Artesia Consulting

South Staffs Water

Non - household demand forecast for Cambridge Water WRMP19

Final report

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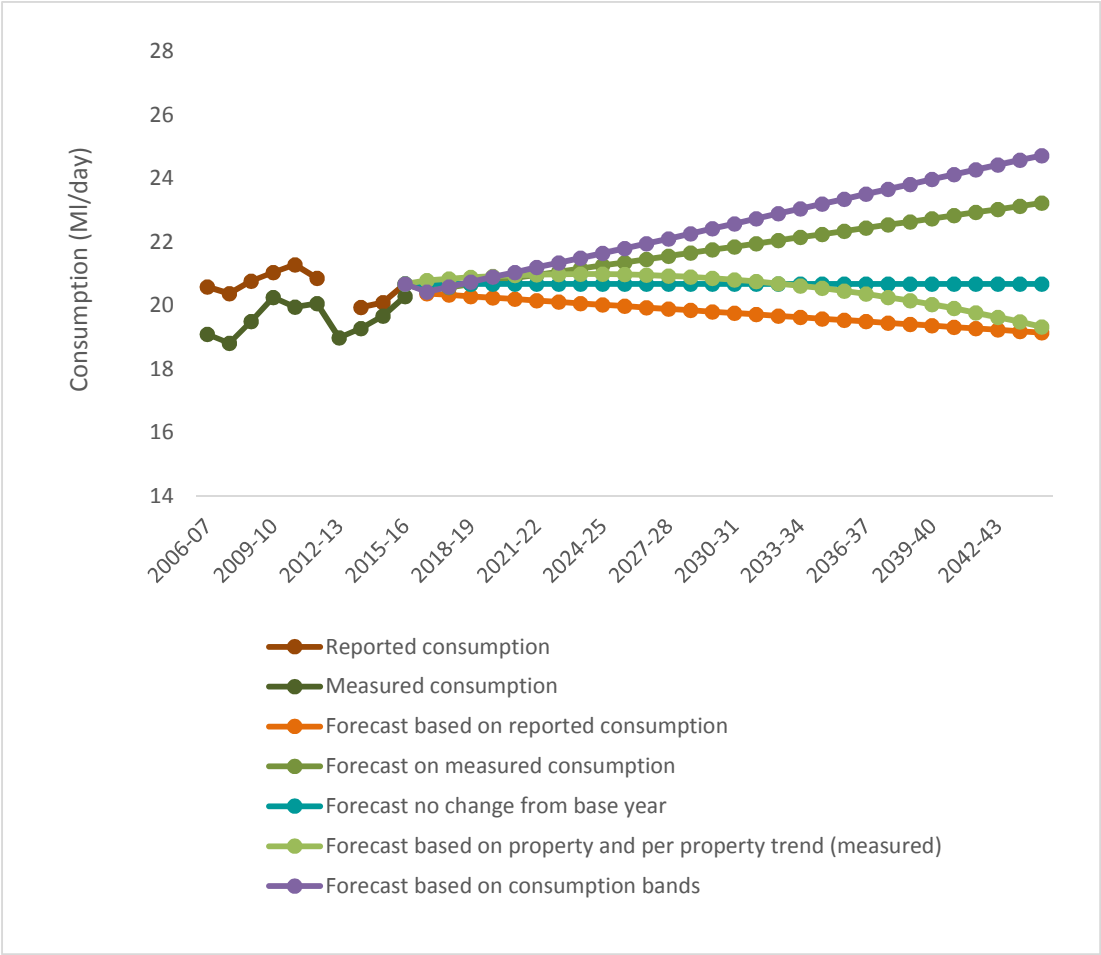
Executive Summary

Artesia Consulting was tasked by South Staffs Water to produce a forecast of non-household consumption projected forward to the year 2045 to cover the Cambridge Water region.

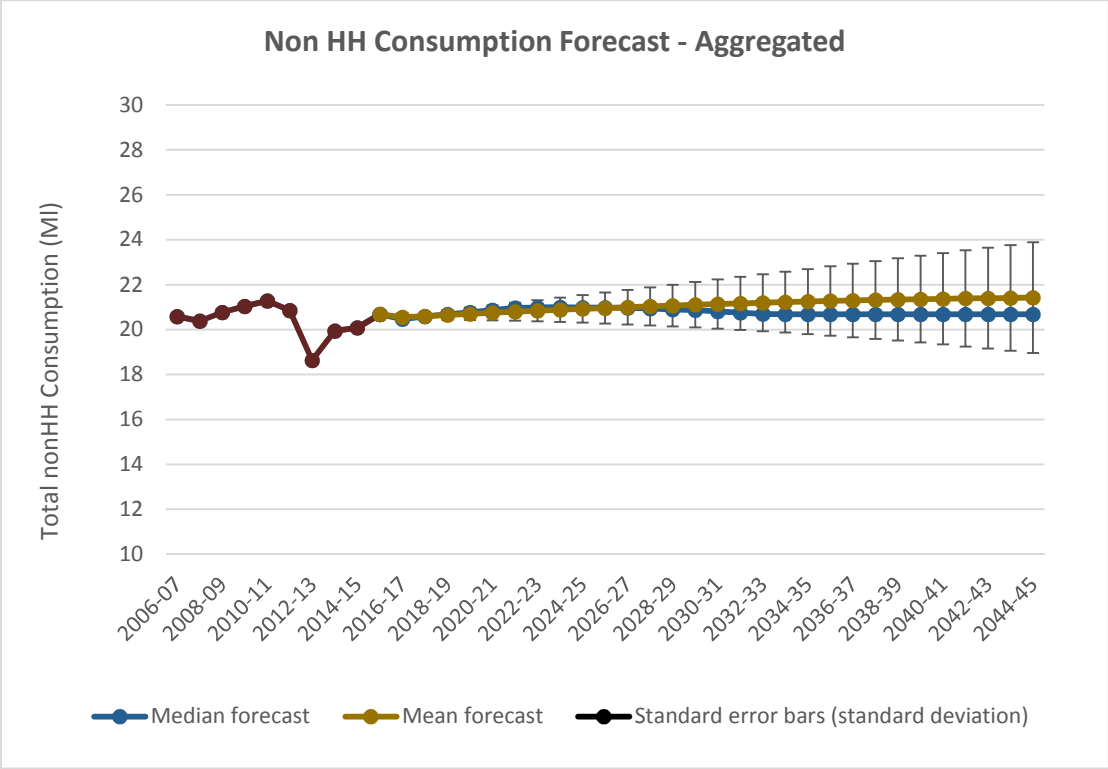
A set of non-household demand forecasts have been developed, covering a 25-year period from 2019-20 to 2044-45. In general, an increase in total non-household consumption is being driven by an increase in property numbers. This is being offset to a degree by reducing consumption amongst larger users.

Analysis of total non-household consumption or water use by the size of the customer did not display strong relationships with economic factors. There were good correlations between individual industries and water consumption however uncertainties in the coding of properties to industry type suggests this type of analysis may be unreliable.

The figure below presents the forecasts that have been produced in this analysis. They are intended to show a broad spectrum of possible futures on water consumption for the year 2044/45 and they are not expected to be equally probable. It can be deduced that some trends represent extreme events or realities. For this reason the highest and lowest forecasts have been removed from the final analysis, for reasons explained in the main report.



The forecasts presented above have been used to derive mean and median forecasts with an uncertainty range based on standard deviation of the range in forecasts, using simple statistical methods, as illustrated below.



These results are also presented in the table below.

Forecast	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45
Mean	20.70	20.92	21.10	21.25	21.36	21.42
Median	20.77	20.99	20.86	20.68	20.68	20.68
Standard deviation	0.27	0.61	1.01	1.45	1.93	2.46

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1 Introduction

The aim of this project is to develop a non-household demand forecast for the Cambridge Water region, to be included in the Water Resources Management Plan 2019 (WRMP19), which will provide annual estimates of the non-household demand for water up to 2044/45.

The forecasts presented in this report are either trend-based, using historic consumption data or use forecasts of explanatory variables such as population, employment and productivity to estimate future non-household consumption. Other forecasting approaches may be possible for specific categories of non-households (e.g. using non-household population), however the methods used in this study are applicable to all property types and are considered appropriate for the proportion of non-household consumption in the Cambridge Water region.

These results are based on available regional data from Cambridge Water and East of England economic forecasts. As such the forecasts presented in this report do not include any judgements or assumptions on what may, or may not happen in the future, and do not include qualitative observations, for example related to future types of non-household growth or levels of water efficiency.

Section 2 describes the data used and methodology for forecasting. Section 3 presents the results of the forecasting based on several different approaches. Section 4 summarises the results of the analysis including an average and uncertainty range based on the forecasts derived in this study.

2 Methodology

2.1 Description of analysis

Two main types of trend analysis have been conducted in this project. The first set of analyses look at overall trends in historic data for total non-household consumption using two different sets of data. The first data set of reported annual figures for metered non-household consumption have been analysed, using data from 2006/07 to 2015/16. The second data set is measured non-household consumption, from actual metered consumption for the period 2005/06 to 2015/16.

The trend analysis of consumption in all non-household properties using these two data sets will be referred to as **reported trend** and **measured trend** respectively. The reported figures for non-household consumption will include adjustments for meter under registration (MUR) and supply-pipe losses (SPL). [1]

The second main type of analysis focuses on more in-depth analysis of measured data by analysing trends in groups of non-household properties that consume different amounts of water (consumption bands) and by examining trends in different types of non-household property (based on standard industry codes). Trends were produced and compared; and consumption data was tested against economic factors which included: population, employment and unemployment rates, Gross Added Value (GVA)[2] , GVA per capita and net commuting[3].

The economic factors to complete the study are publicly available for the full forecasting period and have been obtained from the latest East of England Forecasting Model (2016)[4]. These data are available for Cambridge City, South Cambridge and Huntingdon. Forecasts for the Cambridge City area has been selected to perform the analysis as this forms the largest geographical part of the Cambridge Water region and is likely to dominate the region in terms of economic growth.

Figure 1 summarises the analytical methods described above.

[1] Both these adjustments are made to the measured data using expert judgement in order to account for two key issues. 1) the fact that over time, meters measuring water supplied to properties tend to record less water flow than actually occurs. Current estimates of non-household MUR in Cambridge region is 4 percent. Total reported non-household consumption (at the company level) adds this percentage on to measured consumption to account for MUR. 2) Leakage in supply pipes. These pipes are usually located between a customer's meter and the property itself. Total reported non-household consumption (at the company level) subtracts an estimate of total SPL from measured consumption to account for SPL. Therefore total measured non-household consumption will include supply pipe losses.

[2] Regional **gross value added** is the value generated by any unit engaged in the production of goods and services

[3] Net commuting is the balance of the flow of people into and out of an area for the purpose of work.

[4] http://atlas.cambridgeshire.gov.uk/EEFM/LA_forecasts_baseline_EEFM_2016.zip

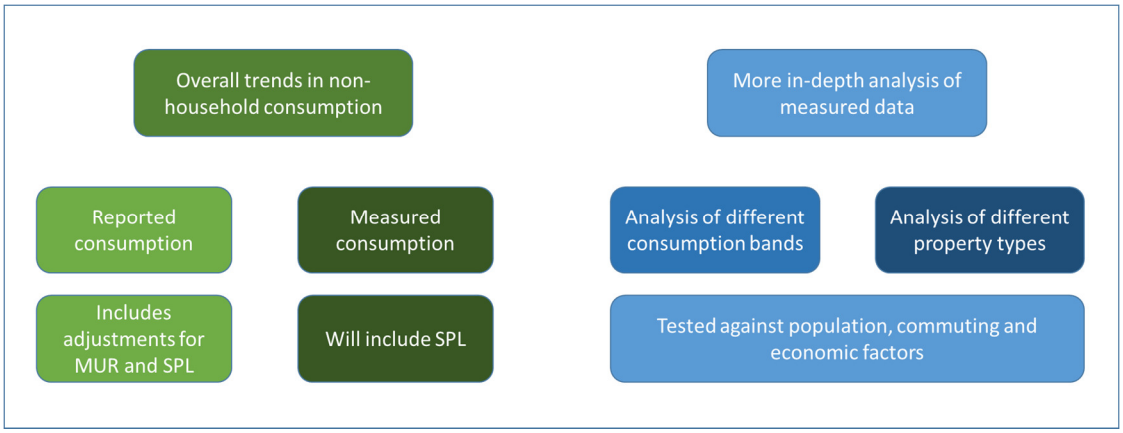

Figure 1 Summary of analyses conducted in this study

2.2 Data sources and data quality

For this analysis, three datasets have been used:

- A data set containing billed reported metered non-HH consumption covering the period: 2006/07 to 2015/16. This set has been used to produce a high level trend analysis which is further specified in section 3.1. It is worth mentioning that, due to the large drop in consumption in 2012/13, it was decided to remove this point as it generated a substantial leverage effect.

- A second set containing measured data for metered non-HH consumption since 2002. However, data prior to 2005/06 was removed for the analysis due to its marked differences in consumption with subsequent years. These differences were too high to assume they were exclusively explained by the inter-annual variations on consumption.

- It is interesting to analyse consumption from a property numbers perspective. To that effect, a third data source was used to match meter references with property references.

2.3 General comments

2.3.1 Retail competition

With the recent changes to the water market, which came in to effect on 1 April 2017, most businesses and organisations in England can now choose which company they want to supply their retail water services. Eligible businesses, charities and public sector customers are no longer restricted to buying retail water services from their regional water company. Instead, they are now free to choose their water retailer[5]. Cambridge Water has an increasing number of retailers who now deal directly with non-household customers.

There is an expectation (from regulators and government) that retail competition will lead to water efficiency in the non-household sector. In addition, the duty to promote the efficient

[5] http://www.open-water.org.uk/

use of water remains with the wholesale water company (i.e. Cambridge Water in this case) and the WRMP requires each water company to plan for water efficiency in its forecasts of non-household demand.

Each retailer has been asked for a policy statement describing its water efficiency strategy in an effort to incorporate third party initiatives within the consumption forecasts. However, there are no data to support this at present. In addition the analysis of historic trend will not capture any likely changes in consumption resulting from retail competition. Therefore the forecasts presented in this study do not take account of any future water efficiency but will reflect efficiencies achieved over the past 10-15 years.

Retail competition has required a careful review of the classification of properties as households / non-households. This split is considered to be accurate for the analysis presented here, particularly as the allocations have been reviewed recently by Cambridge Water.

2.3.2 Links with household consumption

Non-household forecasts are not explicitly related to household forecasts, however the more in-depth analysis will assess if there are any relationships between trends in consumption rates and population. This will be highlighted in the results section where relevant.

3 Results

The following sections present:

- Analysis of the overall trends in total non-household consumption (section 3.1);
- Analysis of the trends in non-household consumption based on groups of non-household properties that consume different amounts of water – or consumption bands (section 3.2); and
- Analysis of the trends in non-household consumption by industry type (section 3.3).

Two high level trends in non-HH demand (section 3.1) were produced using reported and measured consumption. Analysis on consumption bands (section 3.2) and industry code (section 3.3) was based on a single dataset (measured consumption). Given the differences between both datasets (Figure 1 and Figure 2), measured consumption is adjusted to reported consumption by uplifting the raw data until the values in the base year are equal.

These results are summarised in section 4.

3.1 High level trend in non-household demand

A company-level forecast based on reported non-household consumption figures from 2006/07 to 2015/16 is presented in Figure 2. Data was used to develop a first high-level company forecast: 'Forecast based on reported consumption'.

Measured data for metered non-HH consumption were used to create a second high-level forecast: 'Forecast based on measured consumption'. For this second high-level forecast, measured data covering the period 2005/06 to 2015/16 were used[6]. Outputs were calibrated to base year consumption data from reported metered non-HH consumption. Both forecasts are represented in Figure 2.

The use of two data sources is justified by the need to cross-check and validate data, and at the same time provides a broader spectrum of possible futures.

Reported and measured consumption dataset displayed discrepancies in consumption and number of properties which give rise to the different trends in Figure 2. The forecast based on measured consumption results in an increase in non-household demand of 2.55Ml/d over the planning period – an increase of 12.3%. The forecast based on reported consumption results in a decrease in non-household demand of 1.53Ml/d – a reduction of 7.4%.

The relative pattern of the two historic trends also suggest changes in the adjustment to reported data for MUR and SPL, however this has not been investigated further. These trends have been given equal weighting as we believe each one has its own merit.

[6] Data from 2002 were provided however data prior to 2005/06 was removed for the analysis due to its marked differences in consumption with subsequent years.

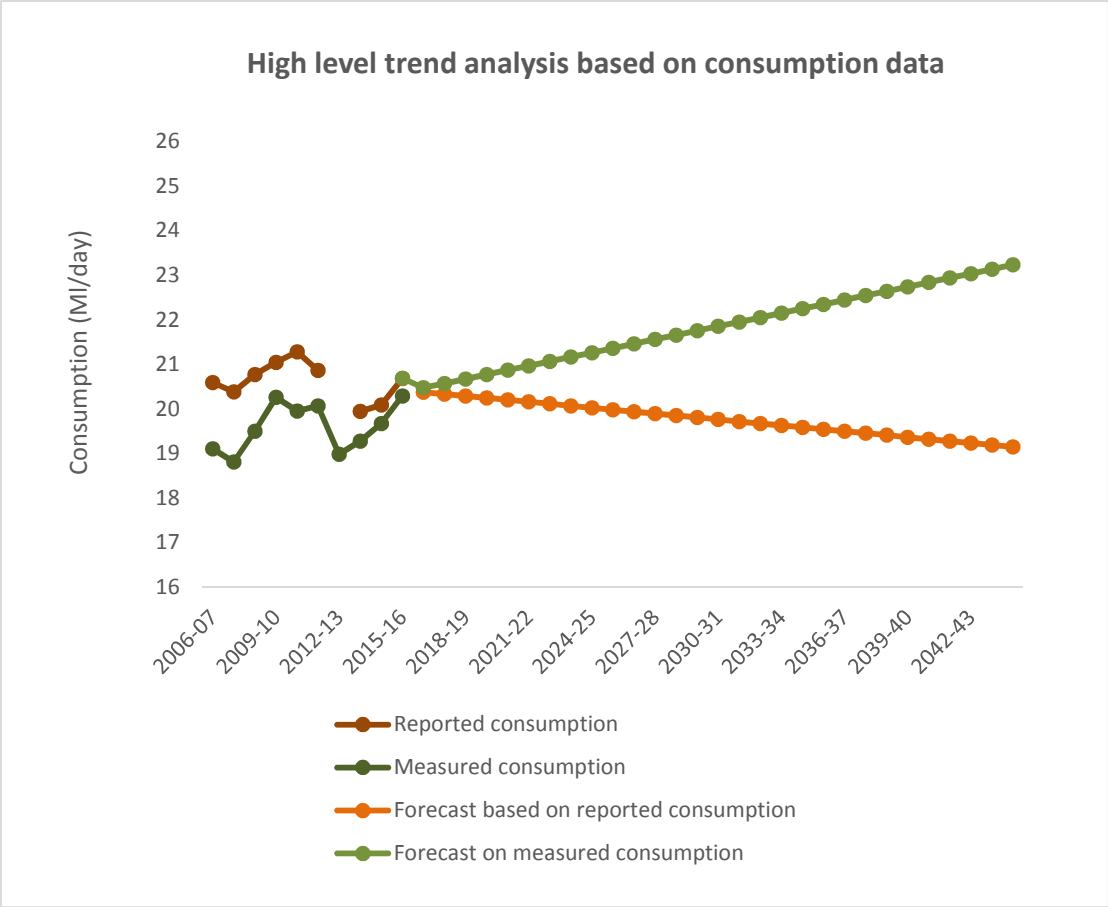

Figure 2 **High level trend analysis based on consumption data**

Trends were calculated for property numbers and consumption per property for both datasets. From these trends, consumption was calculated and added to Figure 3, resulting in a curved downwards shape.

Finally, a trend with no change from base year (blue line) has been included.

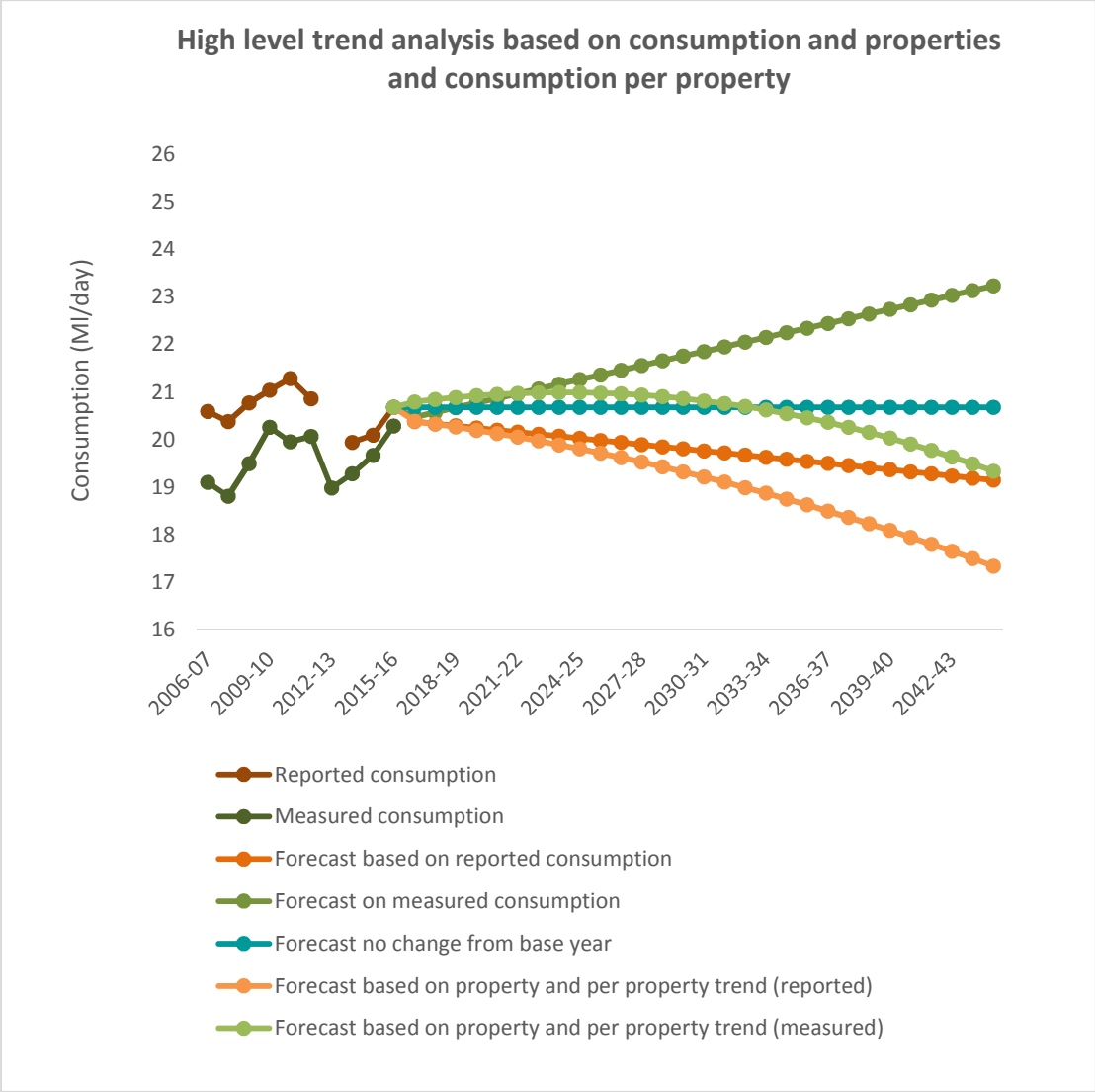

Figure 3 **High level trend analysis based on consumption and properties and consumption per property**

Initial trials have been carried out looking into the correlation and predictive power of some economic factors. The factors used included: total population, employment and unemployment rates, GVA, GVA per capita and net commuting.

There is no significant relationship between total non-household consumption at a company level (either reported or measured) and these factors. However, analysis of the relationships between these factors and the more in-depth data – by consumption bands and industry codes – has provided interesting results which are discussed in following sections.

In the following sections, the measured non-household consumption data has been used to further analyse and evaluate the non-household consumption. The available data has been categorised according to consumption bands and industrial activity defined by industry code.

3.2 Analysis by consumption band

In a first instance, consumption bands were established and properties were assigned to one of the 9 groups presented in Table 1.

Table 1 Consumption bands

Band	Consumption (litres/day)	Property count (2015/16)	Group
Band A	0 – 250	4,185	Low
Band B	250 – 500	1,200	
Band C	500 – 1,000	1,181	
Band D	1,000 – 2,000	1,067	
Band E	2,000 – 5,000	994	High
Band F	5,000 – 10,000	437	
Band G	10,000 – 50,000	311	
Band H	50,000 – 1,000,000	36	
Band I	Over 1,000,000	1	

Based on this, consumption per day in each consumption band is plotted by year below. In order to ease the viewing, the bands have been grouped in two different graphs (Figure 4 and Figure 5) according to their total contribution to consumption per day. Bands A to D are grouped together as 'low consumers' whilst Bands E to H are grouped together as 'high consumers' (Note: only one property exceeded 1 Ml per day (Band I), for this reason, this property is analysed separately on Figure 10)

The first observation is that the total consumption of high consumers (Figure 4) is greater than the total consumption of low consumers (Figure 5). Although this seems obvious, it is worth noting that if the number of low consumer properties increased sufficiently, the total consumption of these properties would be larger than higher consumption bands (Bands E, F, G and H).

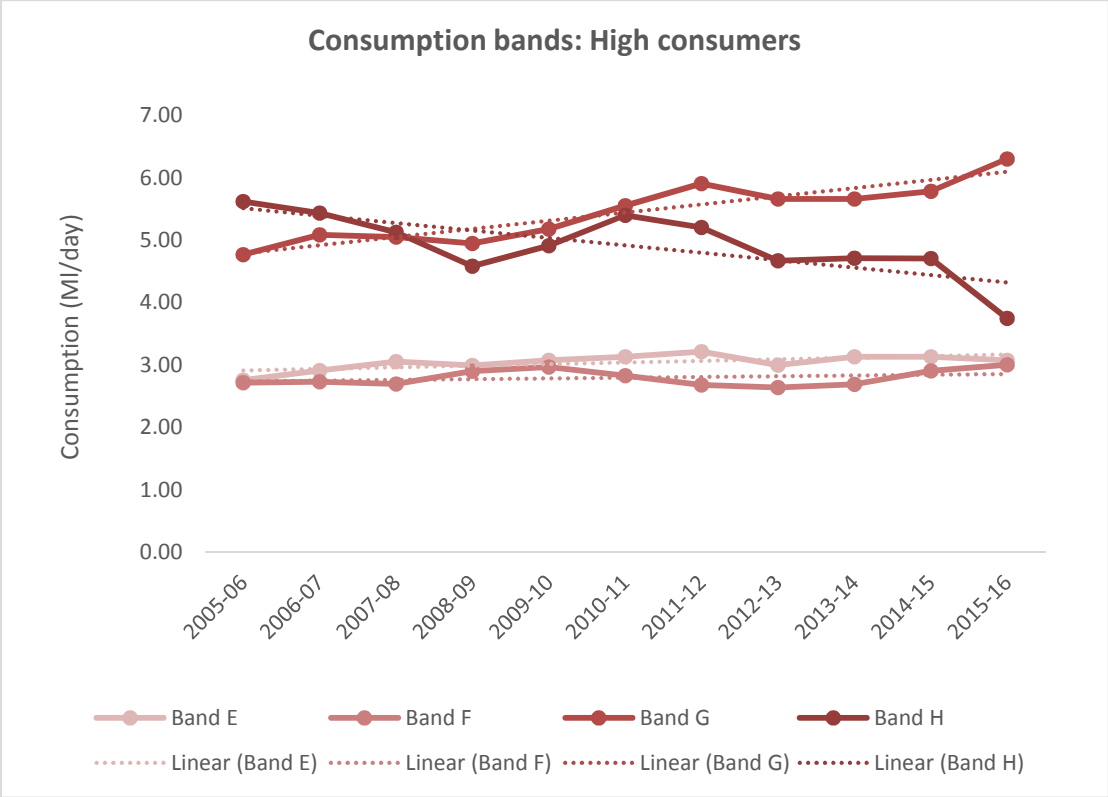

Figure 4 **Consumption bands: High consumers**

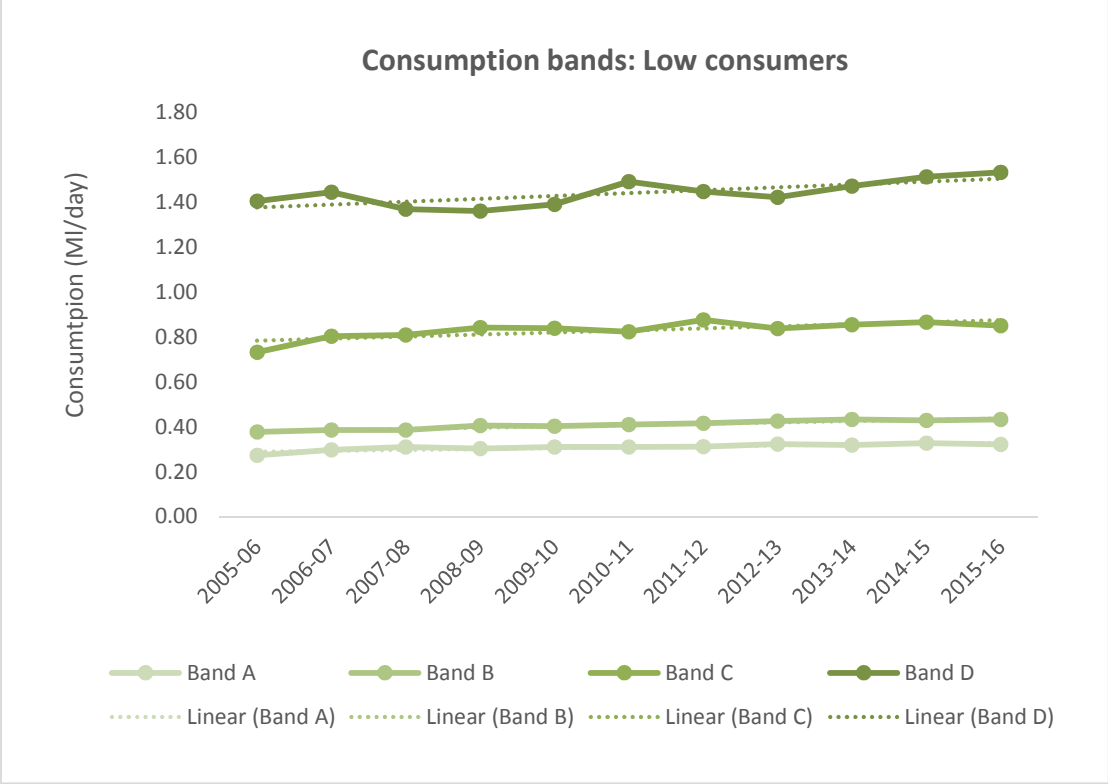

Figure 5 **Consumption bands: Low consumers**

The variation in property numbers by consumption band over time is presented in Figure 6. Overall, there is a general increasing trend in property numbers for each consumption band. These results are consistent with the increasing consumption in each band. It is worth mentioning, however, that these trends tend to flatten in bands H and I, which is in line with a drop in consumption per property.

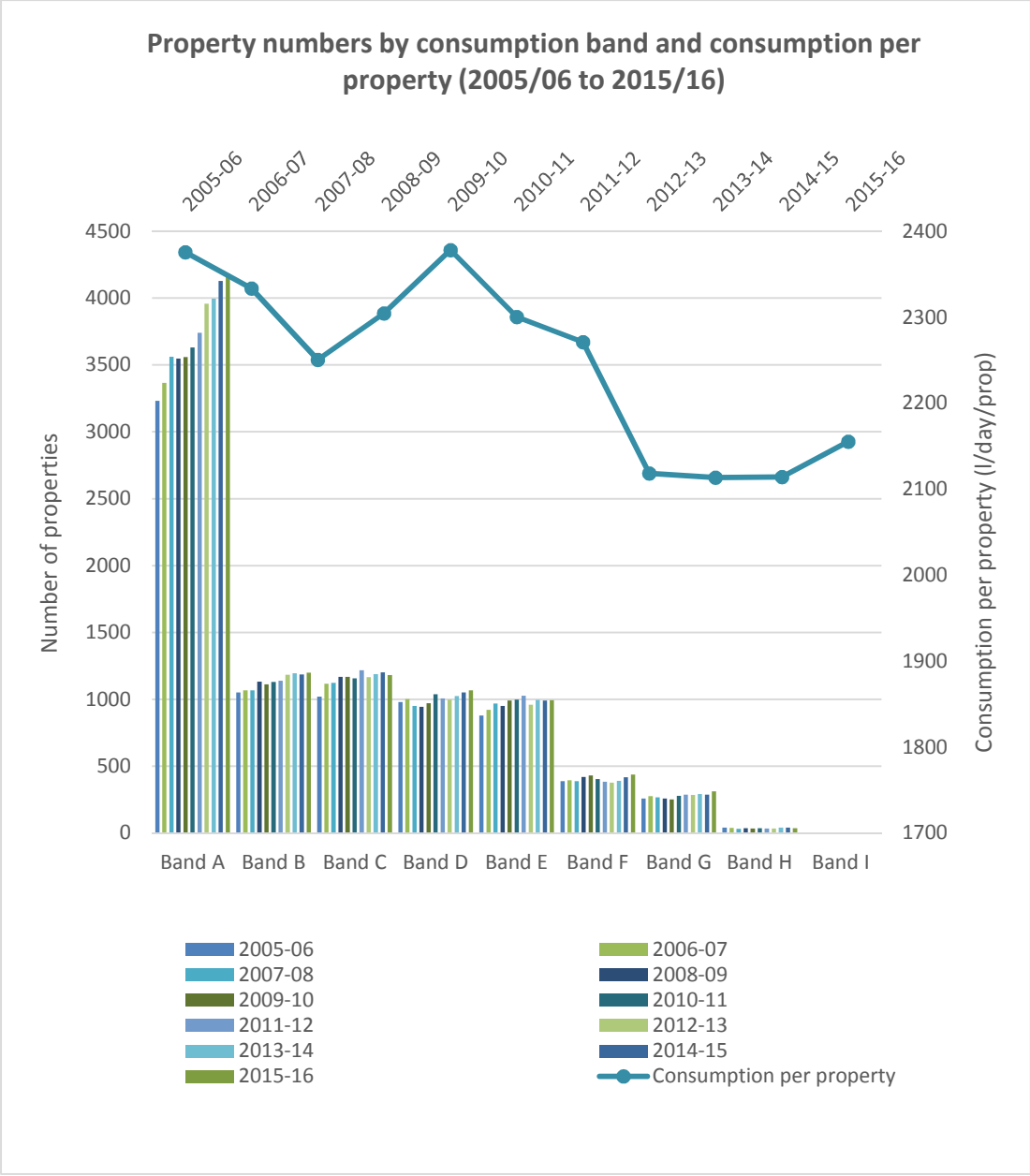

Figure 6 **Property numbers by consumption band**

Almost one quarter of the consumption in 2015/2016 (23.5%) was attributable to properties within Bands H. Bands I and B and G contributed a total of 31% to the overall consumption. In other words, approximately 350 properties (3.7%) accounted for 54% of consumption (Figure 7).

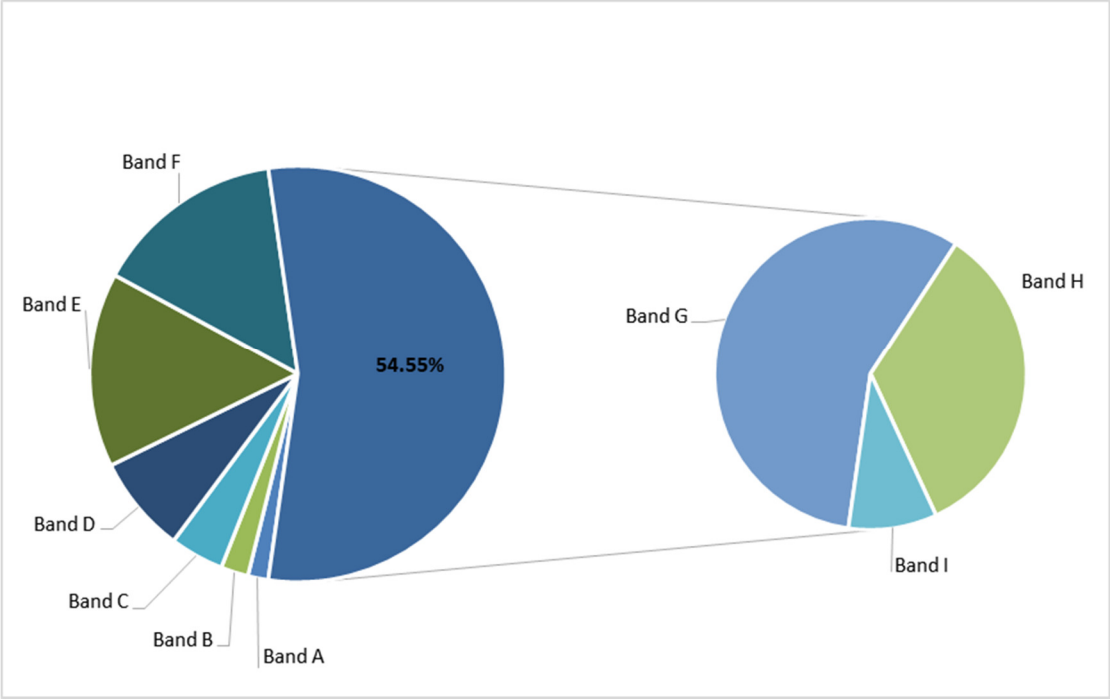

Figure 7 Consumption per day by consumption band in 2015/16

Over the period 2005/06 to 2015/16 the graphs display an increase in consumption for every consumption band except for 50,000 to 1,000,000 litre to 1 Ml (Band H), which shows a decrease in consumption for the same period of time. This decrease may be attributed to consumers moderating their water consumption combined with sharp falls in consumption in some properties. In this way, the overall positive contribution to water consumption experienced by some larger consumers can be masked.

In this regard, it is worth noting that the consumption band classification of a property is likely to change throughout the analysis period, for this reason, forecasts for each consumption band have not been included in Figure 4 and Figure 5.

Due to the impact on the overall consumption and the differences showed by properties in higher consumption bands (H and I), it is worth considering an independent evaluation of large consumers. Amongst the 77 properties that were classified at least one year within consumption band H (50,000 – 1,000,000 litres/day), 32 are displayed in Figure 8 and Figure **9**. These properties have been selected based on their large contribution towards water consumption during the period of measured data. Through these graphs the variation in consumption at individual properties becomes apparent and differences in water use between properties are revealed.

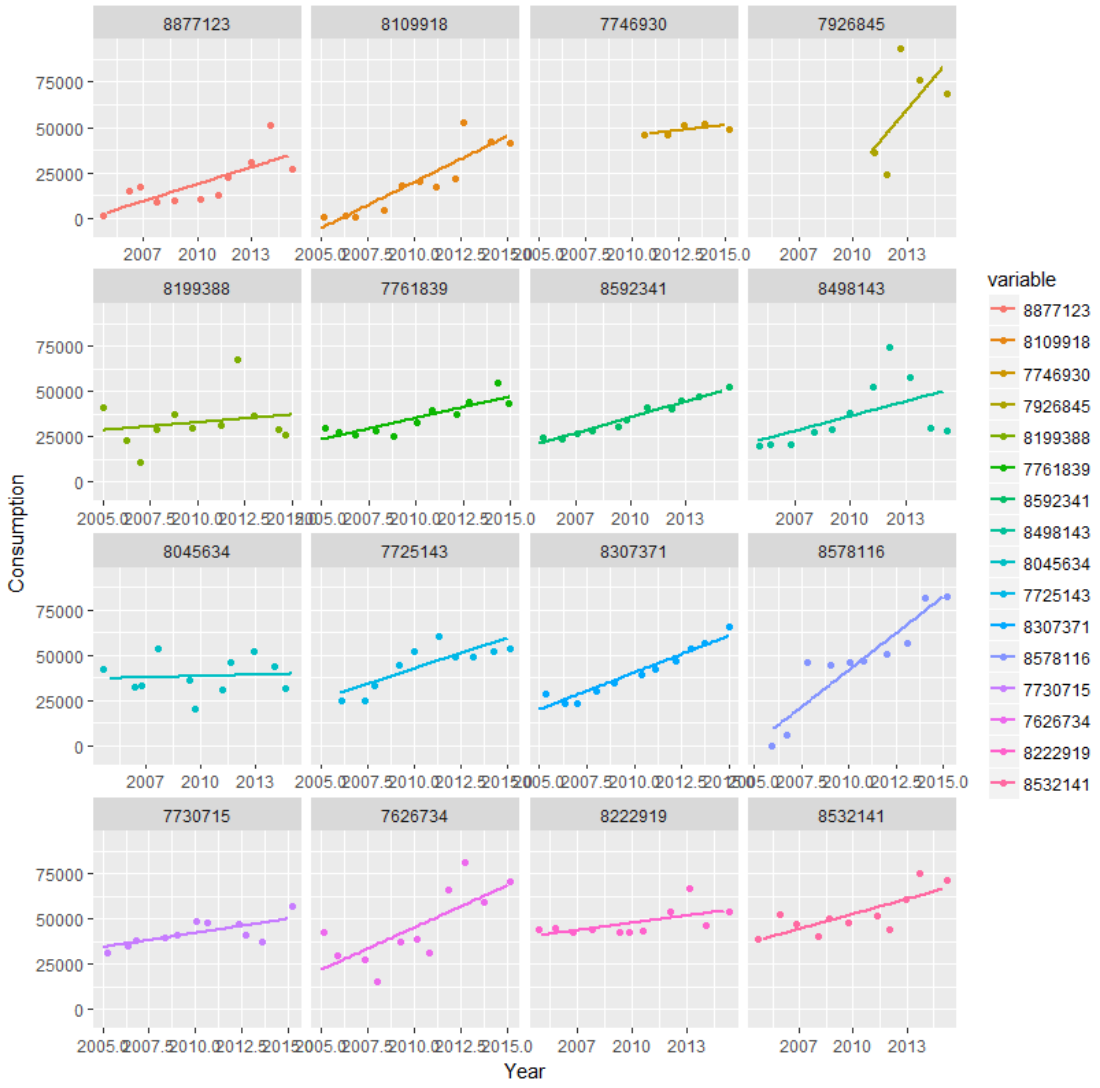

Figure 8 **Larger consumers in Band H with increasing trends in consumption**

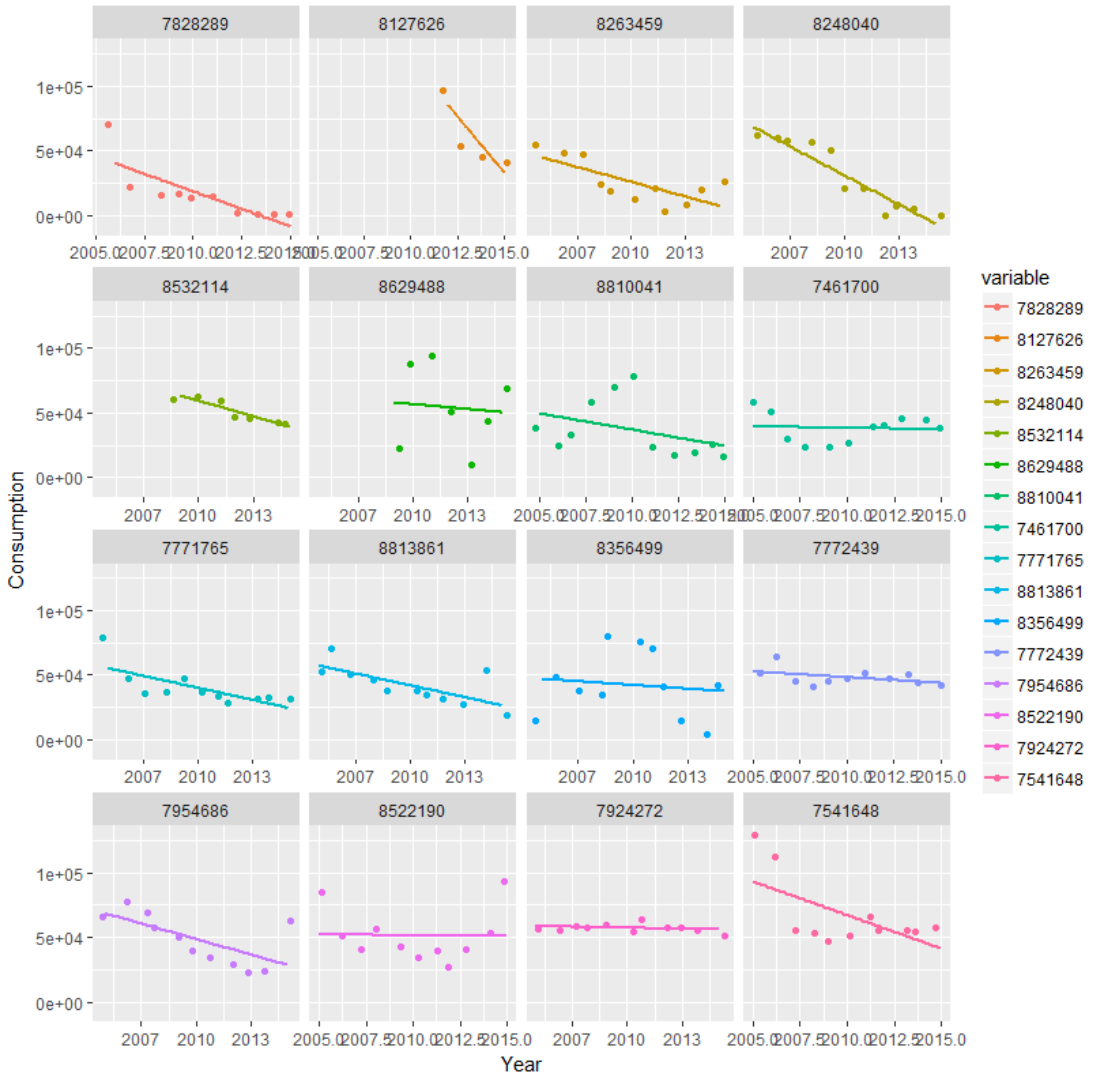

Figure 9 **Larger consumers in Band H with decreasing trends in consumption**

The largest band, corresponding to consumption over one million litres, is explained by a single property 8460792. Because of its impact on total consumption, this property has been analysed independently and a trend of future consumption for this property is presented in Figure 10. Despite the variation in historical water use at this site, a gradual upward trend can be drawn from its measured consumption.

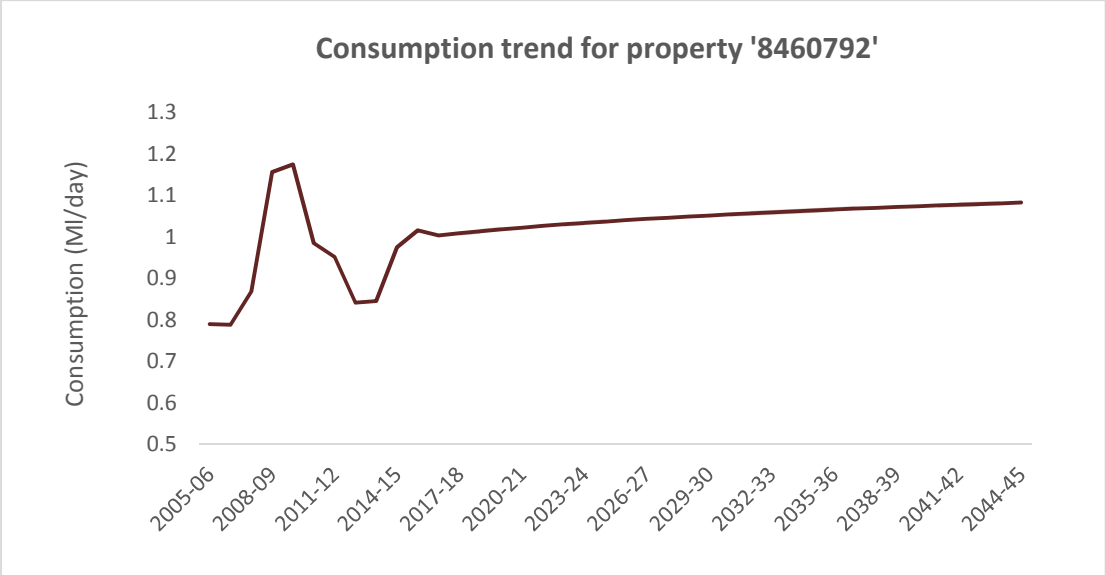

Figure 10 Consumption trend for property 8460792

An additional forecast based on consumption bands has been produced and is displayed in Figure 11: 'Forecast based on consumption bands'. This new forecast is higher than the preceding forecasts, influenced by the upward trend in consumption in most bands (Figure 4 and Figure 5).

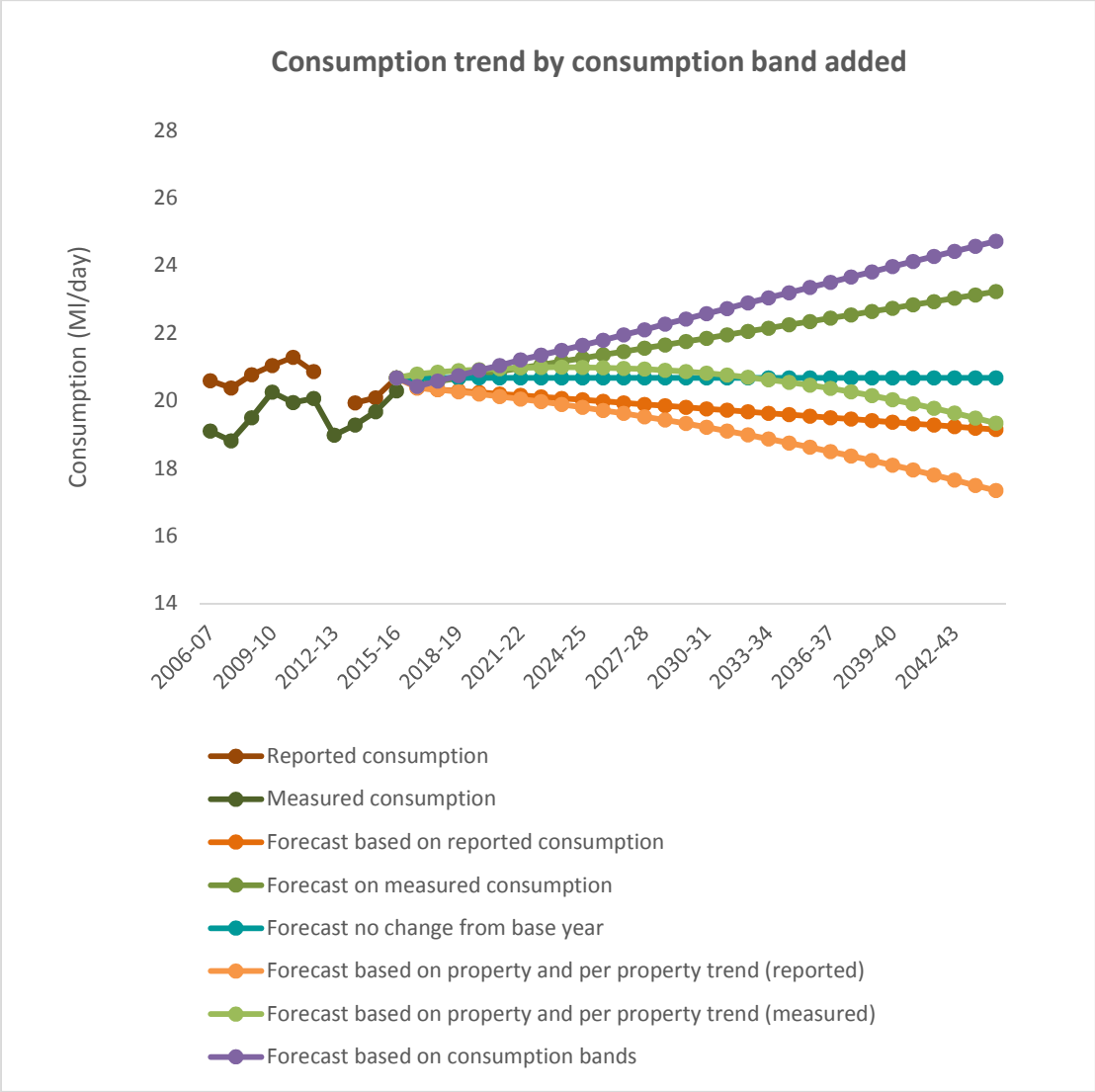

Figure 11 Consumption trend by consumption band added

3.3 Analysis by industry code

In order to further analyse consumption in different sectors, an analysis by industry code has been performed. In the same way as the consumption bands, each industry code was tested separately against a number of parameters such as population, unemployment, GDP and Growth. The results derived from this trend are presented in Figure 12. Although significant relationships affecting individual industry codes were found, further investigation showed that variables were flawed, and, as a consequence of this, results were not as robust as desired.

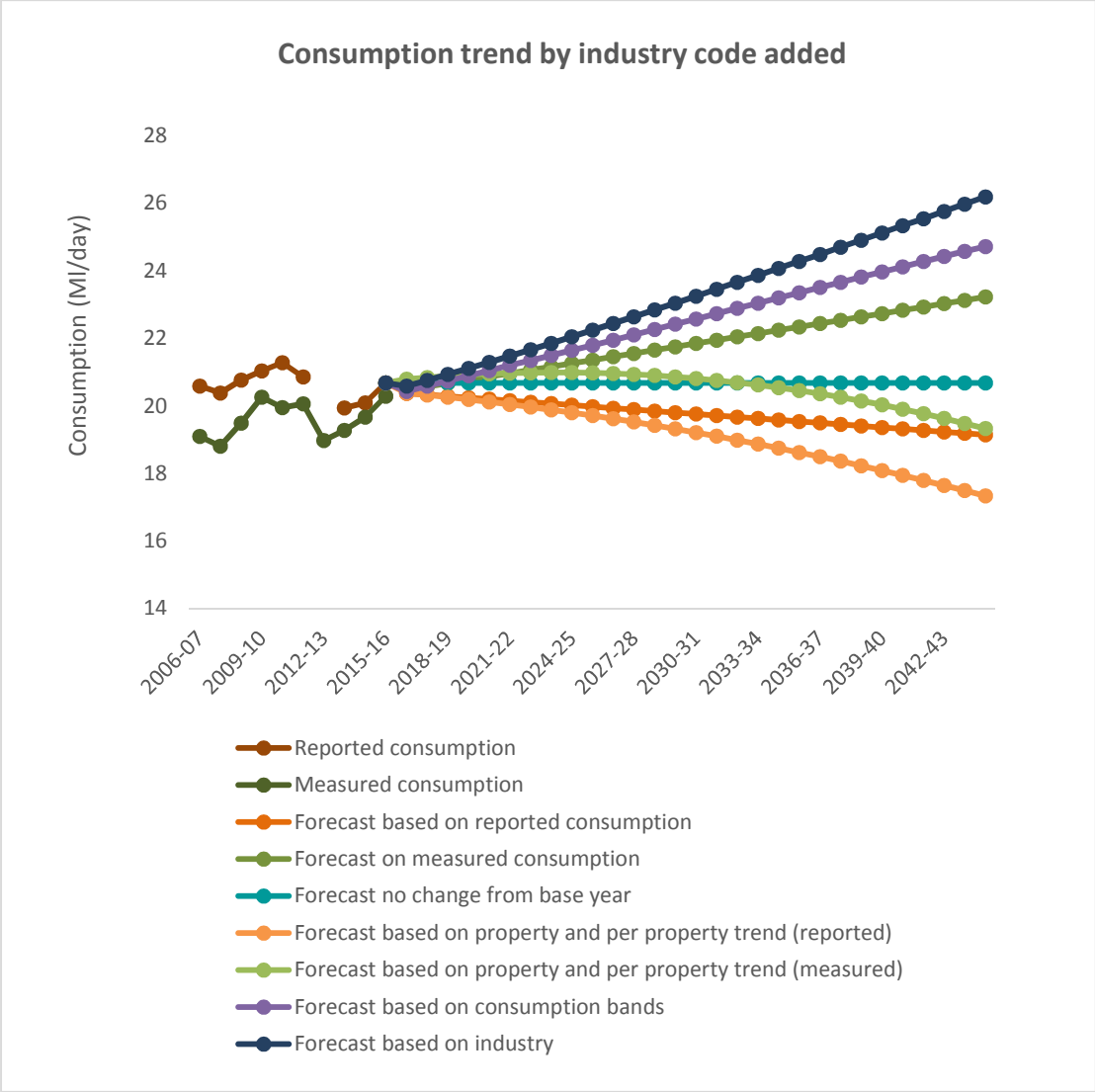

Figure 12 **Consumption trend by industry code added**

4 Summary

A set of non-household demand forecasts has been provided covering a 25 year period. Although the high level trend analysis presented in section 3.1 did not display strong relationships with economic factors, results showed a good correlation between individual industries and water consumption; and these relationships varied in the direction of consumption projections between the industries.

An analysis in consumption by consumption band showed little or no relationship with economic factors. Likewise, trends in consumption by band were statistically less significant than the results derived from industry analysis. In general, an increase in consumption by band mainly driven by property numbers is expected within bands A to G whereas the higher consumption bands (Bands H and I) showed a negative direction.

More importantly, these analysis (by consumption band, industry code and by property) have revealed the 'masking effect' that can be produced when working with high level trends. In this regard, analysis on individual consumption bands and/or industry codes produced more statistically significant trends and forecasts. Likewise, analysis on individual properties with high consumption levels (section 3.2.) has proven to be a useful tool in water consumption analysis.

Figure 13 illustrates the forecasts that have been produced for this analysis. They are intended to show a broad spectrum of possible futures on water consumption for the year 2044/45 and they are not expected to be equally probable. It can be deduced that some trends represent extreme events or realities. Based on this reflexion, 'Forecast based on industry' and 'Forecast based on property and per property trend for reported consumption' have been removed due to the unlikely occurrence and extreme nature of the outcomes:

- 'Forecast based on property and per property (reported)' predicted a significant decreased in consumption. This result was mainly driven by the consumption per property trend that reaches a 30% drop in 2044/45. It was considered this drop did not reflect the market.

- 'Forecast based on industry': this forecast has been finally excluded because it is considered to represent an extreme scenario of low likelihood where consumption experiences an increase of almost 30%. This decision was also supported by the fact thatthe way the codes had been allocated to individual meters, did not enable conclusions to be drawn while guaranteeing that results were error-free.

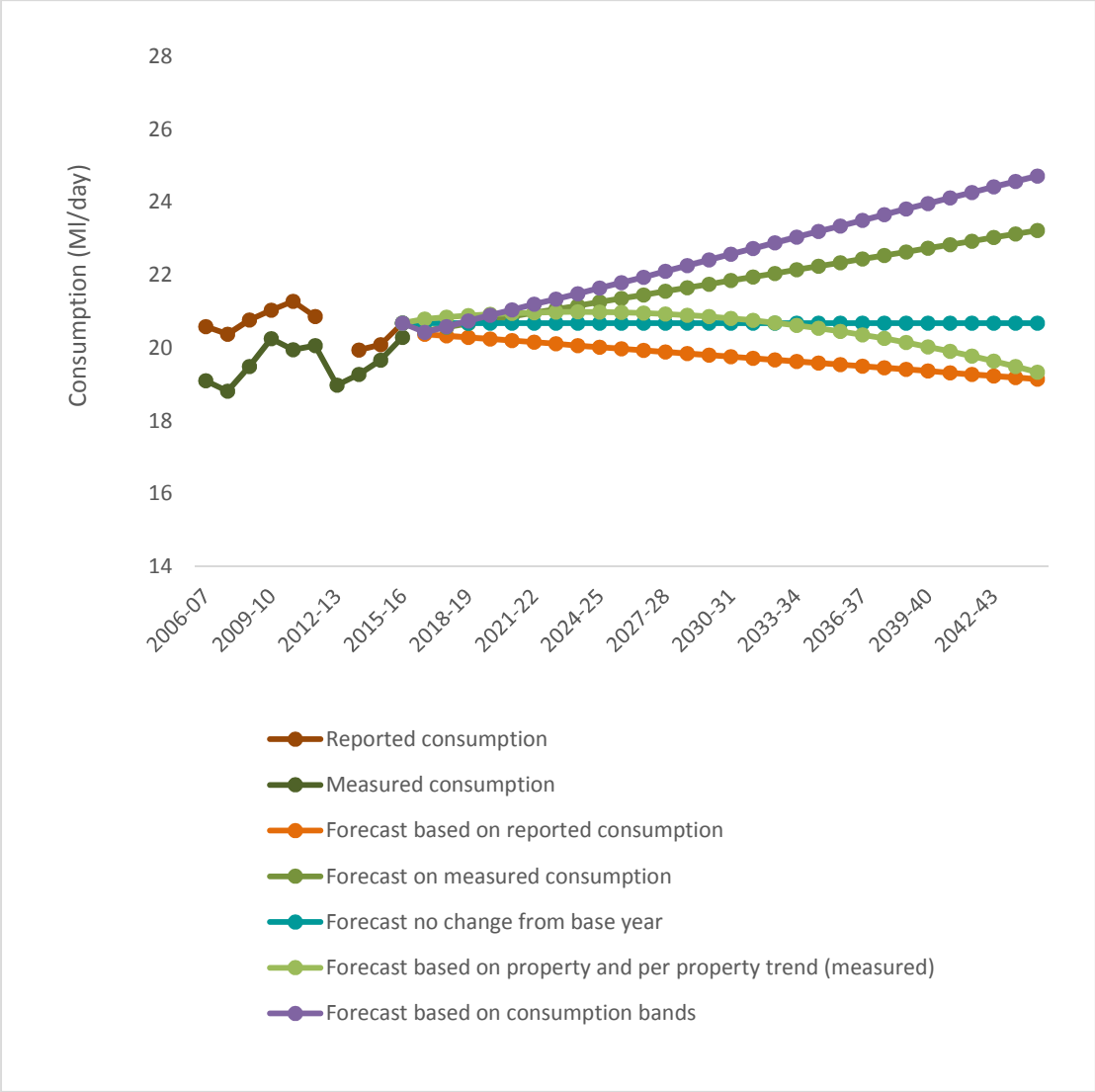

Figure 13 Final forecasts for non-HH consumption

Final forecasts are displayed in Figure 13 and it includes:

- Reported consumption.
- Measured consumption.
- Forecast based on reported consumption calculated as a simple linear trend -excluding data from 2012/13-
- Forecast based on measured consumption calculated as a simple linear trend from calibrated to based year (2015/16) measured consumption
- Trends for properties and consumption per property using the measured dataset were calculated and used to generate a new forecast: 'Forecast based on property and per property trend (measured)'. The same trend was produced using reported figures, nonetheless, it has finally been removed from Figure 13, as it is considered to represent an extreme scenario.
- Forecast based on consumption bands, were consumption bands have been analysed separately and add up all together.
- Forecast no change from based year.

Values for each forecast every five years are displayed on Table 2.

Table 2 Forecasted values for non-HH consumption

Forecast	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45
Total reported	20.24	20.02	19.81	19.59	19.37	19.15
Total measured	20.77	21.26	21.75	22.24	22.74	23.23
Property & per property measured	20.92	20.99	20.86	20.54	20.03	19.33
Consumption bands measured	20.90	21.64	22.42	23.20	23.97	24.72
No change	20.68	20.68	20.68	20.68	20.68	20.68

Finally, a summary graph is provided in Figure 14 and Table 3. This graph illustrates the combination of the set of forecasts provided for the analysis. Bars on the graph represent the standard deviation of the forecasts provided.

Two central tendency measures, mean and median, have been estimated for the set of trends. Given the similarity displayed by both parameters, we can accept a fairly normal distribution, justifying the use of parametric analysis.

We assume equal probabilities for each scenario and, based on the above consideration, we use the mean to get the central estimate and the standard deviation. Through this analysis we can understand the uncertainty around the mean forecast. The standard deviation can be used to define non-household forecast uncertainty in headroom, using a normal distribution around the mean forecast.

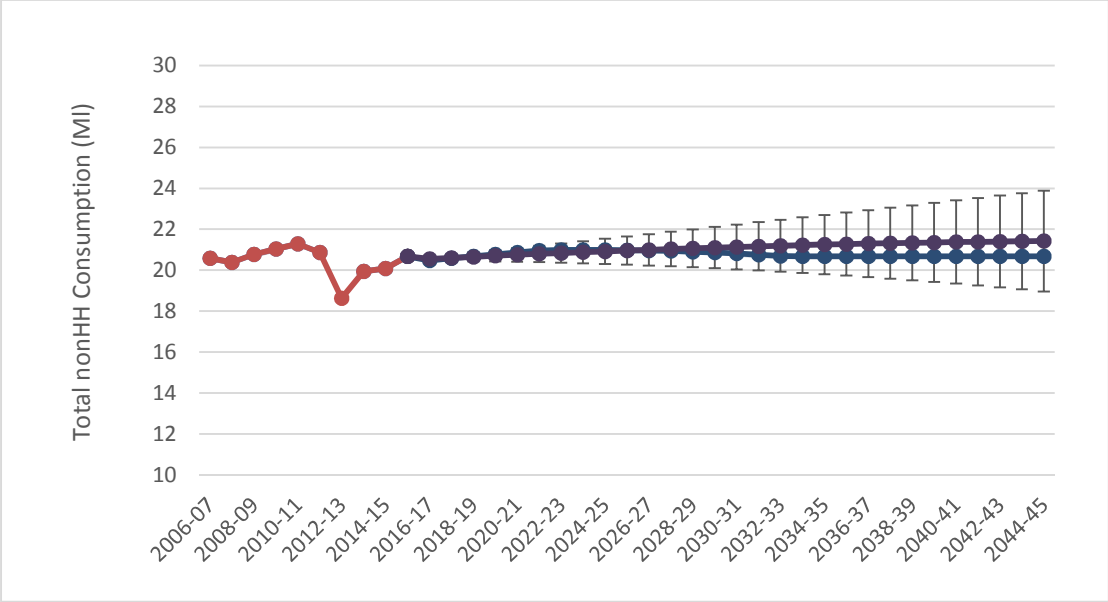

Figure 14 Non-HH forecast aggregated

Table 3 Non-household forecast aggregated

Forecast	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45
Mean	20.70	20.92	21.10	21.25	21.36	21.42
Median	20.77	20.99	20.86	20.68	20.68	20.68
Standard deviation	0.27	0.61	1.01	1.45	1.93	2.46
Upper forecast[7]	20.97	21.53	22.11	22.7	23.29	23.88
Lower forecast[7]	20.43	20.31	20.09	19.8	19.43	18.96

[7] For headroom