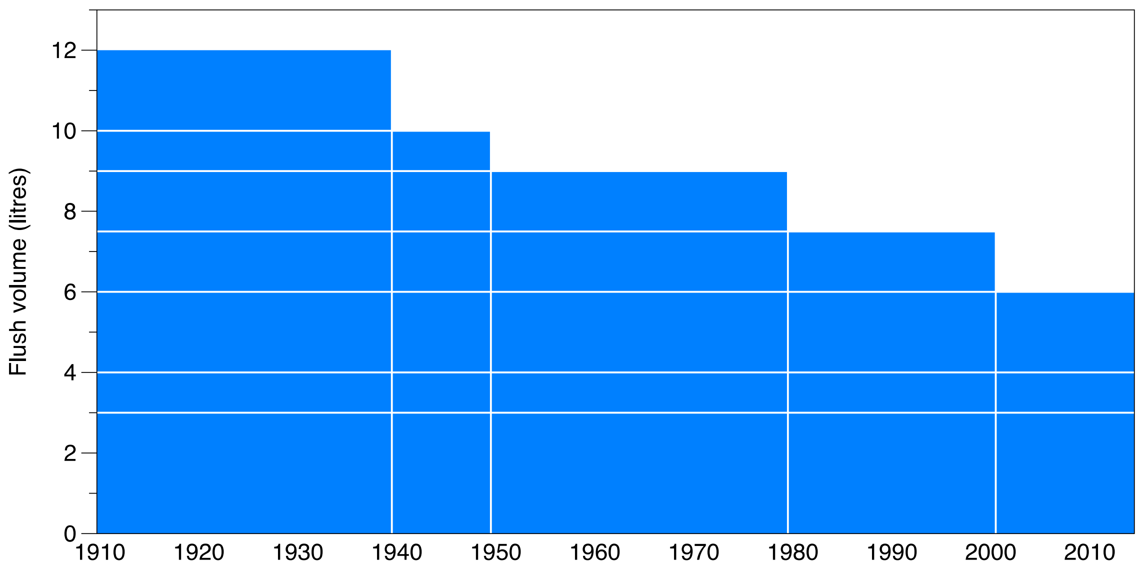

Figure B2.23 Regulatory changes in flush volumes

The latest MTP projections for WC flushing volumes[5] in 2030 for the reference scenario is 4.8 litres/flush. Figure B2.24 shows the mean 2002/04 (CP187), the 2015/16 flush volumes (Existing_mHH and Existing_umHH), and the flush volume from the MTP scenarios in 2030. The blue line shows the linear fit from the 2002/04, 2015/16 and MTP Reference scenarios.

If we assume that the market transformation continues at the current rate (a reasonable assumption for baseline forecasts, as there are no planned regulatory changes in WC flush volumes), then the flush volume in 2028 will be approximately 5.1 litres (shown by the intersect of the lines in Figure B2.24). This provides some confidence in the MTP Reference scenario for WC flush volumes.

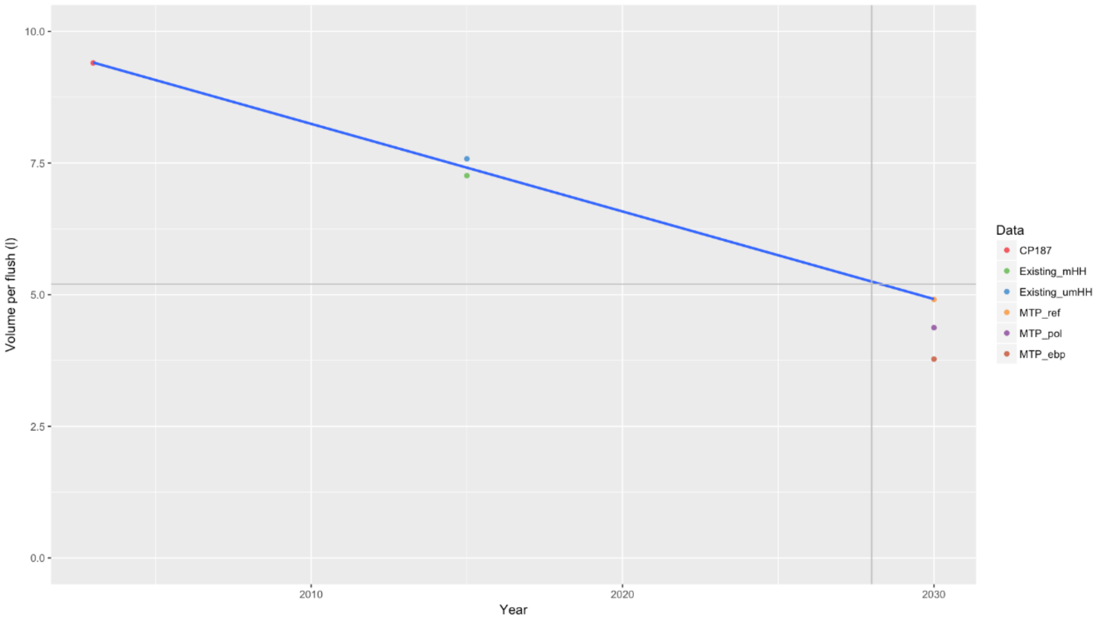

Figure B2.24 Historic, current and future flush volumes

We have created future trends for WC volume per flush (see Figure B2.25) using:

- the base year volumes per flush in Table B2.11 for different property types,
- the 2030 projection for WC flush volume from the MTP reference scenario,
- an assumption that all property types will have achieved the MTP Reference scenario between the forecast base year and 2030 (for the baseline forecast assuming no change to current WC flush regulations)[6],
- and an assumption that the volume per use will then remain relatively constant until 2045.

[5] Source: http://efficient-products.ghkint.eu/spm/download/document/id/954.pdf

[6] This is a reasonable assumption given the rate of change in actual data presented in Figure 2B.18 and discussed elsewhere in this section.

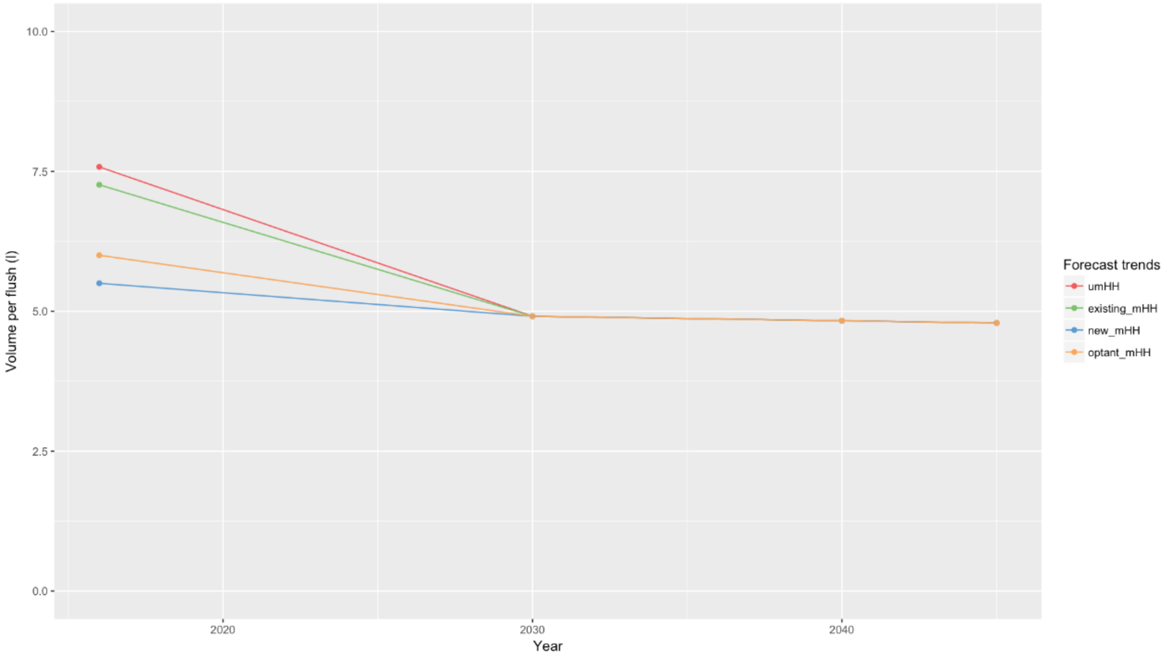

Figure B2.25 Trends for WC flush volumes

From these trends, annual rates of change have been produced for each of the property types. The rates of change are then incorporated into the model.

Showering

To investigate showering trends, we have used the overall daily water use (per household) from shower data. This is because shower use is a complex mix of behaviour (showering time), technology (shower flows), as well as frequency of use and occupancy.

Figure 2.26 shows the following data points on daily shower volumes (l/day):

- 2003 from WRc CP187 report,
- 2016 for Existing_mHH and Existing_umHH, both are approximately 49 l/day,
- 2030 from the MTP reference, policy and early best practice scenarios.

These data points assume an average occupancy for households in their specific years. The blue line shows a linear fit from the 2003, 2015/16 and MTP reference scenario. This shows a rising trend, which is consistent with the observations that shower use is increasing (in terms of ownership, frequency and flow rate).

We have chosen not to fit trend line through the MTP Early Best Practice point as this assumes a very high proportion of water efficient showers being installed in new and existing households (which is not evident in current practice.

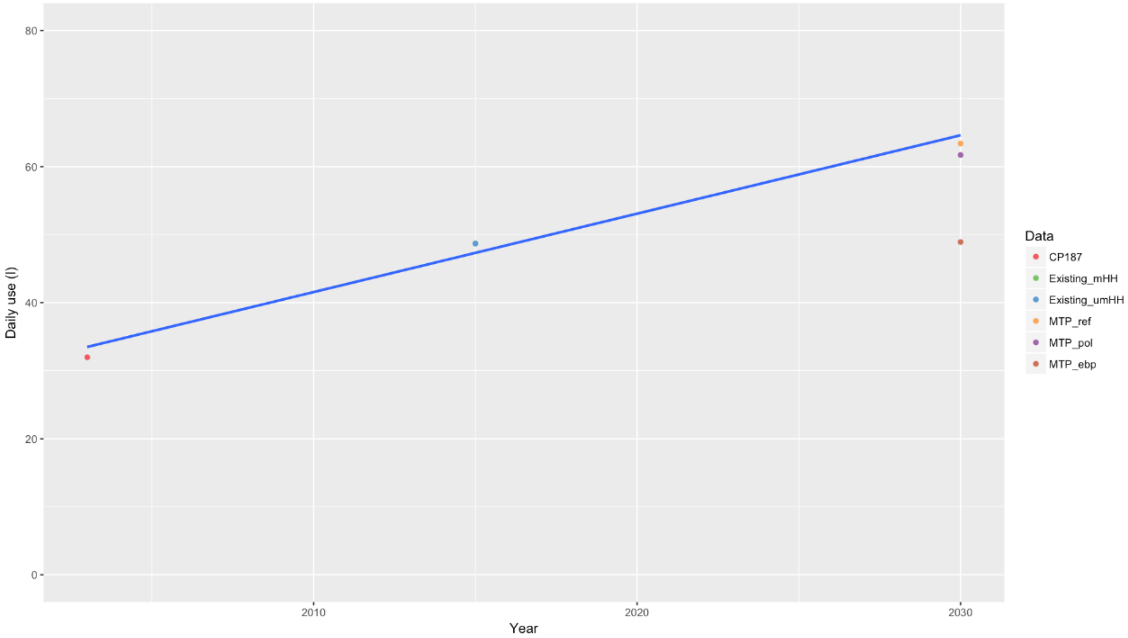

Figure B2.26 Trend of daily volume of water used for showering

Using the trend line from Figure B2.26 and assuming that shower volumes per day plateau at the MTP reference scenario in 2030 and remain flat over the rest of the planning period, we have produced a predicted trend for shower use as shown in Figure B2.27. There is no evidence for different house types having different trends, so the same trend is used for all house types.

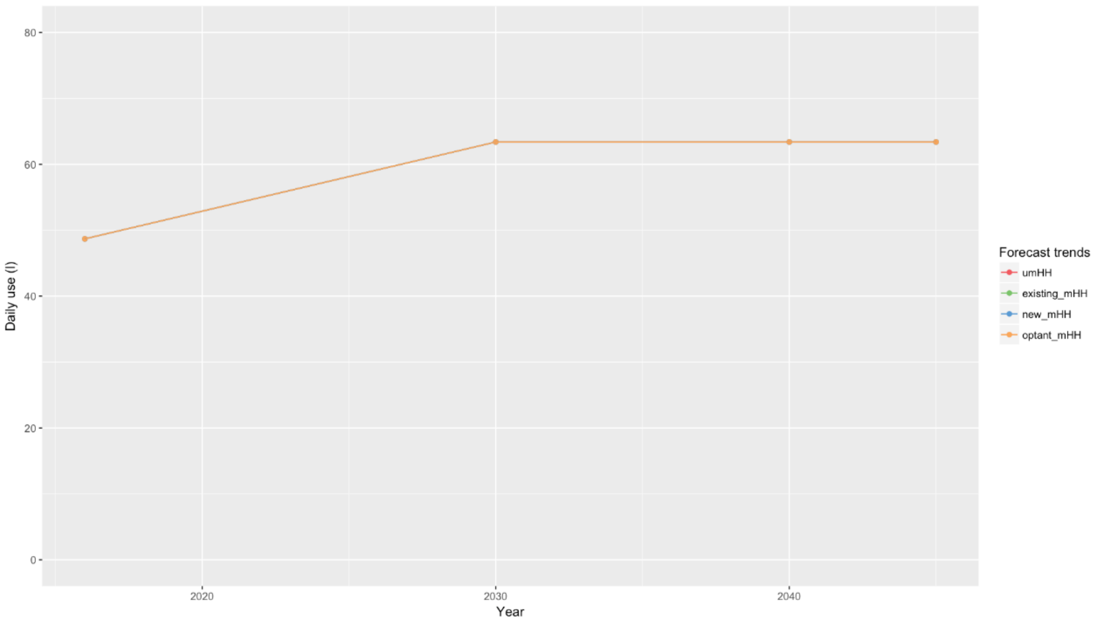

Figure B2.27 Future trend for daily volume of water used for showering

From this trend, annual rates of change have been produced. These are used for each of the property types. The rates of change are then incorporated in the model.

Bath use

For bath use trends, we have used the overall household daily water use from baths. Like showering, bath use is mix of behaviour, frequency of use and volume per use. Figure shows the evidence for daily volume of bath use from the following data points (l/day):

- 2016 from the bath use
- 2030 from the MTP reference, policy and early best practice scenarios.

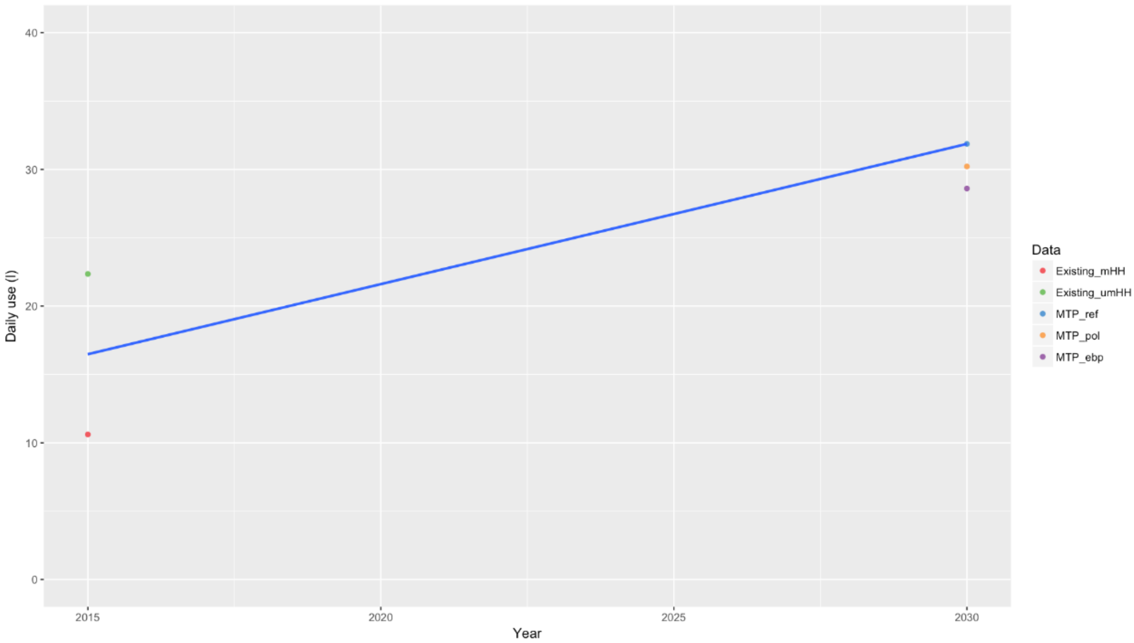

Figure B2.28 Trend of daily volume of water used for bath use

The blue line in Figure B2.28 is a linear fit of the 2016 and 203 data. Using this trend, and assuming that bath use then levels off at 2030 to the end of the planning period, we have created the future trend shown in Figure B2.29.We have assumed that all household types show the same trend. From this trend, annual rates of change have been produced. These are used for each of the property types. The rates of change are then incorporated in the model.

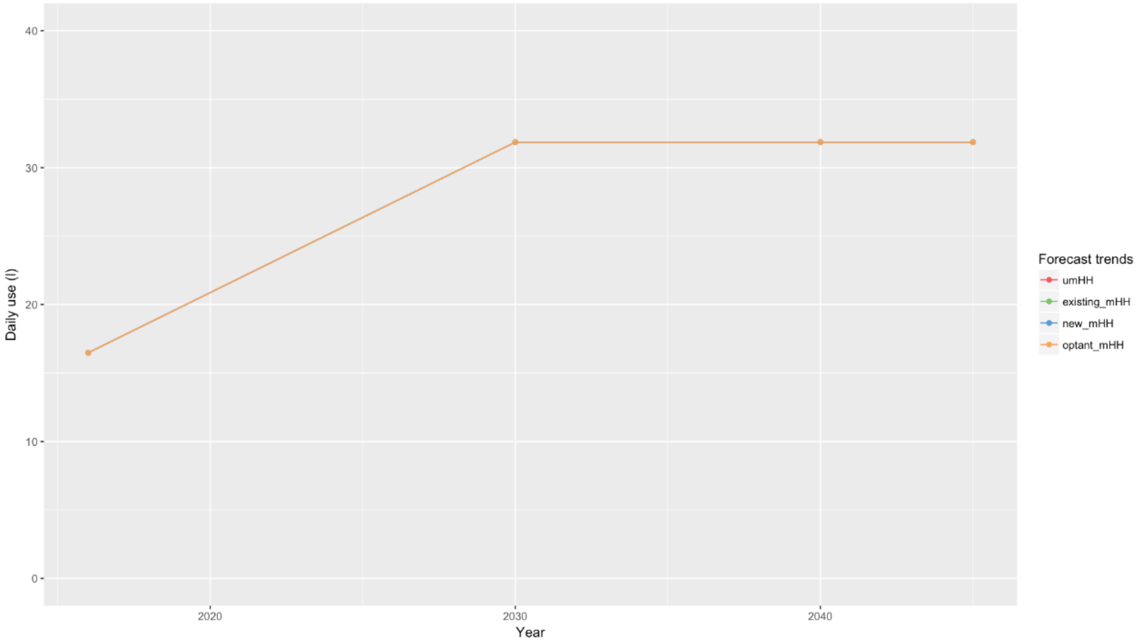

Figure B2.29 Predicted trends of daily volume of water used for bath use

Washing machine use

For washing machine use, the following evidence has been used to derive an historic trend in volume per use:

- Waterwise data on washing machine volume per use from 1999 and 2003,
- Washing machine volume per use in 2016

This data was used to produce a linear trend over time shown in Figure B2.30 (blue line). The volume per use has a trend over time to reflect the improvement in technologies to reduce energy and water use.

For the future trend in washing machine volume per use, we have extrapolated this trend to the end of the planning period (assuming continuous developments in technology). This trend is applied to all household types except new properties. These are assumed to have a starting point of 50 l/use in 2016. The resulting future trends are shown in Figure B2.31. Rates of change are then computed from these trends and incorporated in the model.

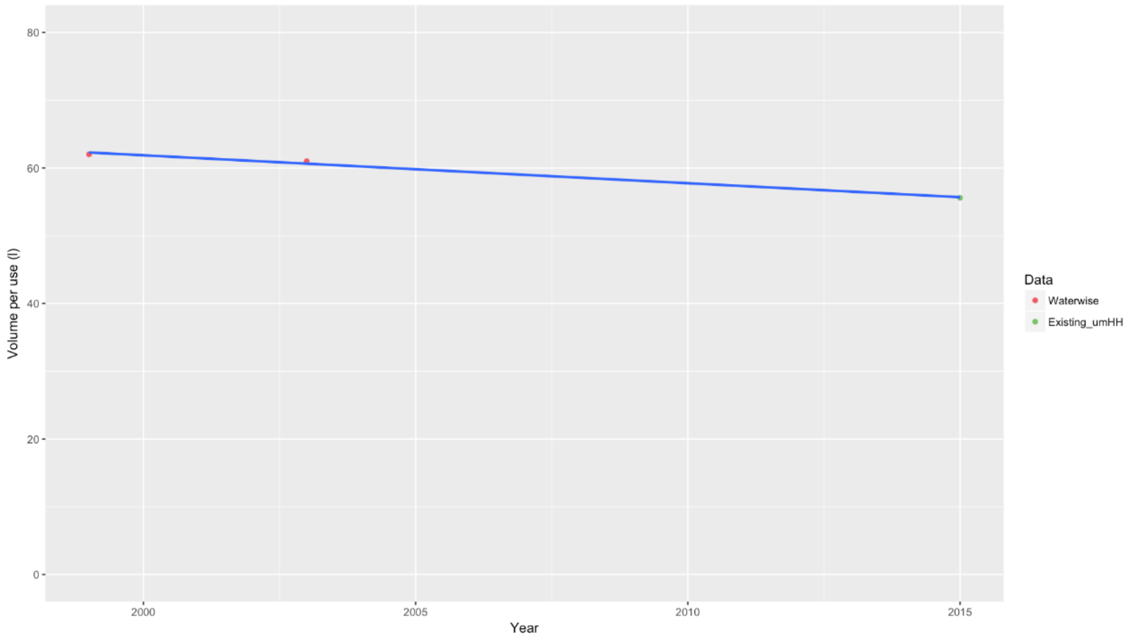

Figure B2.30 Historic trend in washing machine volume per use

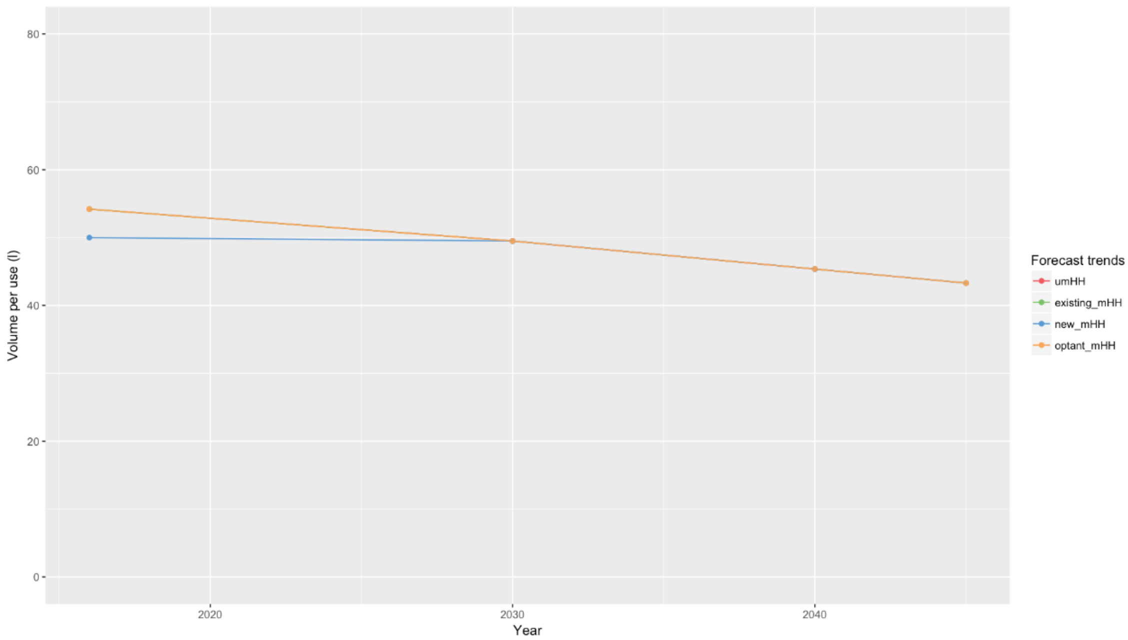

Figure B2.31 Future trend of washing machine volume per use

Dish washer use

For dishwasher use, the following evidence has been used to derive an historic trend in volume per use:

- Waterwise data on washing machine volume per use from 1999 and 2003,
- Washing machine volume per use in 2016 from

This data was used to produce a linear fit over time shown in Figure B2.32 (blue line). The volume per use has a trend over time to reflect the improvement in technologies to reduce energy and water use.

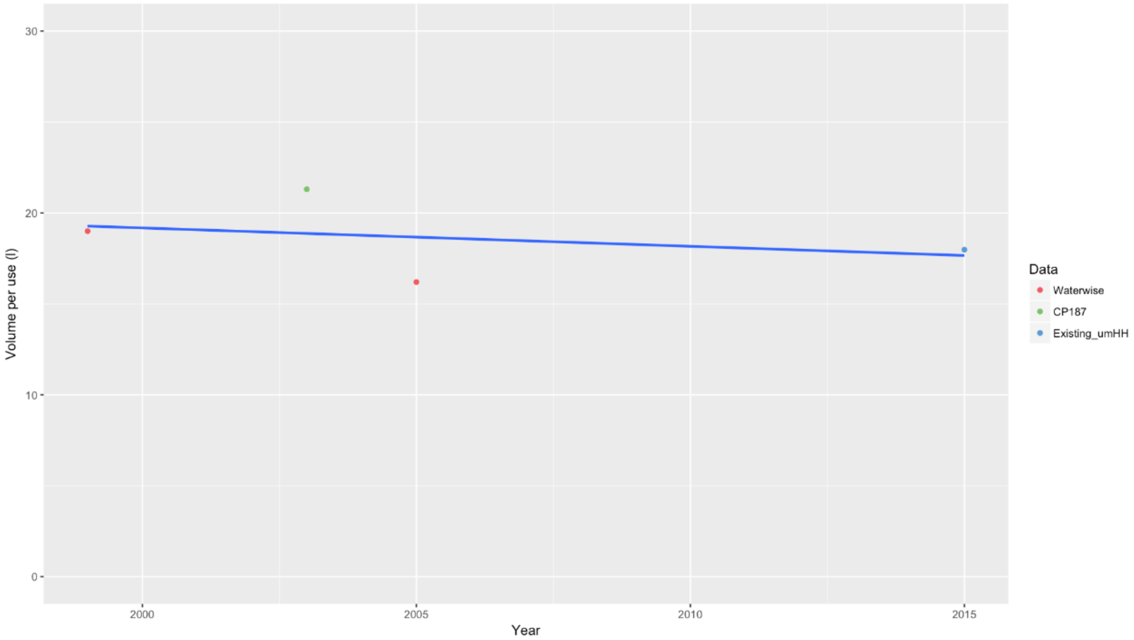

Figure B2.32 Historic trend in dish washer volume per use

For the future trend in dish washer machine volume per use, we have extrapolated this trend to the end of the planning period (assuming continuous developments in technology). This trend is applied to all household types except new properties. These are assumed to have a starting point of 15 l/use in 2016. The resulting future trends are shown in Figure B2.33. Rates of change are then computed from these trends and incorporated in the model.

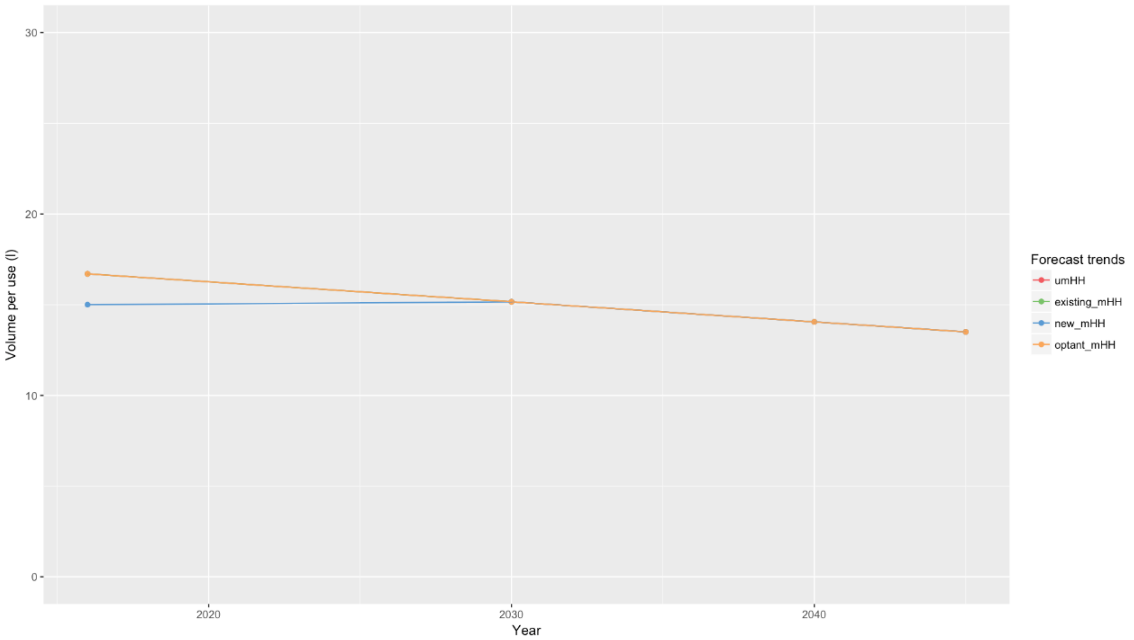

Figure B2.33 Future trends of dish washer volume per use

B2.7. Climate Change

Climate change impacts on consumption have been calculated in accordance to UKWIR *13/CL/04/12 Impact of Climate Change on water demand*. Median percentage climate change impacts on household demand at 2040, relative to 2012 are published for each river basin within the UK. The annual average forecasts use the average of the factors for these basins, therefore have a 0.9% increase in consumption over that period. As the base year is now 2016/17 and the final forecast year is 2044/45 the percentage change is shifted along as there has been no further evidence since this report.

The additional demand from climate change is added to the external use micro-component only. The volume attributed to climate change is displayed in a separate row in the top section of the outputs. The model includes functionality to output forecasts with and

Normal year and dry year adjustments

The methodology for the NYAA and DYAA factors comes from the UKWIR household consumption forecasting guidance[7] report number 15/WR/02/9 –and the UKWIR peak demand forecasting guidance[8].

Stage one is to assess the weather data, more specifically temperature and rainfall. Total summer rainfall is plotted against mean summer temperature, with the mean of all years for the two factors plotted as ablines and presented in Figure B2.34. Data from four Met Office weather stations were reviewed for this analysis – these stations are:

- Pershore: (top left in Figure B2.34);
- Shawbury: (top right in Figure B2.34);
- Watnall: (bottom left in Figure B2.34); and
- Coleshill: (bottom right in Figure B2.34).

also presents annual average unmeasured per capita consumption data for each of the years plotted, illustrated by the shading of the annual 'dot'. These data are from the Severn Trent Water Domestic Consumption Monitor (DCM). This DCM includes approximately 1,000 properties from across the Severn Trent Water region.

The results presented in Figure B2.34 show that 2003/04 is placed relatively highly in the top left quadrant (i.e. dry and warm) for three out of the four weather stations (i.e. all except Shawbury, where it is just below the mean temperature abline but still relatively warm dry). The years 2006/07 and 2014/15 are consistently warmer than 2003/04, but generally not as dry. Importantly, the consumption in both these years is less than in 2003/04. Also, 2003/04 was identified as the dry year for WRMP14, using a different method.

Therefore, 2003/04 is selected as the representative dry year for our region, using the best quality data available, including inter-station weather data.

[7] UKWIR (2015) WRMP19 Methods – Household Consumption Forecasting Guidance manual. Report Ref. No. 15/WR/02/9

[8] UKWIR (2006) Peak Water Demand Forecasting Methodology. Report Ref. No. 06/WR/01/7

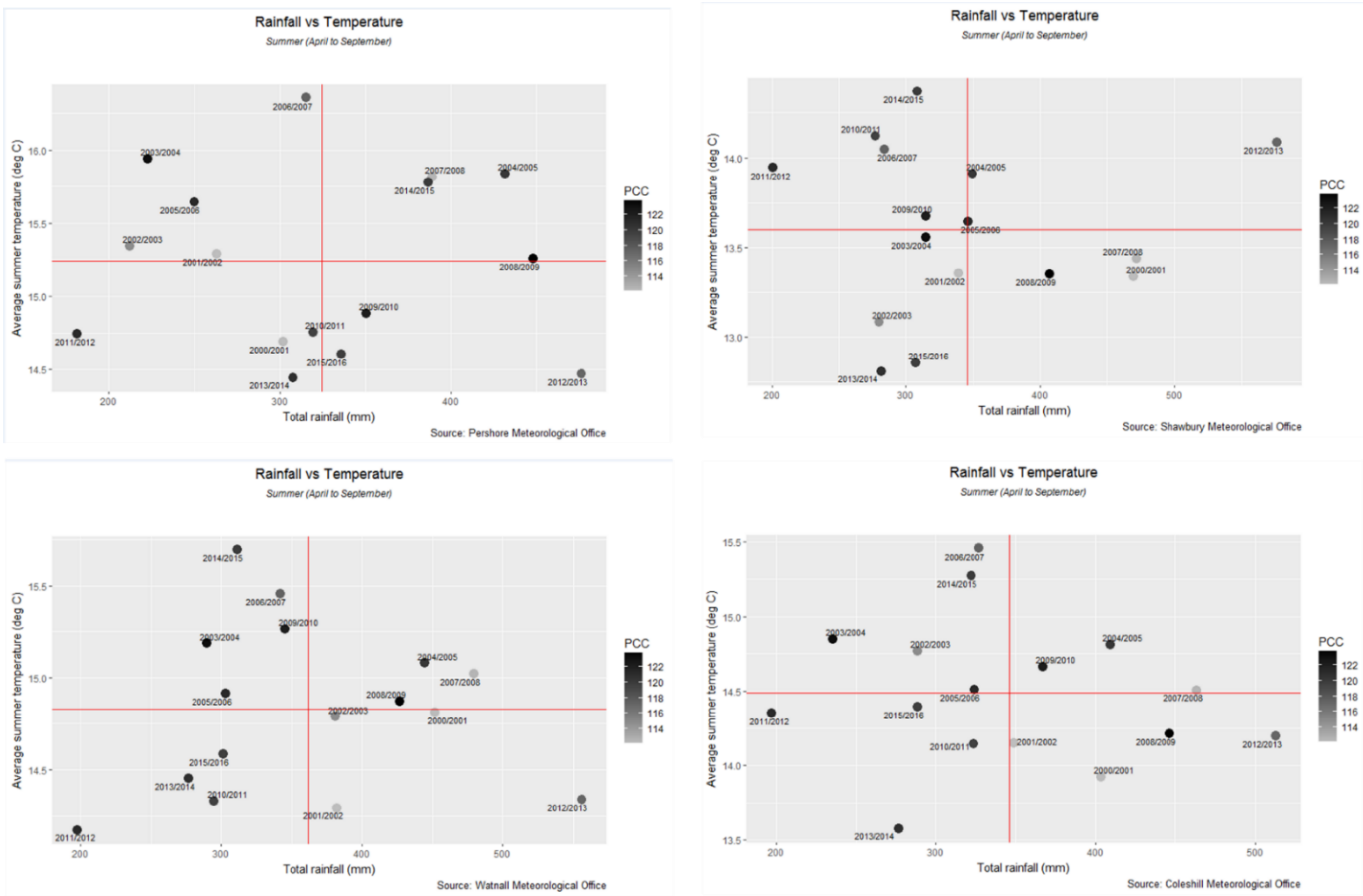

Figure B2.34 Quadrant plot for determining the dry year

Stage two is to analyse the PCC trends for the DCM unmeasured annual average consumption data set, as presented in Figure B2.35.

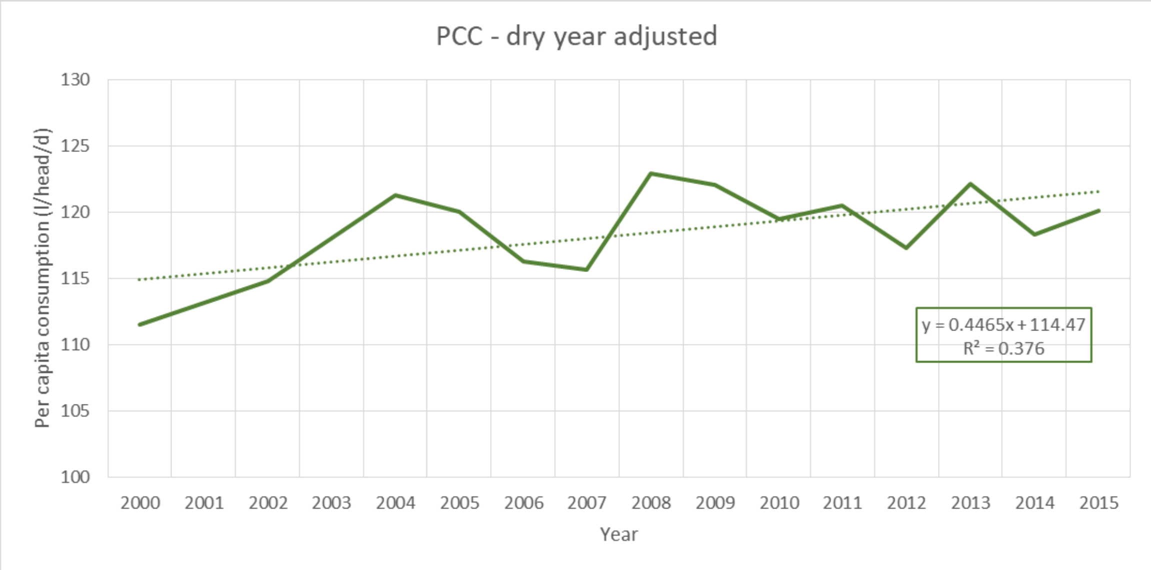

Figure B2.35 Average annual unmeasured per capita consumption for DCM properties

The dry year factor is calculated by removing the dry year, then calculating a trend line through the remaining points. The dry year factor is the actual consumption divided by the modelled consumption for 2003/04 – that is 124.26 l/head/day divided by 116.26 l/head/day. This results in a dry year factor of 1.0688.

Normal year factor calculations are calculated in a similar way, using the same trend line which excludes the dry year point. The normal year factor is the modelled figure divided by the actual figure for 2015/16 – that is 121.61 l/head/d divided by 120.12 l/head/d. This results in a normal year factor of 1.0124.

It is interesting to note the slight upward trend in per capita consumption (PCC) in Figure B2.35. This may due to a range of reasons including the relative dryness of the last three years in the data set (2013/14 – 2015/16), as illustrated in Figure ; or the composition of the DCM itself, which is typical of many consumption monitors in that it will tend to lose relatively low consumption households who opt for a meter.

The option to define different normal years and dry years for each of the company's WRZs (or groups of WRZs) was considered in this study, however this was not pursued for three reasons:

- This method of analysis provides broadly consistent results for the four Met Office weather stations used – not only for 2003/04 but also for other potential dry years such as 2006/07 or 2014/15.
- Other methods for forecasting consumption and dry year factors could provide zonal results but were not implemented due to lack of data. For example normalising for weather is an intrinsic part of regression modelling for consumption forecasting. However we would need to have household-level data on a range of explanatory

variables such as occupancy, household type/size and socio-demographic data and these data are not available for the DCM properties.

- The DCM data provides a good sized sample at the company level of around 1,000 properties. However this reduces significantly in size at the WRZ level, thus reducing the accuracy of the consumption estimate at this level of detail.

Application of the NY factor is different to the DY. The base year to normal year is applied before the calibration of the OVF calculated PHC, the reported figures are adjusted prior to this step so that the forecast is run from the normal year. Once the normal year forecasts are calculated the DY and CP factors are applied. These factors are independent of each other in that they are both applied to the NY forecast. Either option can be selected within the model. The baseline forecast for Severn Trent Water is as a DYAA.

B3. Forecasting non-household demand for water

Our forecast for the amount of water likely to be needed by our non-household customers in the Hafren Dyfrdwy WRZs which were part of the Dee Valley Water draft WRMP18 is primarily based on industrial use trend analysis and assumptions taken from WRMP14.

For the Llanfyllin and Llandinam & Llanwrin WRZs - which were part of the Severn Trent Water draft WRMP18 - the 25 year non-household water demand forecasts have been constructed using econometric models that relate non-household water demand to measures of economic activity (output and employment) in our region. We also take account of trends in water demand that are unrelated to economic conditions and reflect secular trends in the efficiency of water use by non-household consumers. These models follow the best practice guidelines laid out by the Environment Agency in developing water demand forecast for the next twenty five years.

We did consider aligning with the ST methodology for non-household demand but HD does not currently collate non-household billing information using Standard Industrial Classification (SIC) codes for Saltney and Wrexham customers and therefore, the data available was not compatible with ST's methodology.

The table below shows the mapping of the old WRZs forecasts to the new WRZs, and property, population and consumption forecasts for the new WRZs have been derived via apportionment on the basis of Annual Return property data mapped to the England and Wales border for non household customers.

<table>
<tr><th>Old WRZ (dWRMP 2018)</th><th>Border split</th><th>New WRZ (fWRMP 2019)</th></tr>
<tr><td rowspan="2">Shelton (STW)</td><td>Shelton Wales</td><td>Llanfyllin (HD)</td></tr>
<tr><td>Shelton England</td><td>Shelton (in Severn Trent Water Region)</td></tr>
<tr><td rowspan="2">Chester (DVW)</td><td>Chester Wales</td><td>Saltney (HD)</td></tr>
<tr><td>Chester England</td><td rowspan="2">Chester (in Severn Trent Water Region)</td></tr>
<tr><td rowspan="2">Wrexham (DVW)</td><td>Wrexham England</td></tr>
<tr><td>Wrexham Wales</td><td>Wrexham (HD)</td></tr>
<tr><td>Llandinam and Llanwrin (STW)</td><td>N/A</td><td>Llandinal and Llanwrin (STW)</td></tr>
</table>

Table B3.1 Mapping of DVW/STW WRZs to new HD WRZs for non-household demand

The following sections describe the forecasting approach to produce the fWRMP projections for Hafren Dyfrdwy.

Industrial use trend analysis approach

Hafren Dyfrdwy Saltney and Wrexham non household projections have been produced using an industrial use trend analysis originally applied to Dee Valley Water Chester and Wrexham WRZs.

Saltney WRZ

The Saltney Resource Zone is predominantly influenced by planning decisions made by Cheshire West and Chester Council. Small units of industrial land are available for development but the Council is not aware of any potential large water users planning to set up business in the Chester City area. Instead, the City tends to favour the expansion of the service sector, such as the corporate banking sector.

Based on the information provided by the councils and the non-household trend analysis, the proposed non-household demand forecast for the Saltney Resource Zone over the planning horizon is to remain constant at the value calculated for the base year. A slight increase in non-household consumptions is assumed due to the projected impact of climate change on non-household demand.

Wrexham WRZ

Wrexham County Borough Council has set aside areas of land for industrial development but at present there is limited demand for the land apart from Wrexham Energy Centre and Wrexham Prison. Wrexham County Borough Council is not aware of any interest by any other large water user to develop a business in the Wrexham area.

We have analysed the consumption of our non-household customers. The customers are assigned in the billing system to a Property Type based on the type of business, e.g. Property Type 7 is Industrial, Property Type 10 is Farm etc. From this analysis the only Property Type that appeared to have exhibited a significant change in consumption was the Industrial type - see Figure B3.1.

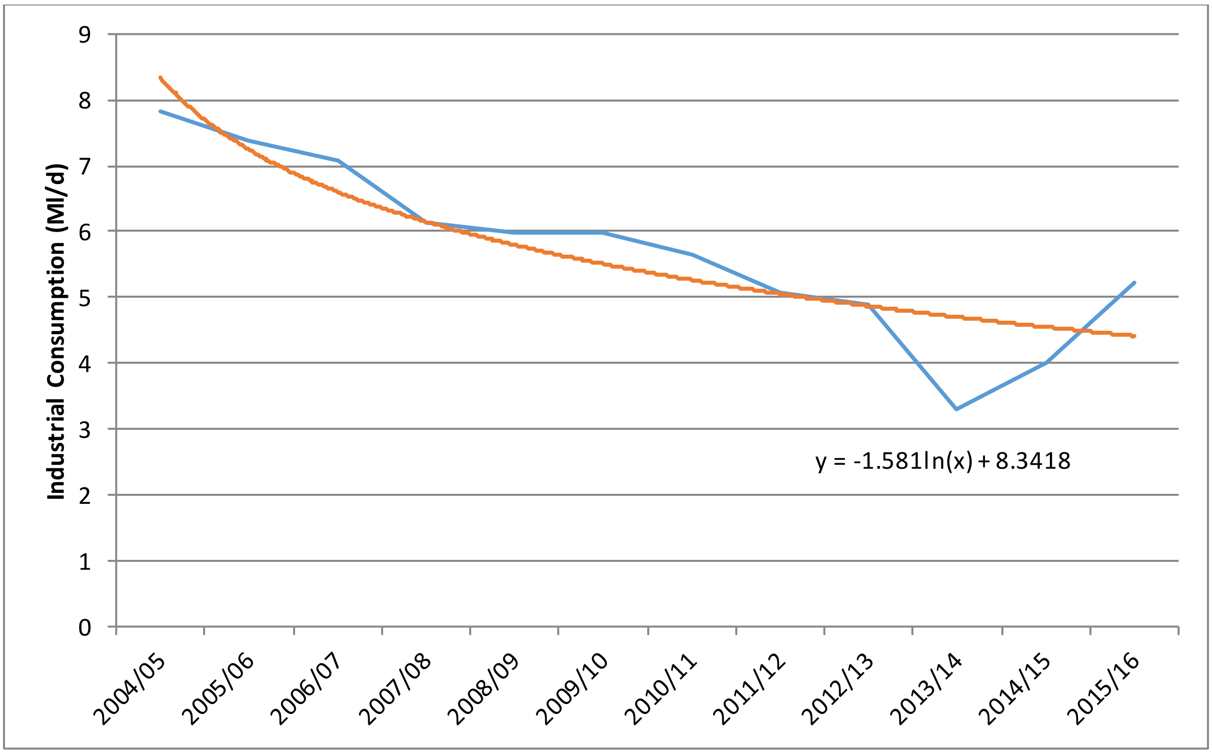

Figure B3.1 - Wrexham industrial potable water trend analysis

Although the actual consumption show a slight increase from 2013-14 onwards, the trend analysis indicates a continued decrease in consumption and this is the assumption we have based the forecast on.

Econometric modelling approach

Hafren Dyfrdwy Llanfyllin and Llandinam & Llanwrin WRZ non household projections have been produced using an econometric modelling approach applied to ST Shelton and Llandinam & Llanwrin WRZs.

The econometric models are constructed on an industry sector basis for which we classify industries by a Standard Industry Classification (SIC) code, a code classification for categorising business activity. We relate historical trends in non-household water demand for each of 30 SIC- based industries to local economic conditions in those sectors. This approach maximises the ability of the forecast models to incorporate industry-specific relationships between economic activity and non-household water demand. We vary the economic measures used (output or employment) and the coefficients relating economic measures to water consumption for each industry to reflect differences in the sensitivity of industry water consumption to economic conditions. An industry-by-industry approach also allows for different trends in water use efficiency for each industry sector. The chart below (Figure B3.2) summarises the approach and is followed by a detailed explanation of the analysis:

Methodology – NHWD Data

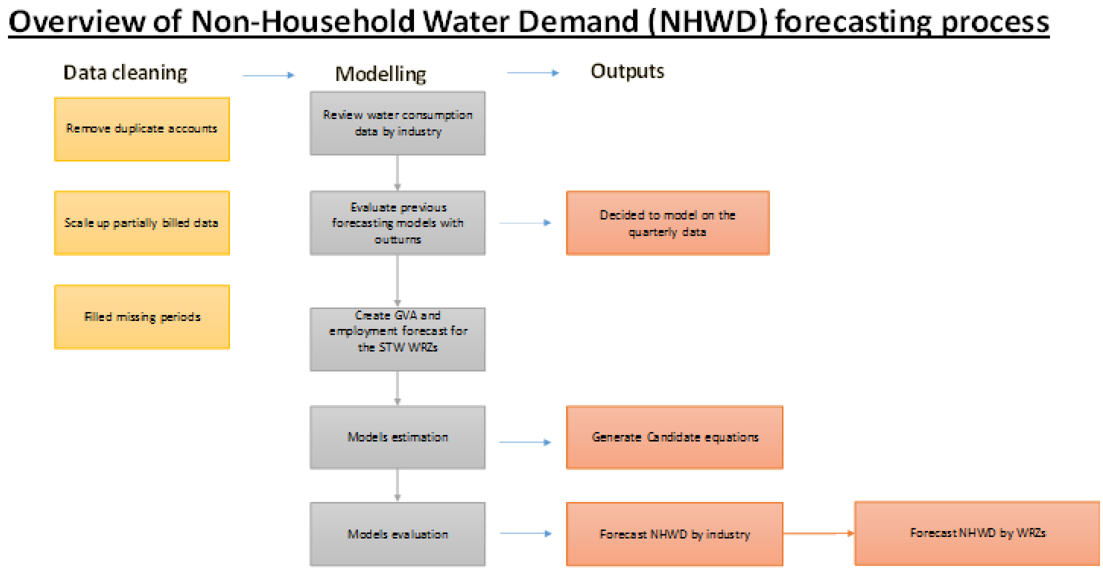

Figure B3.2 Overview of Non-Household Water Demand (NHWD) forecasting process

In order to develop the non-household water demand forecasting model, a set of historical water demand data from Severn Trent Water was required. For this purpose, account level data for non-household customers on a financial year basis between 2005/06 – 2015/16 was provided. Experian analysed the quarterly year consumption data in order to identify the most appropriate basis for model estimation and forecasting NHWD.

The data consisted of individual customer records showing water demand for each quarterly billing period. For each account, Experian received the following information:

- Unique ID
- Location (post code)
- Water usage (Ml/day)
- Industry (SIC)
- Consumption Band

Data Cleaning Process

Experian undertook the task of processing this data to produce a consistent time-series of water demand using techniques developed for the previous study. Checks were applied to the dataset to ensure data quality is consistent and to ensure no duplicate records were included in compiling the water usage data for modelling. These included checking for consistency of samples between the billing records and for consistent SIC industry coding, and other characteristics (name and address details, location details, consumption and tariff details) of individual accounts.

In addition, Experian followed the Forecasting water demand components – Best Practice Manual (UWKIR, 1997) by aggregating individual account into appropriate industry groupings with similar economic characteristics to increase the robustness of the data. Aggregating the data on this basis helps to smooth out volatility in consumption patterns at an account level. The industry groupings used are based on aggregations of SIC industries to the broad sector industry classification. The results from these aggregations were checked for consistency then aligned to the aggregated industry-level annual return data provided by STW.

The historical estimates for the broad sector groupings[9] are presented, on a financial year

Industry (Ml/d)	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
Primary industry	45.7	44.2	42.1	39.9	40.9	42.6	41.2	36.4	36.8	37.5	38.0
Manufacturing	110.8	99.7	95.2	87.7	84.9	86.2	84.4	78.7	79.5	81.5	84.3
Utilities	8.6	7.9	7.3	7.8	8.3	8.4	7.6	7.5	7.6	7.9	8.2
Construction	2.5	2.6	2.6	2.7	2.7	3.0	2.9	2.9	2.8	2.8	2.8
Wholesale & Retail	32.5	31.5	31.3	30.2	30.6	30.4	29.3	27.8	27.5	27.5	27.9
Transport & storage	8.3	7.8	8.5	8.0	8.0	7.7	6.8	6.2	6.3	6.7	6.7
Accomodation, Food Services & Recreation	48.7	48.5	47.9	47.4	49.4	50.2	50.2	48.0	48.3	49.2	49.3
Finance, Business & IT Services	37.4	36.7	36.8	36.6	37.1	38.2	39.0	37.2	37.7	38.6	40.1
Public Administration & Defence	18.6	17.8	17.7	17.4	17.2	17.4	16.0	14.9	14.7	14.5	14.2
Education	28.3	26.1	26.3	26.7	27.2	28.7	28.7	28.4	29.1	30.3	31.0
Health & Social care	22.8	22.2	22.4	22.6	23.5	24.2	23.4	22.6	22.8	23.5	24.7
Unallocated	27.2	23.9	21.1	16.4	12.2	9.5	8.2	8.9	10.4	10.3	13.3
Non-service	167.5	154.4	147.2	138.2	136.8	140.1	136.1	125.5	126.7	129.7	133.3
Service	196.6	190.7	190.8	188.9	193.0	196.7	193.4	184.9	186.4	190.4	193.9
Totals, all sectors:	**391.3**	**369.0**	**359.1**	**343.5**	**342.0**	**346.3**	**337.7**	**319.3**	**323.4**	**330.4**	**340.5**
Source: Severn Trent Water, Experian											

Table B3.2 - Water consumption by broad industry sector

basis, in Table B3.2 below.Most of non-service sectors showed declining water demand over the period 2005/06-2015/16 with the exception of the construction industry. Manufacturing accounted for the bulk of the decline which corresponded to the weakness observed in the GVA estimates and strong efficiency gains in the industry. The long term decline reversed in some industries since 2012/13, notably in the manufacturing industry where the water consumption rose from a decade low of 78.7 ml/day in 2012/13 to 84.3 ml/day in 2015/16. The recent increase in water usage corresponded to an increase in the industry's GVA, which may indicate that the water demand became more sensitive to changes to economic conditions and the water efficiency gain in the industry may be slowing.

Figures B3.3 and B3.4 show the trends in water demand within the service sectors relative to 2005/06. Although water consumption in the service sectors has remained much more stable compare to the non-service sector as a whole, diverging trends can be seen at the individual industry level. Water demand in education, health & social care and finance, business and IT services increased whereas the water demand fell in transport & storage, wholesale & retail and public and administration & defence.

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[9] The industry definitions are presented in Appendix A

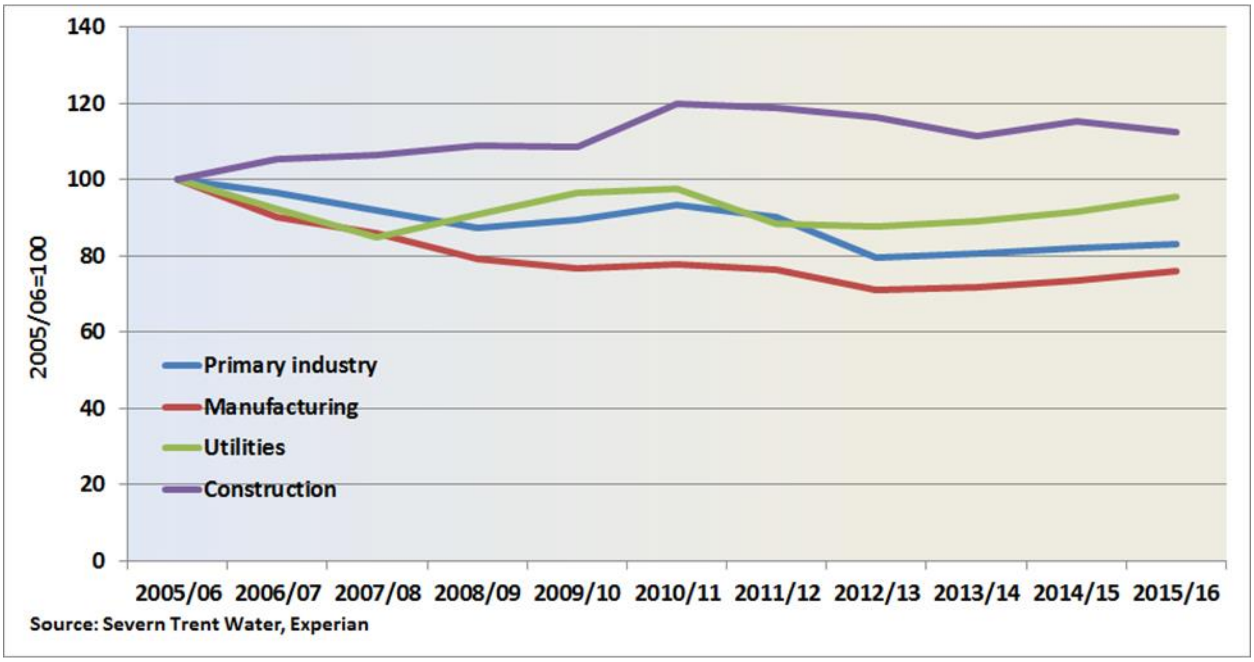

Figure B3.3 - Water consumption by industry in the non-service sector

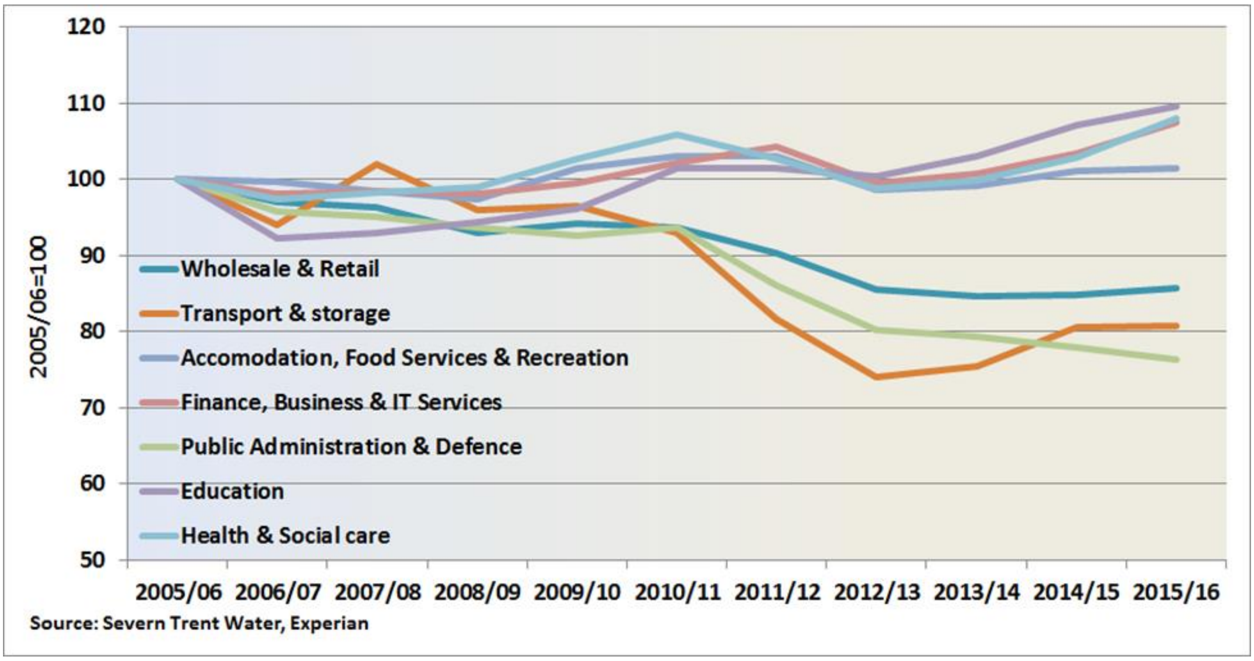

Figure B3.4 - Water consumption by industry in the service sector

Model Development

An econometric model is an analytical forecasting tool which operates by simplifying the real world into a set of variables, equations and identities. It produces forecasts to describe likely future outcomes based on the past interactions between variables under a set of pre-determined macroeconomic assumptions.

Experian followed the EA guidance and an established process of model development. The EA guidance states that the non-household demand model to be developed either using the main SIC categories published by the ONS or simply between service activities and non-service activities, identifying key sectors.

In the first instance, Experian began by exploring economic theories, available data and the desired forecast output. Once a model has been designed, candidate equations are estimated. The statistical properties of these equations are assessed. In particular, the following are considered:

- The fit of the equation (including the significance of individual estimated coefficients);
- The signs and magnitude of estimated coefficients;
- The dynamic properties of the equation;
- The suitability of the equation for forecasting or simulation (as may be required).

It is important to note that emphasis was placed on the forecasting and simulation properties of the model. In places, this meant that variables which were not statistically significant but which had the appropriate signs and magnitudes were included in equations to add explanatory power to the underlying forecast and to ensure that the model was appropriately responsive when used for simulation. Determinants of the demand for water

The economic rationale determines the demand for water is taken from the PR14 Non-household water demand report for Severn Trent Water. Furthermore the analysis of the accuracy of WRMP14 forecasts demonstrated that the demand for water in industry (non-services) is essentially derived demand. In that sense, water is demanded by industry because it is an important input into the productive process. Depending on the industry in question, water may be used directly in production as a raw material. Alternatively, water may be used indirectly in that it is consumed by people in the working environment. Accordingly, the demand for water in non-service industries should vary with output and demand for water in service industries should vary with employment. The relationship between NHWD and the explanatory variable have been re-examined across the broad industries (service and non-service) and more detailed industry groupings.

The factors explored were as follows:

- Sectoral output
- Sectoral employment
- Trends in the efficiency of water usage

The next section describes the estimation process in detail:

Stage 1: Estimation of equations

Based on the procedure set out in the EA guidance, the NHWD forecasting methodology involved pooling the sectoral data into two main groups: non-services and services. The equations were specified in the form of difference in logarithms to remove the non-stationary elements of the time series data.

A water efficiency variable was estimated to capture the changes in water consumption which was not explained by changes in GVA or employment depending on the sector. As recent efficiency gain was exceptionally high - which would be unlikely to continue at past rates - slower efficiency gain was factored into the forecast.

The equations were modelled over the period 2005/06 to 2015/16. It was necessary to be pragmatic at times to estimate the equations where there were large fluctuations in the water consumption data and construct a forecasting model with sensible forecasting properties.

The following two pooled equations were estimated:

For the non-service sectors:

$Dlog(NHWD_{pt})= \alpha_1 + \alpha_2 Dlog(GVA_{pt}) +\varepsilon$

and for services:

$Dlog(NHWD_{st})= \alpha_1 + \alpha_2 Dlog(EMP_{st}) +\varepsilon$

Where NHWD = measured non-household water demand (Ml/day)

GVA = Total output in non-service industries (Gross Value Added in 2012 VCM (Value Chained Measure))

EMP = Full-time equivalent employment in service industries

Subscript t refers to time period (2005/06 to 2015/16)

Subscript p refers to non-service industries

Subscript s refers to service industries

In these equations we capture the relationship between growth of NHWD and growth in economic activity, while the 'constant' term, α, incorporates a constant trend growth rate for NHWD which is independent of economic conditions. So, in this specification, consumption in the relevant sector is tending to increase (or decline, since α is generally negative) at a constant exponential growth rate but this trend growth rate would increase or decrease depending on the strength of the local economy (measured by either output growth or employment growth).

Stage 2: Estimation results

The results from estimating the models on the quarterly data from 2005/06 to 2015/16 were as follows:

Non-services:

(i) $Dlog(NHWD_{pt})= 0.43* Dlog(GVA_{pt})– 0.027$

Services:

(ii) $Dlog(NHWD_{st})= 0.14* Dlog(EMP_{st})+ 0.002$

The initial results indicated that the growth in output has a positive relationship with water consumption in the non-service industry, +0.43 for the (non-services) and employment is

+0.14 for the services. In other words, the equation implies that a 1 per cent increase in output would increase water consumption by 0.43 per cent with everything else remaining unchanged, while a 1 per cent increase in employment would increase water consumption for service industries by 0.14 per cent.

The signs of the coefficients make intuitive sense for the equations for both the service and non-service sectors, since non-household water demand rises in response to increased activity in the sector. However, the magnitude of the employment in the service sector equation is deemed insignificant, therefore only the equation for non-service was accepted. In addition, the efficiency terms in the non-service equation is also considered insignificant to be included in the equation.

Stage 3: Estimation of detailed industry relationships

The broad sector approach produced sensible results for the non-service sector which can be used to estimate demand equations for detailed sectors. The second stage of the modelling phase was to impose the results from stage one on the sectors belong to the non-services industries. This involved running a regression for each category using fixed values for the coefficients of output, estimated in stage 1. These results were then imposed on the demand equations so that each category's own intercept term can be estimated with these restrictions imposed. Therefore despite limitations with the data, the use of both time-series and pooled regression techniques enables each industry's derived demand to depend upon the industry's performance in terms of output or employment. Furthermore, efficiency variables were included in the equations but only retained if the sign and magnitude of the coefficient was sensible.

The pooling method did not produce satisfactory results for the service sector aggregate.

For each service sector, one of following model specifications was used:

$$Dlog(NHWD_{st}) = \square_1 + \square_2\ Dlog(EMP_s) + \varepsilon \quad (1)$$

or

$$Log(NHWD_{st}) = \square_1 + \square_2\ Log(EMP_{st}) + \varepsilon \quad (2)$$

In variant (1), above, the equation attempts to capture the relationship between growth of NHWD and growth in economic activity, while the 'constant' term, $\square_1$, incorporates a constant trend growth rate for NHWD independent of economic conditions. In this specification, consumption in the relevant sector is tending to increase (or decline, since $\square_1$ is generally negative) at a constant exponential growth rate but this trend growth rate is increased or decreased depending on the strength of the local economy (measured by either output growth or employment growth).

In variant (2), the *level* of NHWD is related to the level of local economic output or employment in the relevant industry sector. The log operator means that the coefficient, $\square_2$, relating water consumption to economic activity is an 'elasticity'. It measures the percentage change in water consumption by that industry consequent upon a 1 per cent increase in either output or employment. This specification was considered in cases where there was no evidence of a trend in NHWD unrelated to economic conditions.

The details of each equation can be found in Table B3.2.

It is important to point out at this stage that among the detailed industry level NHWD figures provided to Experian, there were a number of commercial customers that could not be directly aligned to a SIC group. This meant that a small element of NHWD could not be attributed to either service or non-service economic drivers, so no equations could be estimated to forecast future demand. Therefore it was decided to assume the unallocated category constant at a level equivalent to the mean over the period 2005/06 to 2015/16.

Industry	Coefficients			
	constant term	GVA	Employment	Model Specification
Primary industry	-0.001	0.4	0.0	
Manufacturing	-0.002	0.4	0.0	
Utilities	-0.001	0.4	0.0	
Construction	0.00	0.4	0.0	
Wholesale & Retail	-0.01	0.0	0.1	1
Transport & storage	0.00	0.2	0.0	1
Accomodation, Food Services & Recreation	-0.01	0.2	0.0	1
Finance, Business & IT Services	12.69	0.3	0.0	2
Public Administration & Defence	9.76	0.0	1.0	2
Education	-0.01	0.0	0.6	1
Health & Social care	-0.02	0.6	0.0	1
Source: Experian				

Table B3.3 - Model co-efficients by broad sector

Stage 4: Water Resource Zone forecasts

The final stage of the forecast process was to provide non-household water consumption forecasts for the Llanfyllin and Llaninam & Llanwrin Water Resource Zone (WRZ) areas. The method used was to allocate water demand forecasts across the WRZs using the WRZs share of economic activity in that industry. This means that the WRZ area forecasts reflect the most recent composition of water demand in those areas by industry sector, and the industry sector demand forecasts for the region as a whole. A further step is taken to calculate the results of the post-Maximum Likelihood Estimation (MLE).

A scale factor has been derived by averaging the scaling factors between the water consumption from the billing data and the post-MLE data from the Annual return every year between 2011-12 and 2015-16.The non-household water demand does not factor in any explicit assumption regarding to customers swapping from non-public supply. However, it is assumed implicitly in that if a customer had swapped water supply from non-public supply then the water consumption would be higher for a given amount of economic output, and as the constant term in the equation captures water demand that is not explained by either employment or output growth, the demand forecast assumes the customers' behaviour in the past (including swapping from non-public supply) will be a reflection of the future.

B4. Leakage

The final WRMP19 adopts an approach that sets top down AMP8, AMP9, AMP10 and AMP11 leakage reduction targets based on achieving the 50% leakage reduction challenge set by NIC. Our current least whole-life cost modelling suggests that based on existing leakage reduction technology, costs and performance it would not be cost effective to reduce to these levels. However, we recognise that stakeholders and regulators expect us to prioritise long term leakage reduction and to find innovative ways to drive future performance. This will require us to increase investment in the leakage technology and innovation required to achieve these levels of performance. Beyond AMP7, these longer term reductions would be distributed across all zones regardless of supply / demand balance needs as demonstrated

Since the last WRMP was published, we have been working with the other water companies have been working together on a project, coordinated by Water UK and supported by Ofwat, to develop more consistent reporting methodologies for the measurement of leakage. Ofwat has confirmed that the output of this project will not impact on PR14 PCs and ODIs. It is intended to form the basis of public reporting from 2020/21 and to inform the development of PR19 Business Plans.

The project outlined 72 recommendations in the final report, 12 needing significant system, Netbase modelling, and platform changes. The others linked to improvements in monitoring and process. In August 2017 we completed a back run of APR17 and applied where we could, compliant measurement to the leakage calculation. The results gave us a net increase of 1.120 Ml/d.

The Netbase parameter changes to align with the guidance added 1.4Ml/d to the consistency leakage figure. Consistency is not impacting deployable output, it is merely moving between real consumption and reported leakage. Our AMP7 WRMP priority is still to focus on demand management measures through leakage reduction, water efficiency and more metering. As a result of the work done to date we plan to build the results into our PR19 modelling and start position for AMP7.

Following the 2016/17 back run, we are compliant with 5 of the 16 key water balance components. Where we do not currently adhere to best practise we plan to get to full compliance by APR20 so that we can start AMP7 fully compliant with targets set based on full compliance. Tables B4.1 and B4.2 show current and plan to get to full compliance.

Component		Compliance (R/A/G)
1	Coverage	G
2	Availability	A
3	Properties	A
4	Night flow period and analysis	A
5	Household night use	A
6	Non-household night use	R
7	Hour to day conversion	R
8	Annual distribution leakage	G

9	Trunk mains leakage	G
10	Service reservoir leakage	R
11	Distribution input	A
12	Water delivered measured	A
13	Water delivered unmeasured (PCC)	R
14	Company own water use	G
15	Other water use	G
16	Water balance and MLE	A

Table B4.1 - HD current status in relation to each component of the new leakage methodology

Component	17/18 Q2	17/18 Q3	17/18 Q4	18/19 Q1	18/19 Q2	18/19 Q3	18/19 Q4	19/20 Q1	19/20 Q2	19/20 Q3	19/20 Q4	Assumptions
Availability												NHH loggers all installed, changes to HHNU, NHHNU, Properties all improve operability
Properties												DV GIS joining up with STW will lead to geospatial improvements and properties assigned to the correct DMAs
Night Flow Period Analysis												Netbase update completed by end of Q2 18/19
Household Night use												STW HNU estimate is representative of DV, 8 more SAMs can be installed by end of AMP
Non-Household Night Use												STW NHNU estimate is representative of DV, 8 more SAMs can be installed by end of AMP
Hour to Day Factor												Loggers Installed in 17/18
Service Reservoir Losses												Process can be written up, followed and reported properly. Two years data is sufficient to start providing an estimate
Distribution Input												Reporting comes to STW Assurance team, STW verification team can be used to test meter, there are verification facilities for all meters
Water Delivered Measured												There is data available to carry out the relevant studies
Water Delivered Unmeasure												STW PCC estimate is representative of DV, 8 more SAMs can be installed by end of AMP
Water Balance												Uncertainty study will provide reliable uncertainty estimates

Table B4.2 - Expected dates of when components will turn to green

We will dual report consistency internally through the remainder of the AMP and externally as part of APR. As work is completed and components become compliant we will include the impact in shadow reporting so that we are fully compliant by APR20.

B5. Baseline water efficiency activities

Our baseline demand projections incorporate the ongoing benefits of our baseline water efficiency activities.

For AMP 7, we have made a decision to increase our baseline water efficiency programme to undertake as a minimum the same level of activity to all our customer base. This will ensure we meet our on-going statutory water efficiency duty as well as helping customers reduce their demand for water.

In line with our understanding of customer, regulator and Government expectations, we will offer a range of water efficiency services to our customers. We expect the key metrics to deliver on our statutory duty will be:

- Provide information to all consumers on how to save water. This includes maintaining our provision of direct engagement with schools and adult groups and providing information for non-household customers.
- Provide a range of water saving products which are free to customers on request.
- Provide discounted higher value water saving products (e.g. water butts, showerheads).
- Develop links with third parties to form partnerships – internal and external - to take advantage of scheduled visits to promote water efficiency and to retrofit water efficient devices.
- Provide water efficiency advice and access to free water saving devices as part of our free meter optant programme (FrOpt).

In Figure B5.1 below we provide our current expectations of how we will deliver our baseline activity, further explanation of these activities are detailed below. Over time the balance between free products, product installation, and education may change in response to the available opportunities and customer expectations.

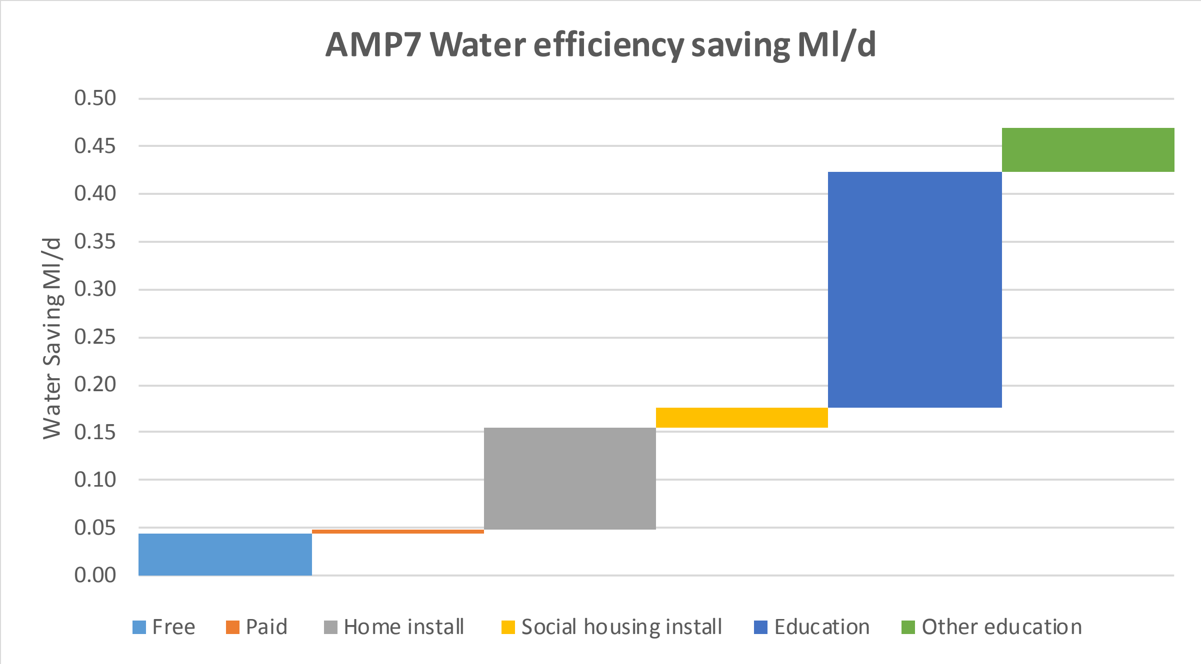

Figure B5.1: Breakdown of forecast activity in AMP7

In developing our proposals, we have made reference to:

- Environment Agency (EA) / Natural Resources Wales (NRW) Final Water Resource Planning Guidance.
- Defra Guiding Principles for water resource planning
- Water Strategy for Wales
- Waterwise Evidence Base Reports
- Market Transformation Programme
- Waterwise Water Efficiency Strategy for the UK
- Our own water efficiency programme and, consumption modelling forecasting analysis
- Water Strategy for Wales

We have also engaged with Environment Agency and Natural Resources Wales.

To inform our dWRMP18, we have assessed the viability of a range of potential water efficiency options building on insight gained from Severn Trent Water's programme:

- providing free products to our household customers on request;
- subsidising higher value water saving products for our household customers;
- carrying out water efficiency audits and install water saving products in the homes of our household customers - Home Water Efficiency Check (HWEC) programme;
- incentives for housebuilders to build new properties to 110 litres per person per or less;
- to work with social housing to carry out water efficiency audits and install water saving products in the homes of social housing tenants;
- to continue to provide education and advice to our household customers on how to use water more wisely;

- rainwater harvesting / water reuse options;
- metering options.

B5.1. Options to be included in our baseline programme

Free and paid water efficiency products

We will increase the range of free and paid for water efficiency products offered to customers. The improved product offers will align the levels of service offered to customers in the Severn Trent Water region

Home Water Efficiency Audits

We will carry out proactive water efficiency audits and install water efficient products in our customers' homes (HWEC).

The size of the programme is finite and limited by the number of household customers and assumed uptake rates. We have trialled this approach during AMP6 in the Severn Trent Water area and we currently see an uptake rate of approximately 20% which we expect to be maintained.

Customer education

We will continue to engage and educate customers on how to use water wisely. Over time, opportunities to retrofit water efficient devices will reduce. Engagement and education to promote behaviour change will become increasingly important to help customers reduce their demand for water.

B5.2. Revisions to demand saving assumptions

Through more accurate measurement of the water savings from our activities we are now more confident in the levels of savings we can forecast for our AMP7 water efficiency programme. We have used our insight from Severn Trent Water's AMP6 water efficiency programme to re-assess the savings we previously assumed from our water efficiency activity. This has included using measured savings and information from the home water efficiency audit and install programme (HWEC) and surveys by our free product supplier. This has resulted in a small reduction in the savings we forecast compared to our old assumed water savings.

B5.3. Decay of savings

Our improved understanding of the amount of water saved through our different water efficiency activities has also helped us to understand how the potential for future savings will likely decay over time. This is because:

- Over time, customers will replace their existing water fittings with more modern and efficient fittings. For example, the Market Transformation Reports conclude that existing toilets and taps will be replaced with more efficient models. The lifespan (replacement rate) of products ranges from 15 – 25 years, e.g. toilets have been assessed as 15 years, taps 25 years, which will limit our opportunities for installing cistern displacement devices (CDDs) and retrofitting WCs to dual flush or flow regulators. In our baseline demand forecasts we assume reductions in consumption from technology and behaviour change, therefore decaying savings from retrofit products ensures we do not double counting savings.

- The product life of retrofit products.
- Customers removing retrofit items.

We use different decay rates for different approaches (Table B5.1). We have based these decay rates with reference to:

- Waterwise evidence base reports
- Revisiting the long term benefits of our previous water efficiency install programme

Approach	% decay of previous year's saving
Free products	5.5%
Paid/Subsidised products	1.25%
HWEC/ Home audits	5.5%
Education	5%

Table B5.1: Percentage decay of previous year's savings

Metering

Previous Dee Valley Water WRMPs set out an ongoing approach to household metering that has been led by customer demand for the free meter option. To date, this has resulted in a meter penetration rate of 60% across the Wrexham and Chester Water Resource Zones (WRZs).

We see metering as key to delivering the long term demand reduction and lower Per Capita Consumption (PCC) ambition set out in the Welsh Government's Water Strategy for Wales and UK Government's 25 Year Environment Plan, as well as the ambition of our stakeholders and customers to use water wisely. As a result, we are including the introduction of proactive metering in our WRMP for Hafren Dyfrdwy. However, we are also mindful that, while Welsh Government recognise the role that metering has to play in encouraging reduction in consumption, they are also clear that any approach to metering would need to be delivered in conjunction with innovative charging structures in order to ensure that households with affordability issues are protected. We will need to work with them and other interested parties to develop a metering and demand management package that benefits and protects our customers while delivering reductions in water use.

Therefore, our plan is for proactive metering to commence in AMP8 in the new Llanfylin WRZ (formerly part of the Shelton WRZ in Severn Trent) and AMP9 in the rest of the Hafren Dyfrdwy supply area. When assessing the benefits of a persuaded optant strategy (implementing metering through engagement and collaboration with householders), we have taken a precautionary approach to the demand management impact of an average 10%

demand reduction. This is less than the 16.5% reduction reported by Southern Water, reflecting the fact that customers would not be forced to adopt measured charges. Our current thinking is that to secure the full benefits would require us to adopt an external metering policy and combine this with a policy of helping customers tackle supply pipe leakage on their properties.

Through both our trials in AMP6 and the yearly phase of the programme in AMP7 in our Severn Trent supply area, we will closely monitor meter installation rates and progress with the roll out. This will provide greater insight for implementation of our metering strategy in Hafren Dyfrdwy in AMP8 and AMP9. Based on current technology and processes, and the metering programmes of other water companies, either already delivered (93% Southern Water) or planned (95% Anglian Water), we believe that ambition beyond 95% is realistic, with innovation. A shortfall of 5% would only equate to an increase of 0.4% on household demand, or the equivalent of 1.06 litres per household, meaning minimal impact in the plan. Given there is no supply deficit in the Hafren Dyfrdwy areas, the impact on any shortfall in metering / demand management will be negligible. Close monitoring of the programme will allow us to continually assess the likely impact of metering shortfalls and develop further mitigatation approaches. An example of a mitigation approach would be offering bespoke in-home audits, advice and devices including leak alarms for properties that we are unable to meter.

However, given the timeframe for delivery we also recognise the potential for innovation in more advanced metering technology, including non-intrusive metering and flow measurement that will provide additional options and opportunities to enable us to install meters in currently challenging locations. Advanced metering and flow measurement technology is already developing to the point that low cost non-intrusive flow measurement devices are a realistic opportunity over the timescale for our programme to help us reach the 100% ambition.

We believe that there are wider demand management benefits that will result from increasing metering coverage, especially if we target the delivery on a geographical basis. In particular, we view the need for increased meter coverage to be a crucial enabler to delivering our very ambitious leakage reduction strategy. Currently around 44% of our household customers are not metered, and that means we have to estimate their consumption when we monitor leakage performance on our network. That makes it very difficult to distinguish changing consumption patterns from any leakage breakout on our network.

By increasing the number of metered properties on our network, we will have greater visibility of changing water demand patterns and better control of our network performance. This will make leaks easier to detect, and will mean we are able to deploy leakage repair more effectively and efficiently. This improvement in leakage detection and repair performance will be crucial to us achieving our challenging 15% leakage reduction target in AMP7 and our long term ambition to reduce leakage by 50% by 2045.

B6. Baseline demand projections

Chapter B1 to B5 explain how we build the components of our baseline projections of demand for water and total distribution input for the next 25 years. Chapter B6 summarises baseline projections used in our final WRMP19.

Water Resource Zone baseline demand projections

The general trends in the baseline demand projections are:

- Measured PCC and unmeasured PCC to modestly decline over the forecasting period
- Measured water delivered to rise as new household property consumption and meter optant customer consumption is added to this category
- Unmeasured water delivered to decline as customers opt to have a meter installed
- Leakage to remain flat to 2045 at the end of AMP6 level in each WRZ (this is what is required in a baseline forecast)

The following charts show the baseline PCC forecast and baseline dry year distribution input forecast with components of the demand forecast.

Saltney water resource zone

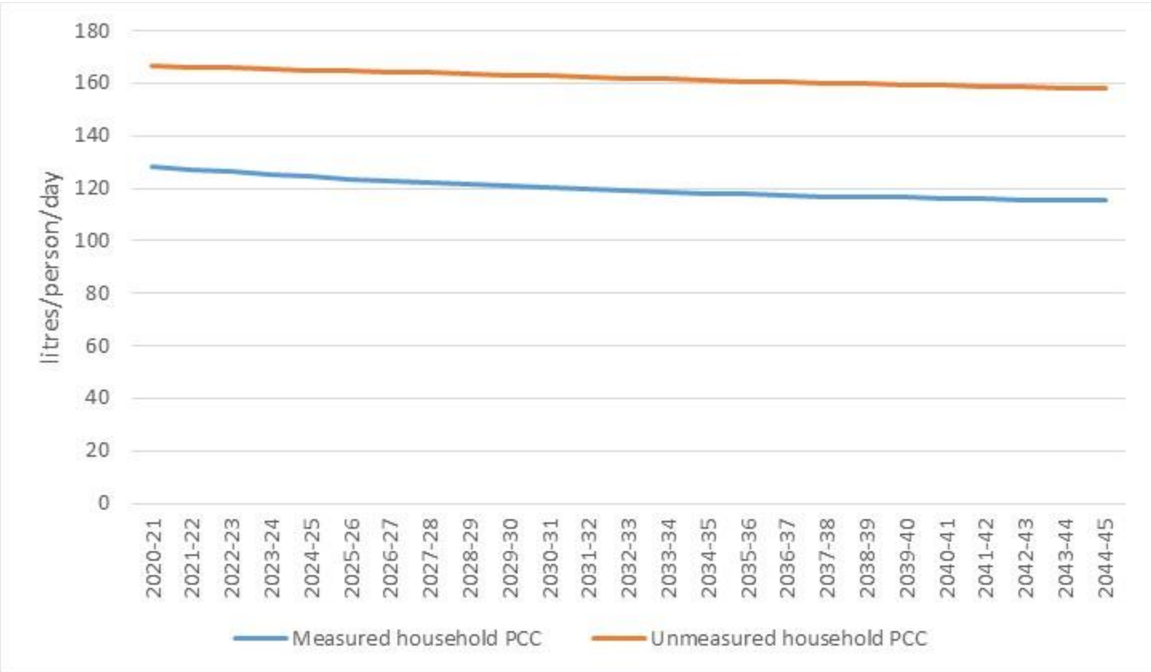

Figure B6.1: Saltney baseline dry year PCC

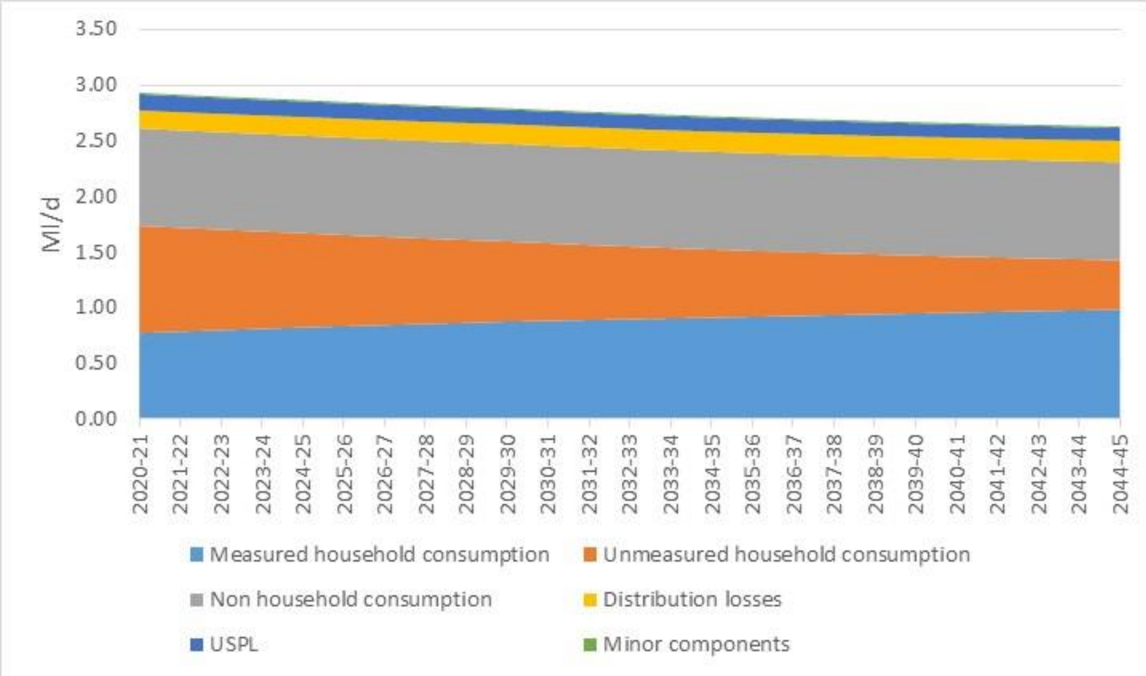

Figure B6.2: Saltney baseline dry year DI

Wrexham water resource zone

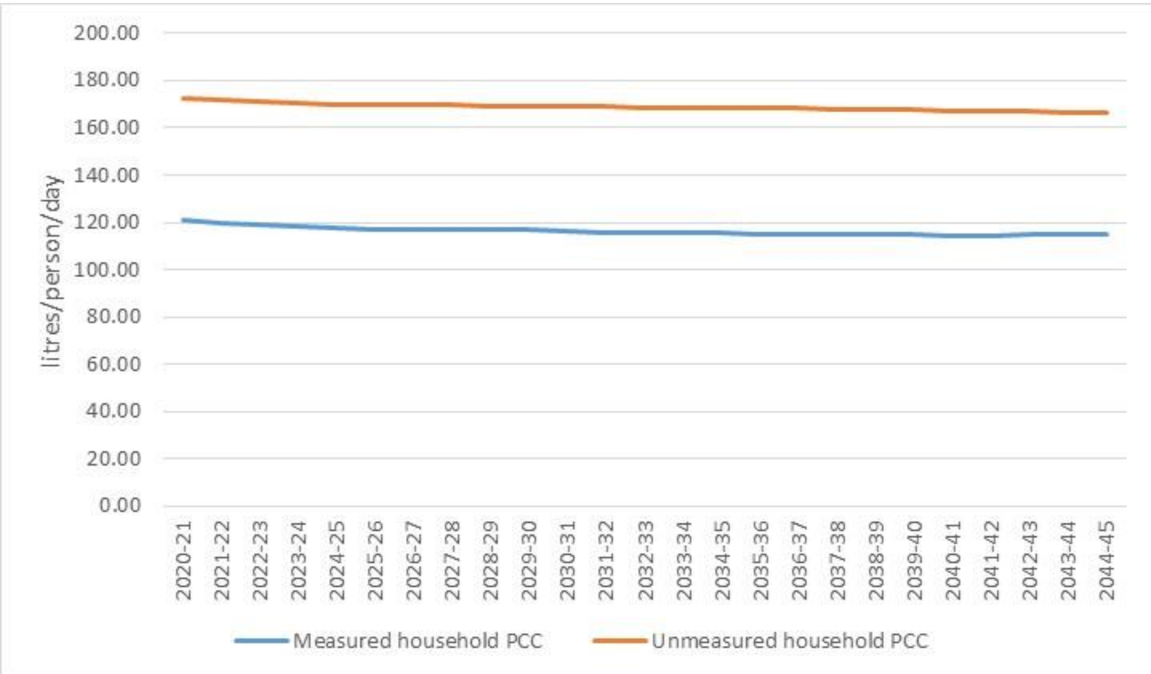

Figure B6.3: Wrexham baseline dry year PCC

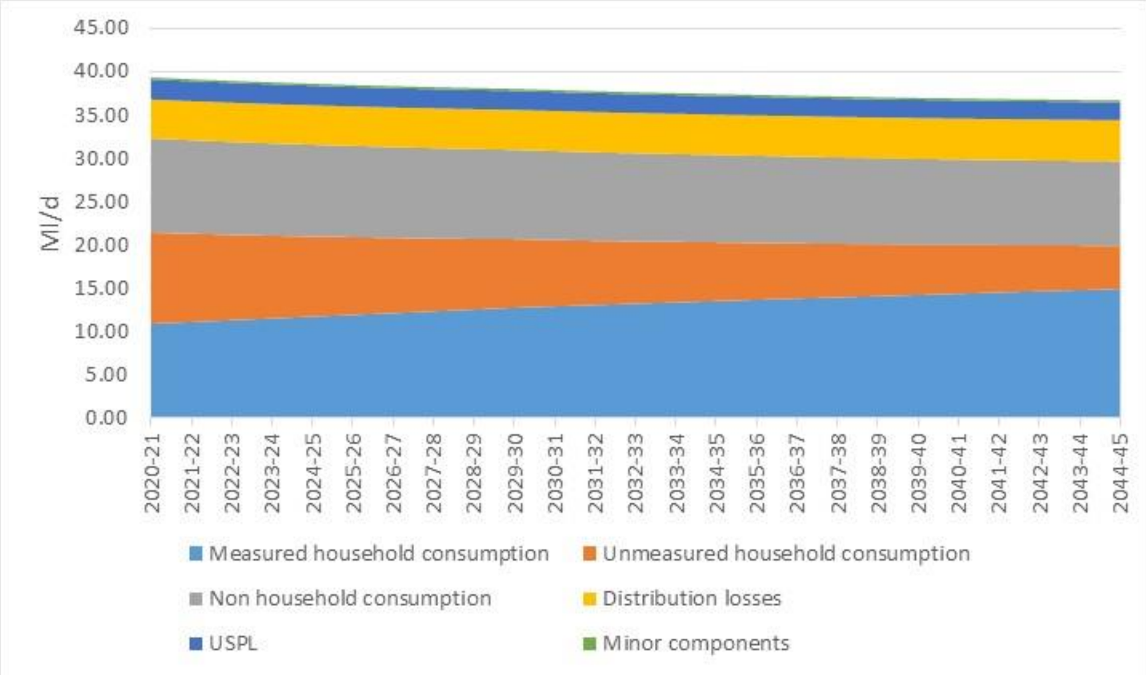

Figure B6.4: Wrexham baseline dry year DI

Llanfyllin water resource zone

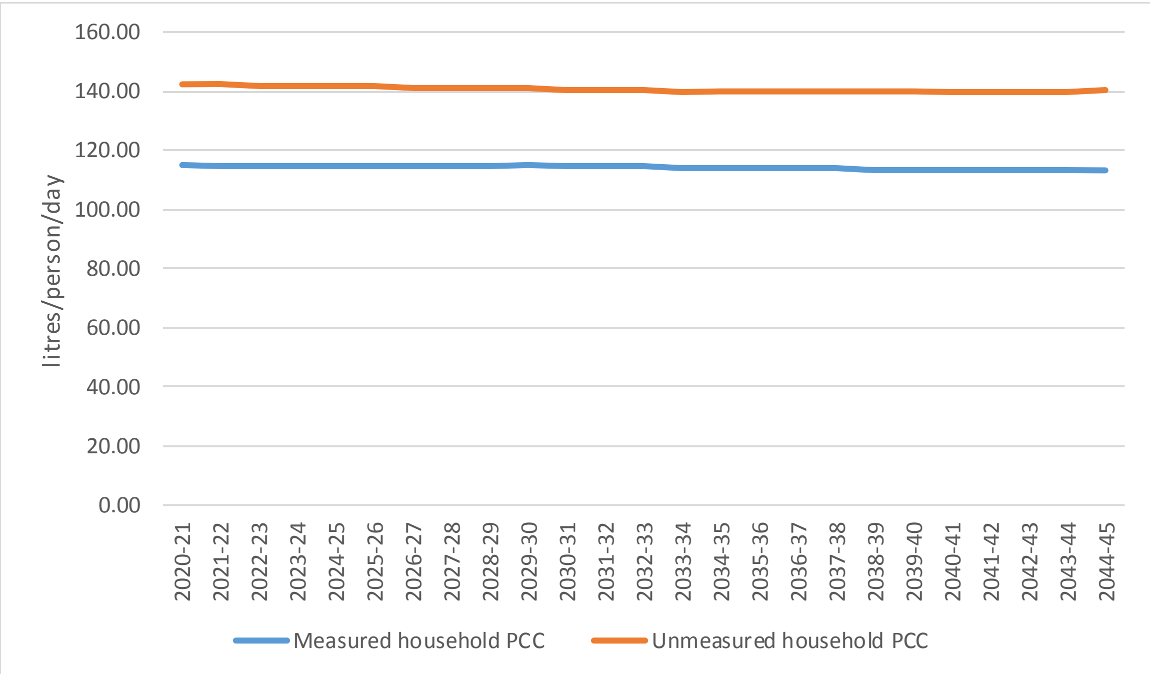

Figure B6.5: Llanfyllin baseline dry year PCC

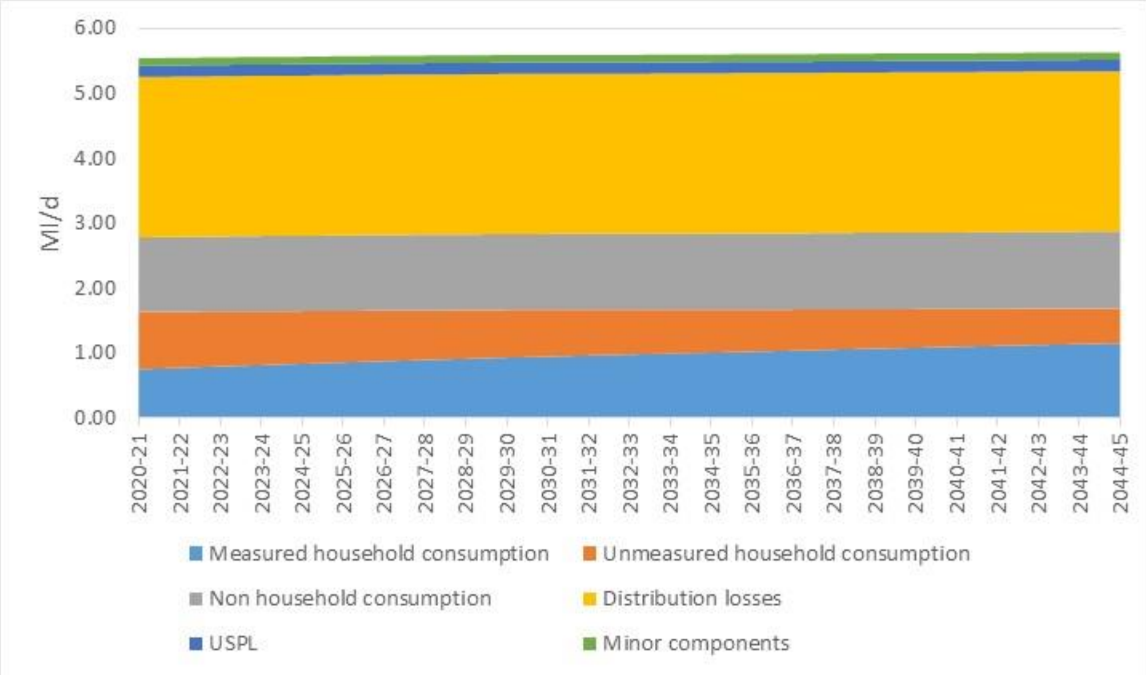

Figure B6.6: Llanfyllin baseline dry year DI

Llandinam and Llanwrin water resource zone

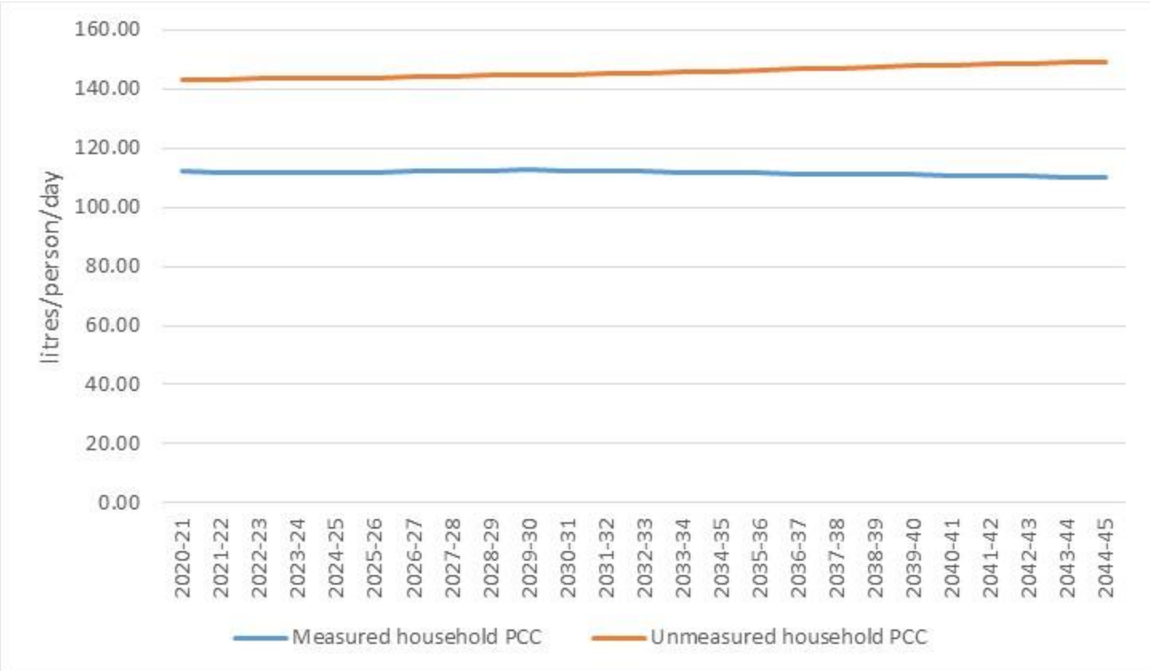

Figure B6.7: Llandinam and Llanwrin baseline dry year PCC

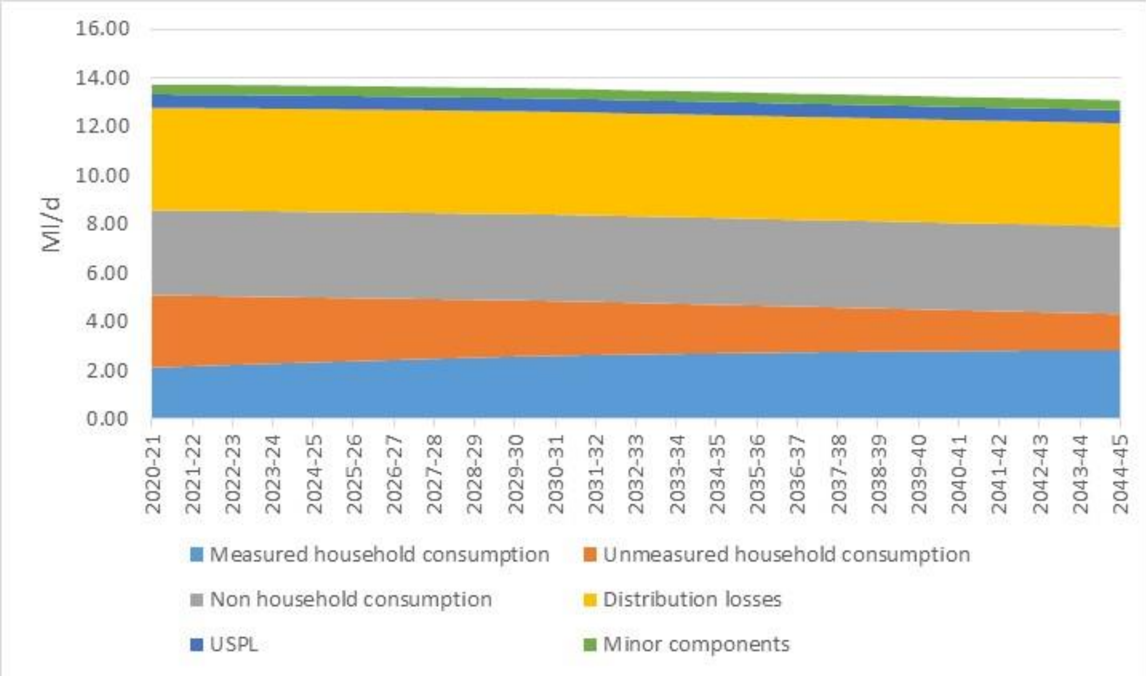

Figure B6.8: Llanfyllin baseline dry year DI