IPART
New South Wales

Independent Pricing and Regulatory Tribunal

Residential water usage in Sydney, Hunter and Gosford

Result from the 2015 household survey

Water — Research Paper
September 2016

IPART
New South Wales

Independent Pricing and Regulatory Tribunal

Residential water usage in Sydney, Hunter and Gosford

Result from the 2015 household survey

Water — Research Paper
September 2016

ISBN 978-1-76049-015-7 RP36

The Tribunal members for this review are:

Dr Peter J Boxall AO, Chair

Ms Catherine Jones

Mr Ed Willett

Inquiries regarding this document should be directed to a staff member:

Bee Thompson (02) 9290 8496

Anna Brakey (02) 9290 8438

Independent Pricing and Regulatory Tribunal of New South Wales
PO Box K35, Haymarket Post Shop NSW 1240
Level 15, 2-24 Rawson Place, Sydney NSW 2000

T (02) 9290 8400 F (02) 9290 2061

www.ipart.nsw.gov.au

Contents

1 Executive summary 1
- 1.1 Overview of key findings 3
- 1.2 Structure of this report 10

2 Overview of water usage in the survey areas 11
- 2.1 Characteristics of the survey areas 11
- 2.2 Characteristics of the survey areas 13
- 2.3 Water supply conditions in the survey areas 14
- 2.4 Water usage in the survey areas 16

3 What are the main drivers of household water usage? 19
- 3.1 Frontier's regression model 19
- 3.2 Main drivers of water usage 23
- 3.3 Predicted water usage by typical households 27
- 3.4 The long-term effect of income on water usage 28

4 Why do households in some areas use more water than those in other areas? 32
- 4.1 How we analysed differences between areas 32
- 4.2 Difference in average usage between Gosford and other areas 33
- 4.3 Other differences between areas 34

5 Why do higher income households use more water than lower income households? 38
- 5.1 How we analysed effect of income on water usage 38
- 5.2 Differences in average usage between income groups 39
- 5.3 Drivers of differences between income groups 40
- 5.4 Reasons for wide variations in usage within income groups 44

6 Do houses discharge more wastewater into the sewerage system than flats? 46
- 6.1 Difference in average total usage between houses and flats 46
- 6.2 How we estimated average indoor usage of houses and flats 48
- 6.3 Findings on estimated average indoor usage of houses and flats 48

1 Executive summary

In 2015, the Independent Pricing and Regulatory Tribunal of NSW (IPART) surveyed residential water, electricity and gas customers in the Sydney, Hunter, Gosford, Riverina and North Coast areas.[1] We collected socio-economic, demographic, attitudinal and behavioural data from 4,404 households across these areas. We also obtained usage data for these households from the relevant utilities.

We explained how we conducted the survey and reported on its findings in a series of fact sheets, information papers, reports and output tables (see Box 1.1). This report discusses the findings on water usage, particularly our analysis of the main drivers of this usage. In this context, a 'driver' means a household characteristic or choice that is **associated** with higher or lower water usage (but does not necessarily **cause** this usage).

To conduct this analysis, we commissioned Frontier Economics (Frontier) to develop a regression model to identify the drivers of household water usage, and to estimate how much more (or less) usage is associated with each individual driver. We also used the results of this analysis to explore:

- why households in some areas use more water than those in other areas,
- why higher income households use more water than lower income households, and
- whether households in houses use more water indoors than those in flats, and therefore discharge more water into the sewerage system.

This analysis of water usage focused on the Sydney, Hunter and Gosford survey areas only, as we were only able to obtain water consumption data for these areas.

1 This is our seventh household survey since 1993.

Box 1.1 Further information on our household survey

We have published the results of the 2015 household survey in a series of fact sheets and information papers together with two reports that investigate our findings on water and energy usage. We have also published a set of output tables (Excel files) that report the detailed responses to each survey question.

Fact sheets and information papers:

- About the survey.
- Water usage (fact sheet only).
- Energy usage (fact sheet only).
- Water and energy conservation.
- Solar PV panels.
- Payment difficulties.
- Concession cards and rebates.

Reports:

- Residential energy usage (electricity and gas).
- Residential water usage (this report).

Output tables:

- Each survey area and NSW as a whole (the latter weighted to represent the regional distribution of the population).
- Sydney, by income group and as a whole.
- Hunter, by income group and as a whole.

We cannot report on the other survey areas by income group because the sample sizes for some of the income categories are too small.

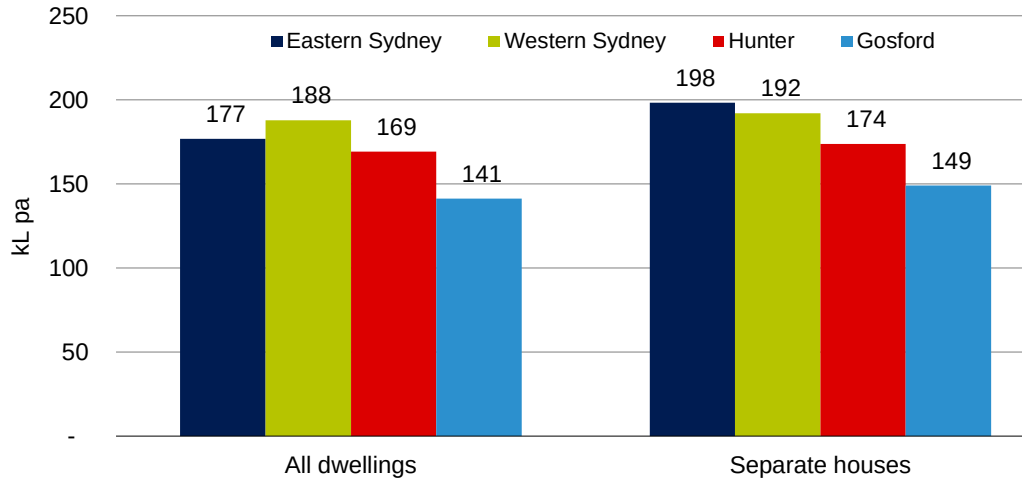
We engaged Frontier Economics (Frontier) to conduct statistical analysis of the survey data for our reports. Frontier analysed the energy usage data and produced a separate report on its findings. It also analysed the water usage data, and we have included its findings in this report on water usage. The reports include detailed technical appendices to allow other parties to conduct further research into residential energy and water usage.

You will find the documents our website.

1.1 Overview of key findings

Across the households we surveyed, the average annual water usage ranged from 188 kL pa in Western Sydney[2] to 141 kL pa in Gosford. Across those that lived in separate houses only, the average annual usage was higher, ranging from 198 kL pa in Eastern Sydney to 149 kl pa in Gosford (Figure 1.1). These findings are consistent with our previous surveys[3] and information from the water utilities.[4]

Figure 1.1 Average household water usage by survey area (kL pa)



Note: Households that rent and do not pay water usage charges are excluded because we did not obtain their water usage data. The data are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

1.1.1 What are the main drivers of household water usage?

How much water an individual household uses depends on a range of characteristics, as well as attitudes to water conservation that influence behaviours in the home. These factors can be positively related to usage (ie, associated with higher usage) or negatively related (associated with lower usage).

2 Western Sydney includes Baulkham Hills and Hawkesbury, Blacktown, Sydney Outer South West, Sydney South West, Sydney - Outer West and Blue Mountains. Eastern Sydney includes all the remaining areas in Sydney Water's area of operation, including the Illawarra.

3 IPART, *Residential energy and water use in Sydney, the Blue Mountains and Illawarra. Results from the 2010 household survey*. December 2010, pp 90 and 95.

4 Information provided by the water utilities indicates that, over the period 2013-14 to 2014-15, residential customers in separate houses used an average of 222 kL pa in Sydney, 188 kL pa in Hunter and 173 kL pa in Gosford.

Frontier's regression model identified that the most important driver of water usage was the number of people in the household, particularly adults, which is associated with higher usage. Another important driver was an area-specific factor – being located in Gosford. For reasons that our survey did not capture, this factor was associated with significantly lower water usage (discussed further below). Table 1.1 summarises the factors Frontier's model identified as main drivers of water usage.

Table 1.1 Main drivers of household water usage

Drivers associated with higher usage	Drivers associated with lower usage
▾ Higher number of people in the home (with higher usage per adult than per child).	▾ Having one or more water saving device (eg, low-flow showerhead or tap aerator).
▾ More frequent use of a dishwasher and washing machine.	▾ Having taken active steps to use less water in the previous five years.
▾ Higher number of bedrooms and toilets in the home.	▾ Using an alternative source of water (such as a rainwater tank or grey water).
▾ Larger plot size (or the absence of information on plot size)[a]	▾ Being located in the Gosford area.
▾ Having a swimming pool.	
▾ Watering the garden frequently in winter and/or using a sprinkler[b]	

[a] The regression model includes a dummy variable to capture plot-related usage for households that did not provide a plot size.

[b] The model did not include a variable for summer watering because 'using a sprinkler' picks up mainly summer watering. Including a variable for watering in summer as well as using a sprinkler would lead to technical problems (collinearity).

Source: Frontier Economics' regression model, IPART analysis.

Frontier's model did not estimate directly the impact of income on usage. Instead, the effect of income is expressed through the choices that a household's income allows it to make, such as number of bedrooms, the presence of a pool, etc.

To get an idea of the impact of income on water usage, we used a simple regression model that includes four drivers - the number of adults, the number of children, household income and being located in Gosford. We found that income has a small but statistically significant impact on usage. We also found that income has a smaller impact on water usage than electricity usage.

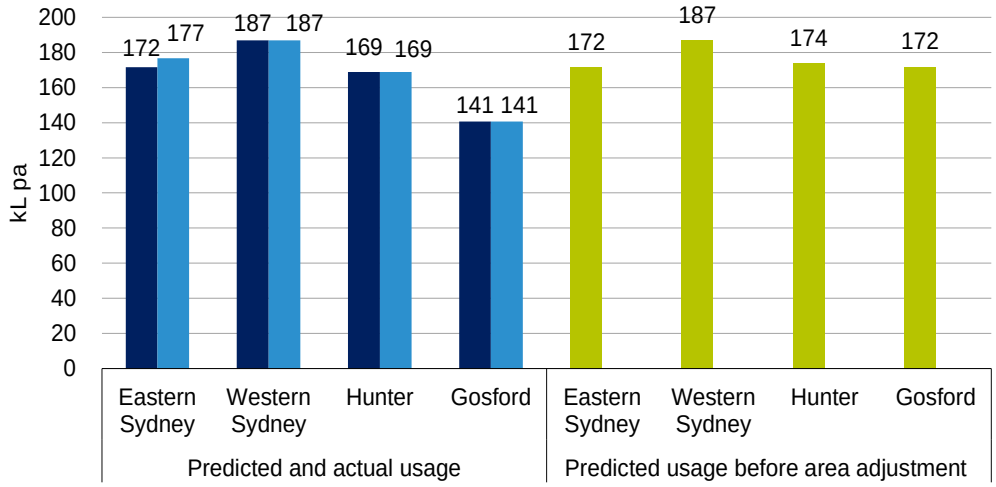
1.1.2 Why does household water usage differ across survey areas?

We used the results of Frontier's model and each area's household characteristics to identify why usage differs between the survey areas. We found that the Gosford area's lower average water usage relative to all other areas cannot be explained by different household, demographic or socio-economic characteristics. Rather it is due to an unexplained difference between the usage in this area and the other survey areas. Were it not for this difference, the model predicts that households in Gosford would use a very similar amount of water to households in the Eastern Sydney and Hunter areas, on average (Figure 1.2).

We think it possible that the severe water shortages experienced in Gosford/Wyong during the 2000s has led to a 'culture' of water conservation in the area. Our survey found that households in Gosford are more likely than those in the other areas to use alternative sources of water to mains water[5] (eg, rainwater tanks). In addition, if they have a garden, they are far less likely to use a sprinkler. But over and above this, they may use less water to do the same things that households in other areas do – for example, by taking shorter showers and watering their gardens for shorter periods of time.

5 Mains water is water purchased from a water utility from mains (pipelines) on the street.

Figure 1.2 Water usage by survey area with and without area adjustments (kL pa)

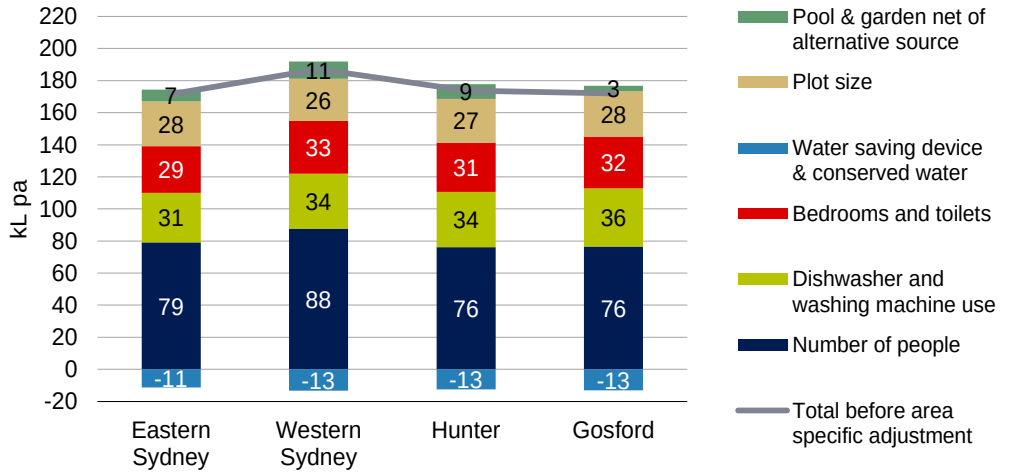


Note: The household characteristics and actual usage are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

Looking at the other factors that drive usage, we found the main reason why households in Western Sydney used the most water was because, on average, they had larger households. They also had slightly larger dwellings, on average, and used a little more water for pools and gardens (after taking into account the reduction in usage due to using water from an alternative source). (See Figure 1.3.)

Figure 1.3 Drivers of water usage by area, excluding area adjustments, all dwelling types (kL pa)



Note: The household characteristics are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

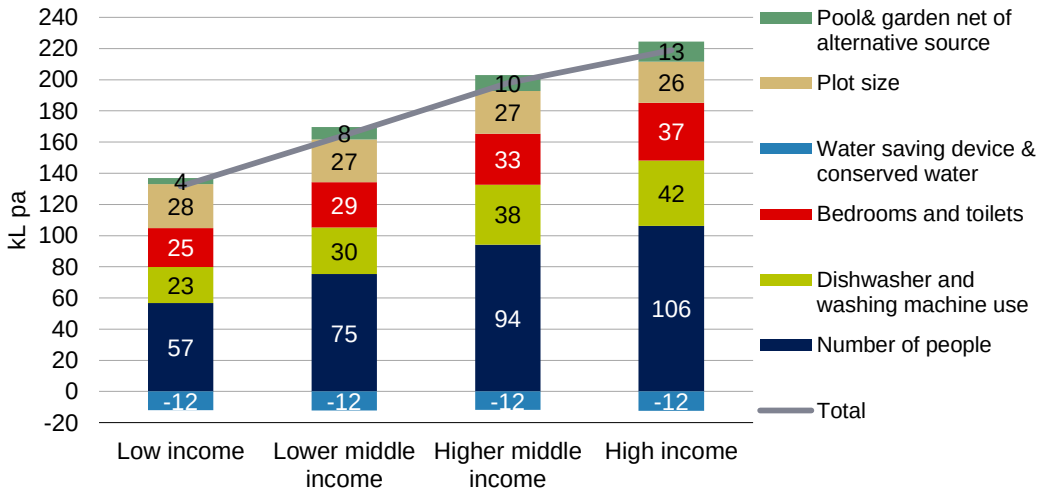
1.1.3 Why do higher income households use more water than lower income households?

Our survey found that on average, higher income households used 215 kL pa while lower income households used 134 kL pa. We used the results of Frontier's model and each income group's average household characteristics to explore the reasons for this finding. We found that, as household income rises, so do the values for most of the characteristics associated with higher usage. For example, on average:

- the number of people increases from 1.8 (in low income households) to 3.5 (in high income households)
- washing machine use increases from 2.6 (in low income households) to 4.3 times per week (in high income households)
- the number of bedrooms increases from 2.6 (in low income households) to 3.7 (in high income households)
- the proportion with a pool increases from 5% (in low income households) to 24% (in high income households), and
- the proportion that use a sprinkler increases from 13% (in low income households) to 31% (in high income households).

Figure 1.4 shows the impact of these characteristics on the average water usage of each income group.

Figure 1.4 Drivers of average water usage by income group (kL pa)



Note: Predicted usage for Sydney, Hunter and Gosford combined. The household characteristics are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

Our survey also found there was a wide range of usage within each income group. We found that this is explained by differences in household characteristics across the group, particularly the number of people. For example:

- Although about 80% of low income households had only one or two people, 8% had four or more people.
- Although more than half of high income households had four or more people, almost 30% had only one or two people.

In addition, some low income households had characteristics or behaviours that are associated with higher levels of usage – such as having a pool and/or using a sprinkler – while many high income households did not have those characteristics or behaviours.

1.1.4 Do houses discharge more wastewater into the sewerage system than flats?

An issue to consider for future price reviews is whether or not households in individually metered dwellings (houses)[6] discharge more wastewater into the sewerage system than those in multi-premise dwellings (such as flats).

6 'Houses' means free standing houses as well as dwelling units such as terrace houses, villa units and townhouses with individual meters.

We used the household survey data and the results of Frontier's regression analysis to shed some light on this issue. We focused on estimating the average **indoor** usage of households in each type of dwelling, as most of this water is discharged into the sewerage system.

We know from our survey that on average, households in houses use more water than households in flats (about 183 kL pa compared with about 138 kL pa in flats). But we do not know how much of this water they use indoors. We estimated this by using the results of Frontier's regression model and the characteristics of households in houses and flats respectively.

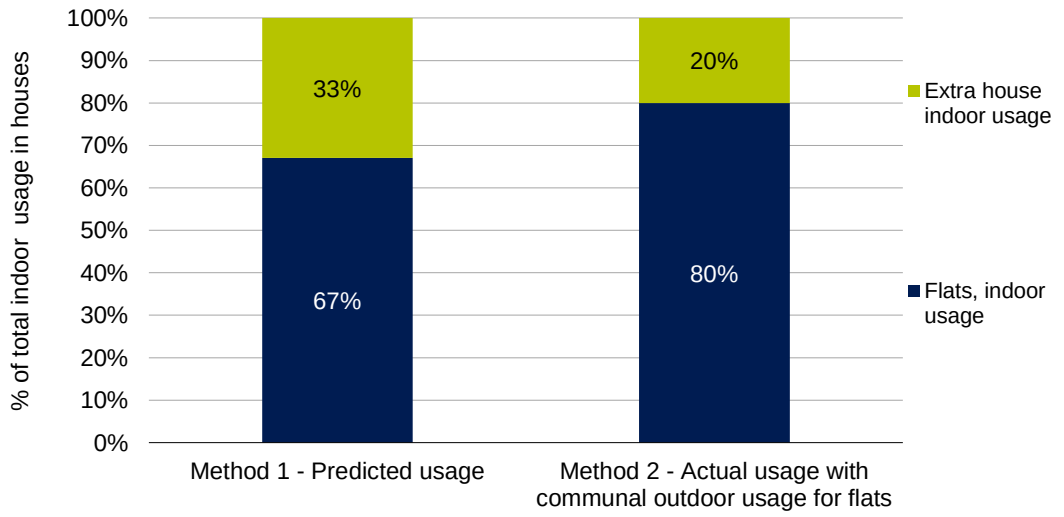
We used the outcomes of this analysis to estimate indoor usage in flats as a proportion of that in houses using two different methods:

1. We compared the indoor usage volumes predicted by the model.
2. We applied the predicted ratio of indoor to outdoor usage to the actual average usage in houses and flats respectively, after including an allowance for watering communal gardens in flats.[7]

We found that households in flats do use less water indoors than those in houses, mainly because households in flats have fewer people. But how much less water they use is less clear, and is probably somewhere between 67% and 80% of the indoor usage of houses (Figure 1.5).

[7] The regression model did not capture water usage for communal purposes. We did not make and adjustment for communal pools because the impact of such an adjustment would be very small. We did not have any information about the prevalence of such pools.

Figure 1.5 Indoor usage by dwelling type (% of total usage)



Note: Houses means individually metered dwellings that are not flats. Analysis for Sydney, Hunter and Gosford combined. The household characteristics are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

1.2 Structure of this report

The rest of this report explains our analysis and findings on water usage in more detail:

- Chapter 2 provides an overview of the survey areas and water usage in these areas.
- Chapter 3 explains Frontier's analysis on the main drivers of household water usage.
- Chapters 4 to 6 discuss our analysis and findings on the differences in water usage across survey areas and income groups, and between households in houses and flats.

The technical appendix provides the detailed results of Frontier's regression model (Excel). The technical appendix and the survey questionnaire are available on our website.

2 Overview of water usage in the survey areas

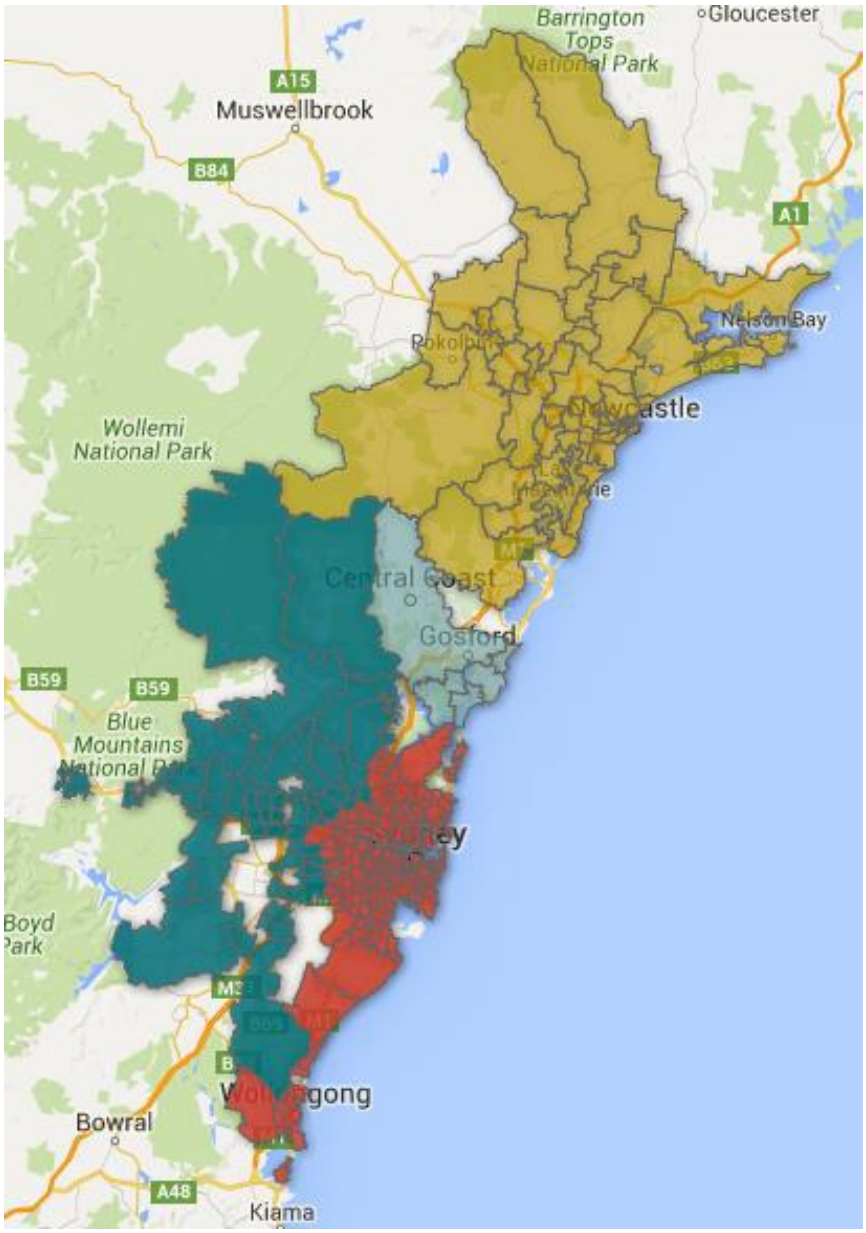
For our analysis of water usage, we focused on the Sydney, Hunter and Gosford areas only, as we could not obtain water consumption data for the other areas we surveyed. We also separately analysed water usage in Eastern Sydney and Western Sydney.[8]

Eastern Sydney, Western Sydney, Hunter and Gosford have different demographic and socio-economic characteristics, as well as different histories of water shortages and water restrictions. These differences have an impact on household water usage, as the following chapters discuss in more detail.

The sections below outline the main differences between the areas, and summarise our survey findings on water usage in each area. Figure 2.1 shows the four areas.

[8] Western Sydney includes Baulkham Hills and Hawkesbury, Blacktown, Sydney Outer South West, Sydney South West, Sydney - Outer West and Blue Mountains. Eastern Sydney includes all the remaining areas in Sydney Water's area of operation, including the Illawarra.

Figure 2.1 Map of the survey areas



Note: The areas are Eastern Sydney (red), Western Sydney (teal), Gosford (light blue) and Hunter (yellow). Western Sydney includes Baulkham Hills and Hawkesbury, Blacktown, Sydney Outer South West, Sydney South West, Sydney - Outer West and Blue Mountains. Eastern Sydney includes all the remaining areas in Sydney Water's area of operation, including the Illawarra.

Source: Frontier Economics.

2.2 Characteristics of the survey areas

There are several important differences in the four survey areas' demographic, socio-economic and dwelling characteristics (see Table 2.1). In particular:

- A smaller proportion of Eastern Sydney households live in separate (ie, free-standing) houses, and a larger proportion live in flats, than households in the other areas.
- A larger proportion of Western Sydney households are couples with children living at home, and lower proportion are one-person households, than households in the other areas. Hunter and Gosford have the lowest proportion of households living with children.
- Households in Eastern Sydney have the highest average incomes while those in Hunter and Gosford have the lowest.

Table 2.1 Key characteristics of survey areas (% of households)

Characteristic	Eastern Sydney[a]	Western Sydney[a]	Hunter	Gosford
Dwelling structure				
Separate house (ie, free standing)	48%	85%	84%	77%
Terrace house, townhouse etc[b]	16%	9%	9%	16%
Flat	36%	7%	7%	7%
Household structure				
Couple with children living at home	36%	43%	31%	31%
Couple without children living at home	26%	25%	29%	28%
One-person household	25%	16%	25%	27%
Income				
Low income	22%	27%	35%	35%
Lower middle income	20%	21%	21%	21%
Higher middle income	32%	30%	25%	26%
High income	16%	12%	8%	8%

a Western Sydney includes Baulkham Hills and Hawkesbury, Blacktown, Sydney Outer South West, Sydney South West, Sydney - Outer West and Blue Mountains. Eastern Sydney includes all the remaining areas in Sydney Water's area of operation, including the Illawarra.

b This category includes terrace and semi-detached houses, townhouses, duplexes, granny flats and combined residential and non-residential dwellings. Households in mobile and improvised dwellings were excluded from the survey.

Note: The data are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

Households in these areas also differ in terms of their water-using appliances, fixtures and behaviours. For example, our survey found that:

- Households in Gosford were the most likely to have a rainwater tank (38%) and those in Eastern Sydney were the least likely to have one (18%).

- Households in Western Sydney and Hunter were more likely to use a sprinkler than households in either Eastern Sydney or Gosford.[9]

Table 2.2 Selected water-using appliances, fixtures and behaviour, by area (% of all households)

Characteristic	Eastern Sydney[a]	Western Sydney[a]	Hunter	Gosford
Have a dishwasher	59%	61%	56%	65%
Have a washing machine	95%	98%	99%	99%
Have a pool	12%	16%	15%	18%
Have a rainwater tank	18%	24%	25%	38%
Have at least one water saving device	70%	82%	79%	83%
Use a hose to water the garden	45%	62%	64%	60%
Use a sprinkler	17%	29%	26%	19%
Have taken steps to reduce usage	67%	80%	73%	77%

a Western Sydney includes Baulkham Hills and Hawkesbury, Blacktown, Sydney Outer South West, Sydney South West, Sydney - Outer West and Blue Mountains. Eastern Sydney includes all the remaining areas in Sydney Water's area of operation, including the Illawarra.

Note: The data are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

2.3 Water supply conditions in the survey areas

Water supply conditions at the time of the survey were similar across the survey areas, with all areas operating under Water Wise rules (see Box 2.1). However, dam levels in Sydney and Gosford/Wyong were low due to drought for most of the 2000s, and water restrictions were imposed on households and businesses in these areas. In Hunter, dams remained at satisfactory levels and there were no water restrictions.

Water shortages were particularly acute in Gosford/Wyong, where storage levels fell to just over 10% of capacity in early 2007.[10] Mandatory water restrictions were in place at a higher level, and for longer, than in Sydney. Additional measures including an extensive community education program were undertaken in Gosford/Wyong to encourage households to use less mains water.[11] Box 2.1 provides more information on the history of water restrictions in the survey areas.

9 The analysis includes all households, whether or not they had their own garden.

10 Gosford City Council/Central Coast/Wyong Shire Council, *WaterPlan 2050 A long-term water supply strategy for the Central Coast*, August 2007, p 2.

11 Gosford City Council/Central Coast/Wyong Shire Council, *WaterPlan 2050 A long-term water supply strategy for the Central Coast*, August 2007, p 3.

Box 2.1 Water restrictions in the survey areas during the 2000s.

Water restrictions in Gosford/Wyong

Level 4 water restrictions applied in Gosford/Wyong between October 2006 and March 2008.[a] Under level 4 restrictions all outdoor use of mains water was effectively banned. The watering of residential gardens, filling or topping up of swimming pools, washing of cars and boats, and showering at beaches were prohibited.[b]

Level 3 restrictions applied between June and October 2006, and again between March 2008 and November 2011.[a] Under the 2009 level 3 restrictions, households were permitted to use mains water to:

- water their gardens using a hand-held hose with a trigger nozzle at certain times only, or using a bucket or watering can at any time
- wash boats and vehicles using a hand-held hose with a trigger nozzle or a bucket, and
- top up a swimming pool with a bucket.[c]

For households with internally connected rainwater tanks, restrictions were relaxed on external use. (Level 2a restrictions applied.)[c]

Water restrictions in Sydney

In Sydney, level 3 restrictions applied between 2005 and 2009. Sydney households were still permitted to use mains water to:

- water their gardens with a hand-held hose at certain times, and
- top up or fill swimming pools (a permit was required to fill pools of over 10 kL).[d]

Water Wise Rules

Water restrictions were lifted in Sydney in 2009 and in Gosford/Wyong in 2012.[a,d] Water Wise Rules were introduced to replace water restrictions, and these rules remain in force. Water Wise Rules include, for example, restrictions on the time of day that gardens can be watered, a requirement that all hand-held hoses have trigger nozzles and restrictions on the hosing of hard surfaces except for health and safety reasons, construction activities or in an emergency.[d]

Water Wise Rules were also introduced in Hunter in 2014. These rules are similar to those that apply in Sydney and Gosford.[e]

a Information provided to IPART by Central Coast Council.

b IPART, *Gosford City Council Wyong Shire Council Prices for water, sewerage and stormwater drainage services from 1 July 2009 to 30 June 2013. Water — Determinations and Final Report,* May 2009, p 108.

c *http://whatsoncentralcoast.com.au/mini-window/cc-water-restrictions.html.*

d *http://www.sydneywater.com.au/SW/findnow/index.htm?fn_url=http://sydneywater.custhelp.com/app/answers/detail/a_id/397*.

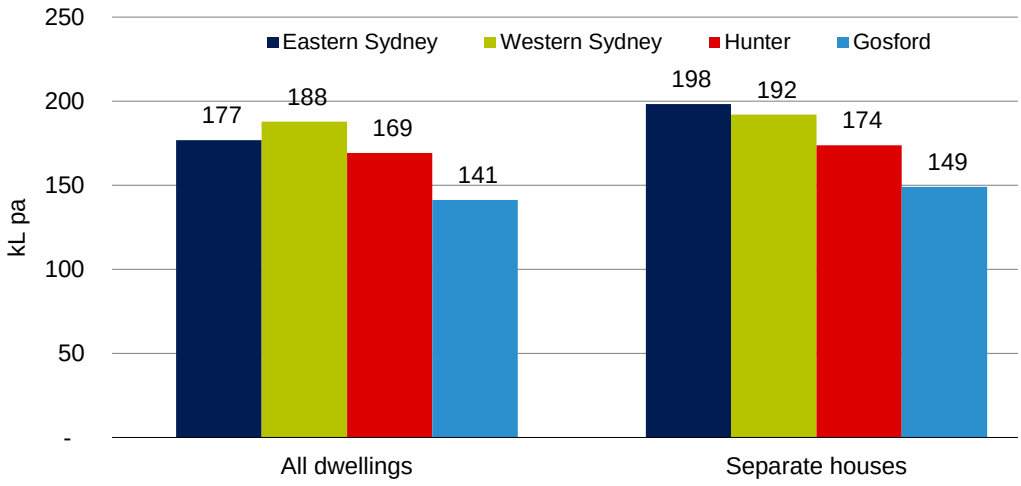
e *http://www.hunterwater.com.au/Save-Water/Water-Wise-Rules.aspx.*

Note: All website documents were extracted between June and July 2016.

2.4 Water usage in the survey areas

Our survey found that, on average, households in Eastern and Western Sydney used more water than households in Hunter or Gosford (Figure 2.2). Looking at households in all dwelling types, those in Western Sydney had the highest average usage (188 kL pa), while those in Gosford had the lowest (141 kL pa). However, looking at households in separate houses only, those in Eastern Sydney had the highest average usage. These findings are consistent with our previous surveys[12] and information from the water utilities.[13]

Figure 2.2 Water usage by survey area (kL pa)



Note: Households that rent and do not pay water usage charges are excluded because we did not obtain their water usage data. The data are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

On average across all survey areas, households in separate houses used more water than those in other dwelling types (196 kL pa compared with 139 kL pa). Therefore, part of the reason why households in Western Sydney had higher average usage than those in Eastern Sydney is because more live in separate houses and fewer live in other dwelling types, particularly flats (see Table 2.1).[14]

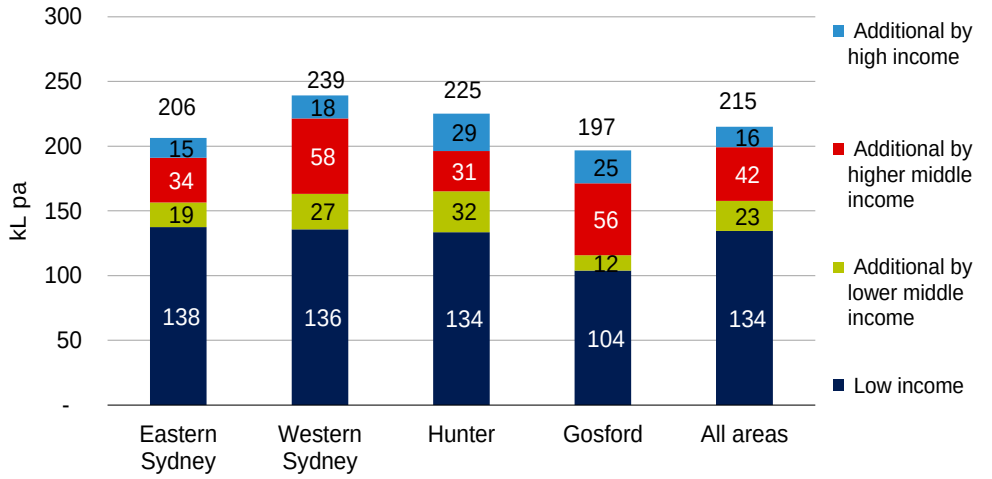
12 IPART, *Residential energy and water use in Sydney, the Blue Mountains and Illawarra. Results from the 2010 household survey.* December 2010, pp 90 and 95.

13 Information provided by the water utilities indicates that, over the period 2013-14 to 2014-15, residential customers in separate houses used an average of 222 kL pa in Sydney, 188 kL pa in Hunter and 173 kL pa in Gosford.

14 Other dwelling types include flats, terrace and semi-detached houses, townhouses, duplexes, granny flats and combined residential and non-residential dwellings. Households in mobile and improvised dwellings were excluded from the survey.

Our survey also found that on average, across all areas, households with higher incomes used more water than those with lower incomes (Figure 2.3). Low income households in Gosford had the lowest average usage (104 kL pa) while high income households in Western Sydney had the highest (239 kL pa).

Figure 2.3 Water usage by survey income group and area (kL pa)



Note: Households that rent and do not pay water usage charges are excluded because we did not obtain their water usage data. The data are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

Box 2.2 explains how we defined income groups and Box 2.3 provides information about the water usage data.

Box 2.2 How we defined the household income groups

We asked survey respondents to provide their total household income from all sources (before tax) in one of nine categories. To simplify our analysis, we consolidated these categories into four groups:

- Low income (up to $41,600 pa).
- Lower middle income (more than $41,600 up to $78,000 pa).
- Higher middle income (more than $78,000 up to $156,000 pa).
- High income (more than $156,000 pa).

Box 2.3 Information about the water usage data

We obtained water usage data for households that pay water usage charges

We obtained water usage (billing) data for 2,688 households from their water supplier, after obtaining the account holders' permission do so. Our information paper about the survey[a] and Roy Morgan's technical report[b] provide more information about how we collected the data.

The survey did not obtain usage data for households that rent and do not pay the water usage charge.

We analysed 365 days' worth of usage data

For each household, we obtained between one and three years' worth of billing data. However, for the purpose of our analysis we used only the most recent 365 days' worth of usage. Households were included in the survey only if they had lived at their current address for at least 15 months.

We estimated usage for households with a shared water meter

Some households share a water meter with other customers, both residential and non-residential units (eg, households that live in flats). For these households, we obtained data on the total amount of water that was used by all units on that meter as well as the total number of units. We then divided the total usage by the total number of units to estimate the surveyed household's usage (ie, we used the average for all units as a proxy for our surveyed household's usage).

We excluded some households

For our analysis of average usage, we excluded about 2% of households. Most of these exclusions were households with shared water meters that had implausibly high usage, or had a property type that was identified as non-residential. We also excluded all households with usage below 5kL pa or above 1,000 kL pa.

For purposes of the regression analysis we excluded all households with a shared water meter and all households that live in flats. (Very few households that live in flats have an individual water meter).

a IPART, *IPART 2015 Household Survey — About the survey*, September 2016.

b Roy Morgan Research, *IPART Household Survey 2015 Technical Report*, March 2016.

3 What are the main drivers of household water usage?

How much water a household uses depends partly on what it uses the water for. This, in turn, depends on things like how many people there are in the household, what appliances it has, and whether or not it has a swimming pool. And these things are related to socio-economic factors like household income, location and type of accommodation. In addition, it depends partly on water-using behaviours in the home, such as whether the household takes short or long showers, which in turn depends partly on attitudes to water conservation.

We commissioned Frontier to develop a regression model to **identify** the main drivers of residential water usage,[15] and estimate **how much** more (or less) usage is associated with each of the identified drivers, keeping all other things the same. Then, to help illustrate what these regression results mean, we used them to predict the water usage of four 'typical' households.

We also developed a simple regression model to get an idea of the relative impact on usage of household income and the number of adults and children.

The sections below provide more information on the models, and then discuss the results of the models and the predicted water usage.

3.1 Frontier's regression model

How much water a household uses depends on a complex interaction between a number of short, medium and long term factors. Observed differences in household water usage can be driven by differences in location, dwelling type and household characteristics as well as water-using appliances, equipment, fixtures and behaviours.

To help understand how these factors interact, Frontier broke them down into long term, medium term and short term household choices:

- Over the long term, households are able to choose the characteristics of their dwelling – such as its location, dwelling type and plot size. These choices, in turn, are driven by things like income and household size.

[15] A 'driver' means a variable that is associated with higher or lower water usage. As indicated in Box 3.1, regression analysis shows association rather than causation.

- Over the medium to long term, households can change fixtures (eg, taps, pools and rainwater tanks), equipment (eg, sprinklers) and their appliance stock. These choices are mainly driven by socio-economic factors – such as income, household size and location – as well as attitudinal factors.
- Over the short to medium term, households have a fixed set of fixtures and a fixed appliance and equipment stock but they can still choose how much to use them. These choices depend on things like location, household size and attitudes (see Table 3.1).

Table 3.1 Frontier's classification of household choices

Determinants of usage	Household choices	Significant drivers	Short term	Medium term	Long term
Socio-economic drivers	▼ n/a	▼ Income ▼ Household size	✗	✗	✓
Household choice 1	▼ Location ▼ House/plot size ▼ Number of bedrooms and bathrooms	▼ Income ▼ Household size	✗	✗	✓
Household choice 2	▼ Appliance and equipment stock ▼ Fixtures ▼ Alternative water sources	▼ Income ▼ Household size ▼ Number of bedrooms ▼ Dwelling type ▼ Location ▼ Attitudes	✗	✓	✓
Household choice 3	▼ Use of appliances, equipment and fixtures ▼ Outdoor usage	▼ Appliances, equipment and fixtures ▼ Location ▼ Household size ▼ Plot size ▼ Attitudes	✓	✓	✗

Source: Frontier Economics, unpublished report to IPART (adapted by IPART).

Using this breakdown, Frontier developed a 'short term' or conditional regression model for our analysis. This model assumes that for an individual household, many of the characteristics and choices that influence its water usage (such as number of adults in the household, and number of bedrooms) are fixed in the short-to-medium term.

One of the consequences of using a conditional model is that the effect of income on water usage cannot be directly observed. Instead, the effect of income is expressed through:

- household characteristics that are correlated with income, such as the number of people in the household, and
- the choices that a household's income allows it to make, such as number of bedrooms, having a pool, etc.

Section 3.4 looks at the effect of income in a simple, long-term model that includes as drivers only the number of people, income and location.

Box 3.1 explains what information regression analysis provides and Box 3.2 provides the mathematical expression of Frontier's model.

Box 3.1 What information regression analysis provides

Regression analysis uses statistical techniques to investigate the relationships between a dependent variable, such as water usage, and a set of independent variables (drivers). It **identifies** the drivers and **measures** by how much the dependent variable changes when each driver changes, *ceteris paribus*. For example, for households that are similar in all respects except the number of adults, it measures the impact on water usage of each additional adult. This impact is known as the regression coefficient.

It also measures **how reliable** each regression coefficient is (t-values, significance levels and confidence intervals). The larger the t-value, the more confident we can be that the value of the coefficient is, on average, reliable (ie, the narrower the confidence interval). As a rough rule of thumb, a t-value of 2 or more (in absolute terms) means we are confident that the explanatory variable is related to the dependent variable at the 95% level of confidence. The higher the t-value, the higher the level of confidence.

Regression analysis also measures how much of the variation between households the model explains (R- squared). In other words, R-squared is a measure of how closely the actual values cluster around the predicted values.

Importantly, **regression analysis does not show causation.** Rather, it simply identifies associations (or correlations) between variables.

Box 3.2 Mathematic expression of Frontier's regression model

Frontier used a linear regression model that may be expressed as follows, for household *i*

$$Household\ water\ \text{usage}\ i =$$

$$\beta 1\ WesternSydney i + \beta 2\ \text{Hunter} i + \beta 3\ Gosford i + \beta 4\ \text{Adults} i + \beta 5\ \text{Children} i + \beta 6\ Bedrooms i +$$

$$\beta 7\ Frequency\ of\ dishwasheruse i \beta 8\ Frequency\ of\ washingmachineuse i +$$

$$\beta 9\ \text{Number of toilets} i + \beta 10\ \text{Use of a water saving device} i +$$

$$\beta 11\ \text{Presence of a pool} i + \beta 12\ \text{Plot-size} i + \beta 13\ \text{Missing values for plot size} i +$$

$$\beta 14\ \text{Use of alternative water} i + \beta 15\ \text{Steps to reduce usage} i +$$

$$\beta 16\ \text{Use of a sprinkler} i + \beta 17\ Frequency\ of\ watering\ in\ winter i + Constant$$

Source: Frontier Economics

3.2 Main drivers of water usage

Using this model, Frontier identified that the most important driver of a household's water usage is the number of people it includes, particularly adults, which is associated with higher usage. Another important driver is the household's location. For reasons that our survey did not capture, being located in Gosford is associated with significantly lower water usage.

Table 3.2 summarises the results of Frontier's regression model. The first column lists the identified drivers of water usage. The second column shows how much more or less water usage is associated with each driver (the coefficient). The third and fourth columns show how reliable the coefficient for each driver is (t-value and level of confidence). The results for each survey area are provided in the technical appendix.

Table 3.2 Results of regression analysis for households in the Sydney, Hunter and Gosford areas

Driver of water usage	Co-efficient (kL pa)	t - value[a]	Level of confidence
Households in all areas:			
Per adult (16 years or older)	34.3	14.4	99%
Per child	12.9	4.9	99%
Per bedroom	5.9	2.5	99%
Per time a dishwasher is used in a week	1.6	2.3	95%
Per time a washing machine is used in a week	8.4	8.6	99%
Per toilet	6.1	2.5	99%
Use a water saving device	-9.2	-2.1	95%
Have a pool	24.1	5.1	99%
Plot size, per sq km	31.6	4.2	99%
No information on plot size	10.7	1.7	90%
Use an alternative water source	-15.9	-4.2	99%
Have taken steps to reduce usage	-7.3	-1.7	95%
Use a sprinkler	29.1	7.2	99%
Per time per week the garden is watered in winter	8.9	4.2	99%
Constant	8.5	0.8	not significant
Area-specific variable:			
(compared with otherwise similar households located in Eastern Sydney)			
Western Sydney	-0.2	-0.1	not significant
Hunter	-4.8	-1.0	not significant
Gosford	-31.4	-6.2	99%

Number of observations	2,356
R-squared (proportion of variation between households that the model explains)	36%

a The analysis used robust standard errors and t-values, which take account of potential heteroscedasticity in the data. However, the ordinary least squares (OLS) method provided similar results (see Appendix A).

Note: The analysis includes only individually metered household in dwelling types other than flats. Data for tenants that do not pay the water usage charge are excluded. The data are not weighted.

Source: Frontier Economics.

3.2.1 Household size has major impact on water usage

The results of the model confirm our previous finding that one of the main drivers of household usage is how many people live in the home.[16] Every adult (16 years or older) adds about 34 kL pa of usage, and every child adds about 13 kL pa.

Other characteristics that have a positive association with indoor usage include the number of bedrooms and toilets in the home, and how frequently the household uses a dishwasher or a washing machine.

3.2.2 Watering the garden and having a pool add to usage

Water is used outdoors mainly to water the garden and to fill or top-up pools. The model identified that:

- using a sprinkler adds 29 kL pa of usage
- watering the garden once a week in winter adds 9 kL pa, and[17]
- having a pool adds 24 kL pa.

3.2.3 Bigger plot sizes add to usage

The model identified a strong relationship between the size of the plot and using more water. The regression coefficients mean that households on large plots use more water than households on small plots.[18] Specifically, living on a

- small plot (on average 250 square meters) adds 8 kL pa
- medium plot (on average 700 square meters) adds 22 kL pa
- large plot (on average 1,200 square meters) adds 38 kL pa
- plot of unknown size[19] adds 11 kL pa, on average.

---

16 For example, see IPART, *Determinants of residential energy and water usage in Sydney and surrounds. Regression analysis of the 2008 and 2010 IPART household survey data. Electricity, Gas and Water – Research Report*, December 2011, pp 5-6, 72-74, 77 and 83.

17 The model did not include a variable for summer watering because 'using a sprinkler' picks up mainly summer watering. Including a variable for watering in summer as well as using a sprinkler would lead to technical problems (collinearity).

18 We asked households that live in separate houses whether their block of land is small (less than 500 sq meters), medium (between 500 and 900 sq meters) or large (more than 900 sq meters). We then allocated to each plot size a value in square kilometres corresponding to the midpoint of the size of the block of land (0.25 for small, 0.7 for medium and an arbitrary 1.2 for large plot sizes).

19 This category includes around 10% of households in separate houses that did not know their plot size, and all households other dwelling types.

A larger plot could mean a larger house and/or a larger garden, and the model does not identify whether this additional water is used indoors or outdoors. However, it probably represents mostly outdoor usage because the size of the dwelling is already taken into account by other variables in the model (specifically, the number of bedrooms and toilets). To the extent that the additional water is used outdoors, this finding possibly indicates that most households use some water in the garden in summer.[20] It also suggests that households on larger plots use more water in the garden and for their pools than households on smaller plots.

3.2.4 Three water saving characteristics that reduce usage

The model identified three water saving characteristics that reduce a household's (mains) water usage:

- having at least one water-saving device, such as a low-flow showerhead or tap aerator (-9 kL pa)
- using an alternative source of water to mains water, such as a rainwater tank or grey water (-16 kL pa), and
- having taken active steps to reduce water usage in the previous five years (-7 kL pa).

3.2.5 Being located in Gosford reduces usage for unexplained reasons

The model also measures whether the area a household is located in has an independent impact on water usage. Specifically, it measures how much more (or less) water a household uses compared with an otherwise similar household in Eastern Sydney. The analysis found that, on average:

- a household in Gosford uses 31 kL pa less water
- a household in Hunter uses about 5 kL pa less water (but the statistical level of confidence in this result is low and the result could be due to chance), and
- there is no (statistically significant) difference in usage by households in Eastern Sydney and Western Sydney.

These finding suggest that the temperature differences between Eastern and Western Sydney do not affect water usage. They also mean that households in Gosford, and possibly Hunter, use less water for 'unexplained' reasons (ie, for reasons that our survey did not capture). These unexplained reasons are discussed further in Chapter 4.

[20] More than 70% of households with no plot size said that they have their own garden, and more than 20% said that they have a communal garden.

3.3 Predicted water usage by typical households

We used the results of the model to predict the amount of water that four 'typical' households in Sydney would use in a year.[21] Table 3.3 summarises our findings. For example, we found that a household of four adults would use 289 kL pa if it:

- lives in a four-bedroom house with two toilets on a large plot
- uses a dishwasher and a washing machine on average four times per week
- has a pool, uses a sprinkler and waters the garden once a week in winter
- uses water saving devices (eg, low-flow shower heads) and has a rainwater tank, and
- has taken active steps to reduce usage.

At the other end of the spectrum, a household of one adult would use 90 kL pa if it:

- lives in a two-bedroom terrace house with two toilets
- uses a washing machine 1.5 times per week, on average, but does not use a dishwasher
- does not water the garden or have a pool
- does not use water-saving devices or alternative sources of water, and
- has not taken active steps to reduce consumption.

[21] To predict the usage of a particular type of household, we multiply each coefficient by the value of the corresponding household characteristic. For example, two adults would add 2x34.25 kL pa = 68.50kL pa. For variables that have only yes or no answer (eg, having a pool), we use the value of the coefficient if the answer is yes, and zero of the answer is no. To give the total predicted usage we sum the usage for each variable plus the constant value.

Table 3.3 Predicted usage for four 'typical' households (kL pa)

	Co-efficient	4 adults in a house		2 adults and 2 children in a house		2 adults in a house		1 adult in a terrace house	
	kL pa	Value	kL pa	Value	kL pa	Value	kL pa	Value	kL pa
Adults	*34.3*	4	137.0	2	68.5	2	68.5	1	34.3
Children	*12.9*	0	0.0	2	25.8	0	0.0	0	0.0
Bedrooms	*5.9*	4	23.6	4	23.6	4	23.6	2	11.8
Dishwasher use per week	*1.6*	4.0	6.4	4.0	6.4	2.5	4.0	0.0	0.0
Washing machine use per week	*8.4*	4.0	33.6	4.0	33.6	2.5	21.0	1.5	12.6
Toilets	*6.1*	2	12.1	2	12.1	2	12.1	2	12.1
Use a water saving device	*-9.2*	yes	-9.2	yes	-9.2	yes	-9.2	no	0.0
Have a pool	*24.1*	yes	24.1	no	0.0	no	0.0	no	0.0
Plot size	*31.6*	1.2	37.9	0.7	22.1	0.7	22.1		0.0
No plot size	*10.7*	no	0.0	no	0.0	no	0.0	yes	10.7
Use an alternative water source	*-15.9*	yes	-15.9	no	0.0	no	0.0	no	0.0
Have taken steps to reduce usage	*-7.3*	yes	-7.3	yes	-7.3	yes	-7.3	no	0.0
Use a sprinkler	*29.1*	yes	29.1	no	0.0	no	0.0	no	0.0
Water garden in winter per week	*8.9*	1.0	8.9	0.5	4.4	0.5	4.4	0.0	0.0
Constant	*8.5*	1	8.5	1	8.5	1	8.5	1	8.5
Total usage			**289**		**189**		**148**		**90**

Note: To predict usage, we multiply each coefficient by the value of the corresponding household characteristic (where yes = 1 and no =0).

Source: 2015 Household Survey.

3.4 The long-term effect of income on water usage

As section 3.1 noted, one of the consequences of Frontier's conditional regression model is that the effect on water usage of income cannot be directly observed. Instead, this effect is expressed through the choices that a household's income allows it to make.

Frontier's model nevertheless suggests that the number of people in a household is a far more important driver of usage than income. The model identifies as the biggest single driver of usage the number of people (adults and children), and this accounts for around 45% of total predicted usage. In addition, some of the other drivers are related to the number of people in the household. This is the case particularly for the number of times a washing machine is used, which accounts for further 15% of total predicted usage.

To get a better idea of the long-term impact of income on water usage, we used a simple regression model that included the following drivers:

- the number of adults and children
- income, and
- being located in Gosford.

We found that income has a small but statistically significant impact on usage (Table 3.4). Specifically, we estimated that every $100,000 pa of additional income adds about 14 kL pa to household water usage. This means, for example, that a household in Eastern Sydney with two adults , two children and an income of $200,000 pa would use about 20 kL pa more water than another household with the same number of adults and children living in the same area but an income of $45,000 (Table 3.5). This amount of additional usage is around 10% more than the amount used by the low income household.

For comparison, we also identified the long-term impact of income on electricity usage. We found that income has a larger impact on electricity usage than water usage. For example, the high income household in the example above would use almost 25% more electricity than the low income household, compared with around 10% more water (Table 3.5). Table 3.6 shows the results of the simple regression model for electricity.[22]

[22] Households in flats are excluded from the regression analysis for both water and electricity.

Table 3.4 Regression results for household water usage (simple long-term model)

		Coefficient (kL pa)	t - value[a]	Level of confidence
Per adult (16 years or older)		46.6	22.6	99%
Per child		18.1	7.6	99%
Per $100,000 income		13.7	3.8	99%
No information on income		9.0	1.4	not significant
Located in Gosford		-31.0	-5.8	99%
Constant		53.6	10.9	99%
Number of observations	2,374			
R-squared[b]	26%			

a Ordinary least squares (OLS) method.

Note: Data for flats, households with shared meters and tenants that do not pay the water usage charge are excluded. The data are not weighted.

Source: 2015 Household Survey.

Table 3.5 Predicted water and electricity usage by households with two adults and two children living in a house[a] in Eastern Sydney, by income

	Water usage (kL pa)		Electricity usage (kWh pa)	
	High income $200,000 pa	Low income $45,000 pa	High income $200,000 pa	Low income $45,000 pa
Adults	93	93	3,335	3,335
Children	36	36	1,441	1,441
Income	27	6	2,436	548
Constant	54	54	2,338	2,338
Total usage	210	189	9,550	7,662
Increase compared with low income household	11%		25%	

a A house means a dwelling that is not a flat.

Source: 2015 Household Survey.

Table 3.6 Regression results for household electricity usage of households in houses (simple long-term model)

		Coefficient (kWh pa)	t - value[a]	Level of confidence
Per adult (16 years or older)		1,668	18.0	99%
Per child		720	6.6	99%
Per $100,000 income		1,218	6.7	99%
No information on income		832	2.9	99%
Live in Western Sydney[a]		909	4.7	99%
Constant		2,338	11.2	99%
Number of observations	1,424			
R-squared[b]	31%			

a Frontier identified that living in Western Sydney had a statistically significant impact on electricity usage, but living in Gosford did not. See Frontier, *Determinants of household energy consumption*, September 2016, p 30.

b Ordinary least squares (OLS) method.

Note: Data for households in Sydney, Hunter and Gosford that do not use gas. Households in flats are excluded. The data are not weighted.

Source: 2015 Household Survey.

4 Why do households in some areas use more water than those in other areas?

Our survey found that households in the different survey areas used different amounts of water on average. Across households in all dwelling types, those in Western Sydney had the highest average usage (188 kL pa), and those in Gosford had the lowest (141 kL pa). For households in separate houses only, those in Eastern Sydney had the highest average usage (198 kL pa) and those in Gosford had the lowest (149 kL pa). (See Figure 2.2.)

We used the results of Frontier's regression model and each area's household characteristics to analyse the possible reasons for these differences. The sections below explain how we did the analysis, and our findings on the difference in average usage between Gosford and other areas, and other differences between areas.

4.1 How we analysed differences between areas

To analyse the reasons why average household water usage differs between areas, we took the following steps in each survey area:

1. We identified the 'average' value of each variable in the regression model. For example, we identified the average number of adults per household, the average number of times per week they used a washing machine and the proportion with a pool.
2. We multiplied each value by the relevant regression coefficient to predict the total usage volume that is associated with each variable for the area.
3. We summed these usage volumes to give the total predicted usage for the area.
4. We compared the predicted usage with the actual usage, to check that the model produced sensible results.
5. We identified which household characteristics are mainly responsible for the differences in usage between the areas.

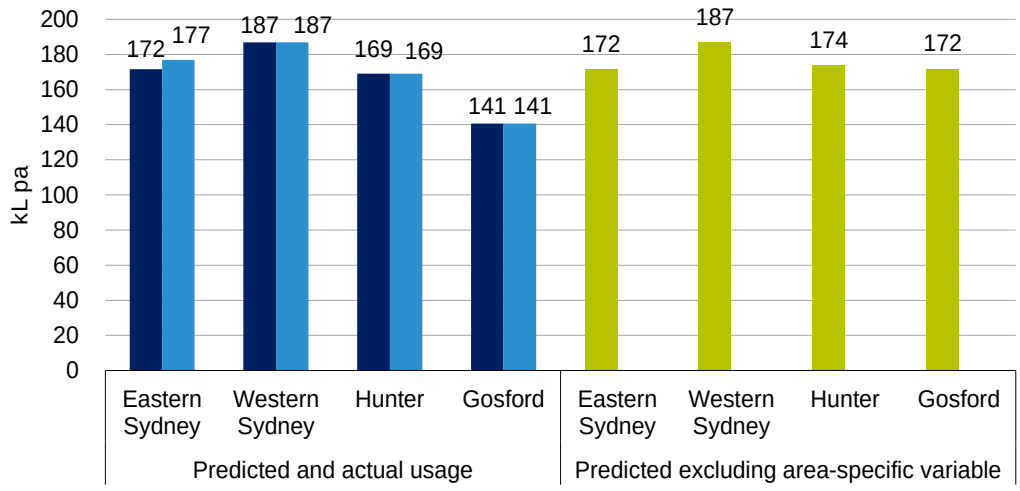
Tables 4.1 summarises our results. As this table shows, the predicted usage was very close to the actual average usage. For example, the difference was 3% in Eastern Sydney and less than 1% lower in the other areas. This gives us confidence that we can use the use the model to help explain the differences in usage between survey areas.

4.2 Difference in average usage between Gosford and other areas

As section 3.2.5 explained, Frontier's regression model includes an area-specific variable to measure whether a household's location has an independent impact on its water usage. Specifically, it measures how much more (or less) water a household uses compared with an otherwise similar household located in Eastern Sydney. The model found that on average a household in Gosford uses 31 kL pa less water, and there is a high level of confidence in this result (Table 3.2).

This lower usage cannot be explained by any of the information we captured in our survey, other than being located in Gosford. Indeed, if we exclude the impact on usage associated with a household's location, the model predicts that the average usage of households in Gosford would be very similar to those in the other areas (Figure 4.1).

Figure 4.1 Predicted average usage, with and without area-specific variable (kL pa)



Note: The household characteristics and actual usage are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).
Source: 2015 Household Survey.

We can only speculate about the reasons for the impact of being located in Gosford on a household's water usage. One possible reason is that the severe water shortages experienced on the Central Coast around 10 years ago has led to a 'culture' of water conservation in the area. As Chapter 2 discussed, the area's water storage levels fell to just 10% of capacity in early 2007 and residents were subject to strict water restrictions between 2006 and 2011 (see Box 2.1.) Additional measures including an extensive community education program were

undertaken to encourage households to use less mains water.[23] A consequence may be that Gosford households are particularly mindful about how they use water in their homes.

The regression model also found that a household in Hunter used about 5kL pa less water than an otherwise similar household in Eastern Sydney. However, this finding was not statistically robust and could be due to chance (see Table 3.2). There are no obvious reasons why households in Hunter should use less water than similar households in Sydney. Unlike Sydney and Gosford, Hunter did not experience water shortages or water restrictions during the 2000s drought (see Box 2.1).[24]

4.3 Other differences between areas

The regression analysis identifies how much water usage is associated with each of the other variables in the model. We used these results to identify what other household characteristics account for the differences in usage between the areas. We grouped all the variables (excluding the area-specific variable) into six categories:

1. the number of people in the household (adults and children)
2. how often the household uses a dishwasher and a washing machine (average for all households)[25]
3. number of bedrooms and toilets (which indicates the size of the dwelling)
4. having at least one water saving device (eg, low-flow showerhead or tap aerator) and having taken active steps to use less water in the previous five years (as an indicator of conservation behavior)
5. plot size (or the absence of information on plot size), and
6. having a pool and watering the garden in winter net of a reduction in usage due to having an alternative source of water (mainly rainwater tanks and grey water) (as an indicator of differences in outdoor usage).

We looked at the model's predicted usage for each of these categories to identify the main drivers of water usage in each survey area (other than location) (Figure 4.2). We also compared the model's predicted usage in Eastern Sydney with that in each of the other areas to more clearly identify the differences between the areas (Figure 4.3).

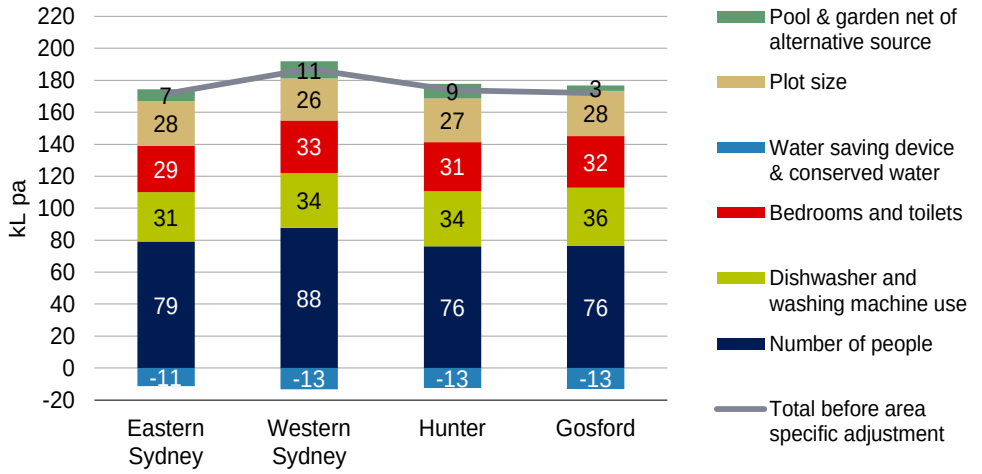
---

23 Gosford City Council/Central Coast/Wyong Shire Council, *WaterPlan 2050 A long-term water supply strategy for the Central Coast*, August 2007, p 3.

24 Usage charges have been fairly similar since 2007, and at the time of the survey were $2.23/kL in Sydney and Gosford and $2.19/kL in Hunter.

25 A value of zero times per week was assigned to households that did not have a dishwasher or a washing machine.

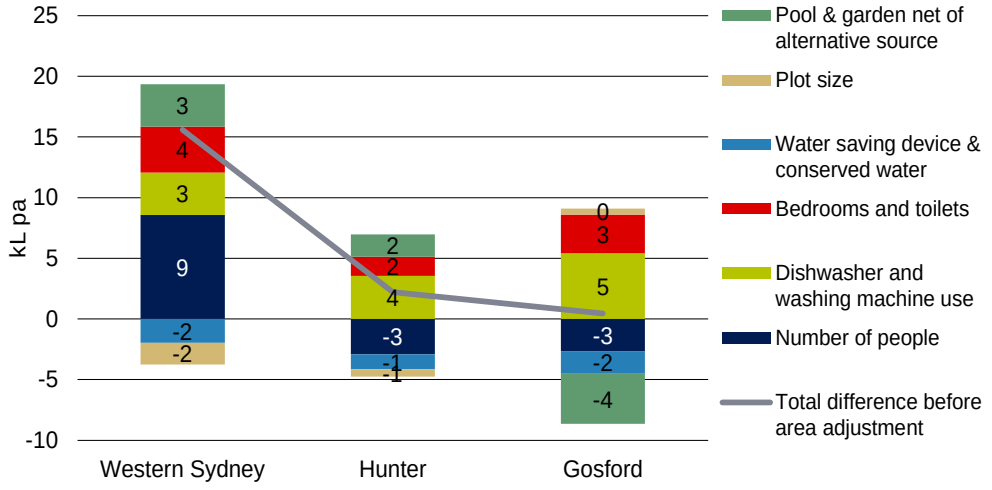
Figure 4.2 Drivers of water usage by area, excluding the area-specific variable, all dwelling types (kL pa)



Note: The household characteristics are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

Figure 4.3 Differences in usage between Eastern Sydney and the other areas, excluding the area-specific variable, all dwellings (kL pa)



Note: The household characteristics are weighted by area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

We found that, compared with households in Eastern Sydney, households in Western Sydney had higher average usage mainly because they had more people and larger dwellings, and because they more frequently used their dishwashers and washing machines. They also used a bit more water outdoors, both in the garden and because a higher proportion of households had a pool (16% compared with 12%). To a small extent, their higher usage was offset by a greater likelihood that they used at least one water-saving device and had taken steps to reduce consumption (Figure 4.2, Figure 4.3 and Table 4.1).

Compared with households in Eastern Sydney, households in Hunter and Gosford displayed some characteristics that are associated with lower (mainly) indoor usage. Specifically, they had fewer people, were more likely to have at least one water-saving device and to have taken steps to reduce their usage. On the other hand, they also displayed some characteristics that are associated with higher (indoor) usage, namely they more frequently used dishwashers and washing machines and had larger dwellings. The net effect of these differences is that average **indoor** usage in Eastern Sydney, Hunter and Gosford would likely be very similar, were it not for the unexplained differences in usage between Gosford and the other areas (Figure 4.2 and Table 4.1).

The model predicts that households in Gosford use less water **outdoors** than households in any of the other areas, even in the absence of any area-specific differences. This finding stems from the higher proportion of households in Gosford that used an alternative source of water to mains water (53% compared with between 36% and 23%) and the smaller proportion of households that used a sprinkler or watered their gardens in winter. These characteristics more than offset the additional usage that is associated with a higher proportion of households having a pool (18% of households in Gosford compared with between 12% and 16% in the other areas). (See Figure 4.3 and Table 4.1.)

Table 4.1 Predicted usage by area, all dwelling types (kL pa)

	Co-efficient	Eastern Sydney		Western Sydney		Hunter		Gosford	
	kL pa	Average value	kL pa	Average value	kL pa	Average value	kL pa	Average value	kL pa
Adults	*34.3*	2.13	73	2.35	80	2.06	71	2.09	72
Children	*12.9*	0.48	6	0.56	7	0.44	6	0.38	5
Bedrooms	*5.9*	2.91	17	3.52	21	3.28	19	3.39	20
Dishwasher use per week	*1.6*	2.14	3	2.28	4	2.21	4	2.55	4
Washing machine use per week	*8.4*	3.27	27	3.66	31	3.68	31	3.83	32
Toilets	*6.1*	1.97	12	2.00	12	1.87	11	2.03	12
Use a water saving device	*-9.2*	70%	-6	82%	-7	79%	-7	82%	-8
Have a pool	*24.1*	12%	3	16%	4	15%	3	18%	4
Plot size	*31.6*	0.70	22	0.75	24	0.78	25	0.80	25
No plot size	*10.7*	56%	6	24%	3	26%	3	30%	3
Use an alternative water source	*-15.9*	23%	-4	31%	-5	36%	-6	53%	-8
Have taken steps to reduce usage	*-7.3*	67%	-5	80%	-6	73%	-5	77%	-6
Use a sprinkler	*29.1*	17%	5	29%	8	26%	8	19%	6
Water garden in winter per week	*8.9*	0.36	3	0.40	4	0.43	4	0.21	2
Constant	*8.5*	1	9	1	9	1	9	1	9
Total usage excluding area-specific variable			**172**		**187**		**174**		**172**
Area-specific variable			0		0		-5		-31
Total predicted usage			**172**		**187**		**169**		**141**
Actual usage			**177**		**188**		**169**		**141**

Note: To predict the usage that is associated with each variable, we multiply the coefficient by the value of the corresponding characteristic. We then sum to amounts to give the total usage. The household characteristics are weighted by the area weights (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

.

5 Why do higher income households use more water than lower income households?

Our survey found that on average, higher income households used more water than lower income households, but there was a wide variation in usage within each income group. We used the results of Frontier's model and each income group's household characteristics to explore the reasons for these findings.

The sections below explain how we analysed the effect of income on household water usage, our findings on the differences in average usage by income group, the main drivers of these differences, and the reasons for the wide variation in usage within income groups. Box 2.2 explains how we defined the income groups.

5.1 How we analysed effect of income on water usage

We used the same methodology we used to analyse usage differences between survey areas (section 4.1) to look at differences between income groups. In summary, we used the results of Frontier's model to predict the average usage for each income group by:

- finding the average value for each of the variables for that income group, then
- multiplying this value by the relevant regression coefficient to give the usage volume associated with that variable, then
- summing all the usage volumes to give the total predicted usage.

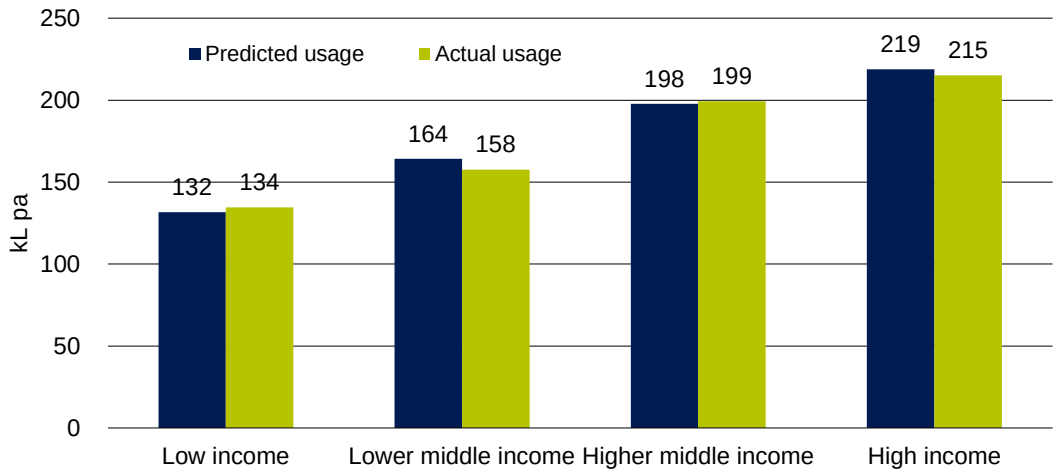
This allowed us to identify the main drivers of usage for each income group, and thus explain the observed differences between groups. We also drew on this analysis to discuss possible reasons for the variation in usage within each income group.

5.2 Differences in average usage between income groups

Consistent with our previous surveys, we found that on average higher income households use more water than lower income households (Figure 5.1). For example, high income households used about 60% more water than low income households (215 kL pa compared with 134 kL pa). However, also consistent with our previous surveys, we found that there is a wide range of usage within each income group. For example, looking at low income households, about 40% used less than 100 kL pa but about 15% used more than 200 kL pa (Figure 5.2).[26]

Like our analysis of water usage by region, the model's predicted average usage for each income group is close to its actual usage (Figure 5.1).[27] This gives us confidence that we can use the use the model to help explain the differences in usage between the income groups and across each income group.

Figure 5.1 Actual and predicted usage by income group (kL pa)



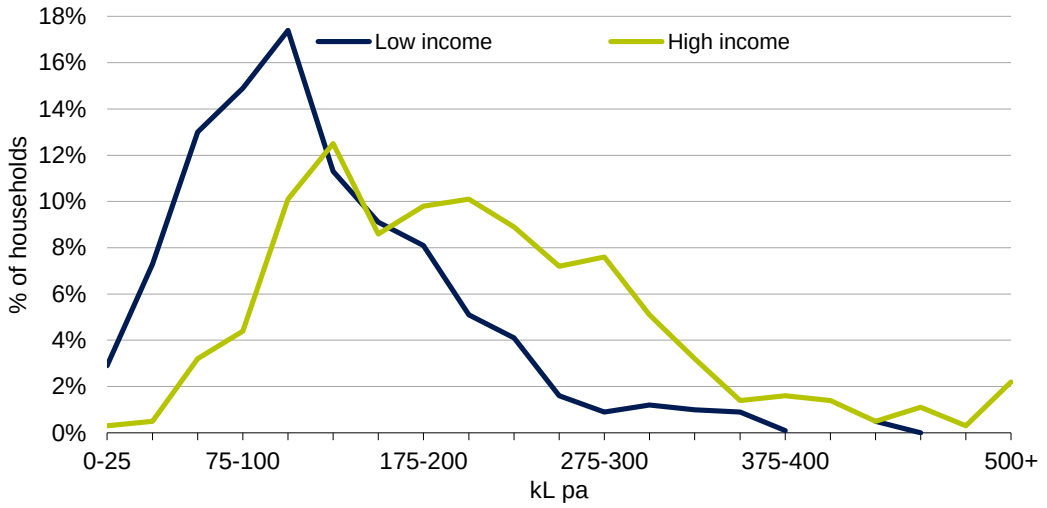
Note: Analysis for Sydney, Hunter and Gosford combined. Data are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

26 IPART, *Residential energy and water use in Sydney, the Blue Mountains and Illawarra. Results from the 2010 household survey*, December 2010, pp 116 – 119.

27 Specifically, there is a 4% difference between predicted and actual usage for lower middle income households and 1% to 2% difference for the other income groups.

Figure 5.2 Distribution of actual usage for low and high income households (% of households)



Note: Analysis for Sydney, Hunter and Gosford combined. Data are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

5.3 Drivers of differences between income groups

As we did for usage by survey area, we grouped the model's variables into six categories. We then looked at the model's predicted usage for each of these categories, namely:

1. the number of people in the household (adults and children)
2. how often the household uses a dishwasher and a washing machine (average for all households)[28]
3. number of bedrooms and toilets (which indicates the size of the dwelling)
4. having at least one water saving device (eg, low-flow showerhead or tap aerator) and having taken active steps to use less water in the previous five years (as an indicator of conservation behavior)
5. plot size (or the absence of information on plot size), and
6. having a pool and watering the garden in winter net of a reduction in usage due to having an alternative source of water (mainly rainwater tanks and grey water) (as an indicator of differences in outdoor usage) (Figure 5.3).[29]

[28] A value of zero times per week was assigned to households that did not have a dishwasher or a washing machine.

[29] We did not include the area-specific variable in this analysis, because it reduces the usage for all income groups by the same small amount (1.8 kL pa).

We also compared the model's predicted usage by low income households with usage by each of the other income groups to more clearly identify the differences between the groups (Figure 5.4).

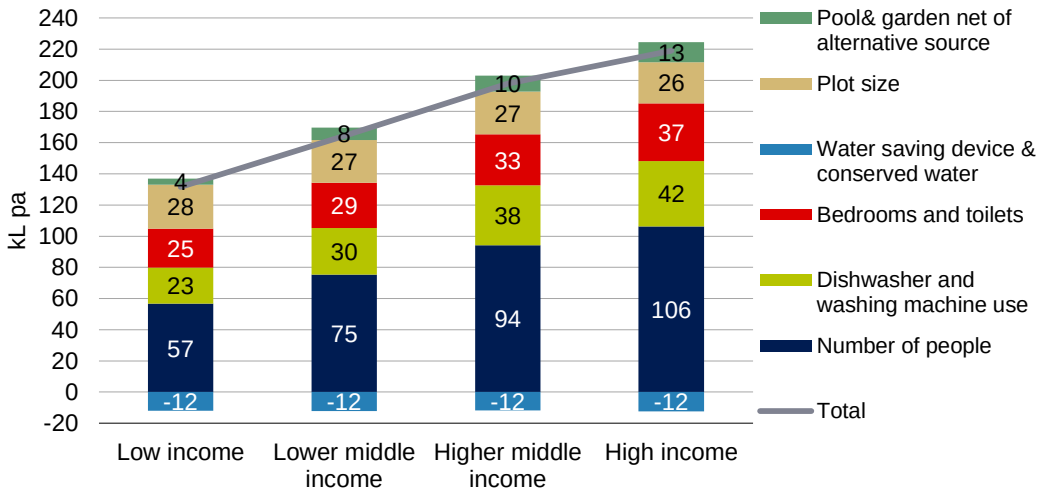
5.3.1 Usage increases with income for multiple reasons

We found that, as incomes rise, so do the values for most of the characteristics that are associated with higher usage. For example, looking at the characteristics of low income and high income households respectively:

- the number of people increases from 1.8 to 3.5 (mainly adults)
- washing machine use increase from 2.6 to 4.3 times per week
- the number of bedrooms increases from 2.6 to 3.7
- the proportion of households with a pool increases from 5% to 24%, and
- the proportion of households that use a sprinkler increases from 13% to 31% (Table 5.1).

On the other hand, higher income households are more likely to use an alternative source of water and a water-saving device, and both of these characteristics are associated with lower usage. However, they were less likely to have said they had tried to reduce their water usage over the previous five years. The net effect is that these characteristics reduce usage by a similar amount across income groups (Table 5.1).

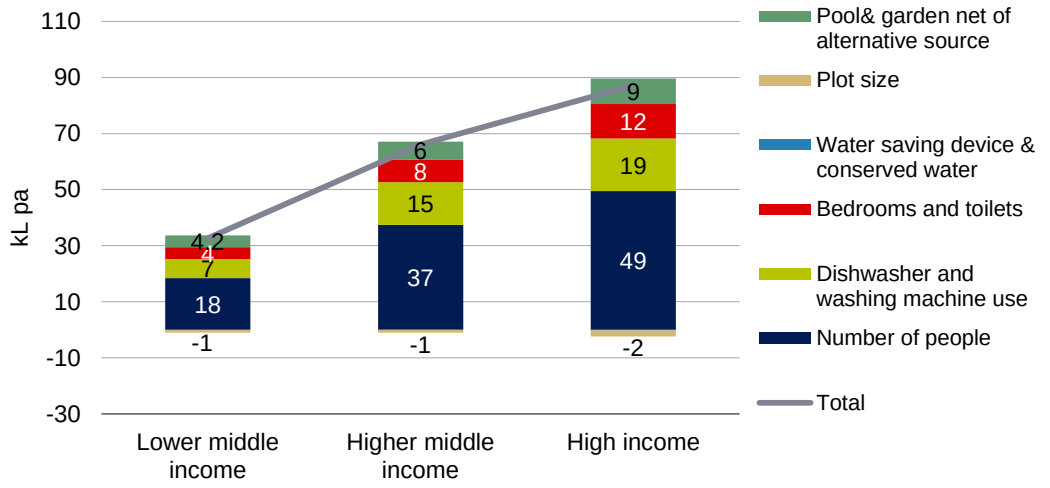
Figure 5.3 The drivers of water usage by income group (kL pa)



Note: Analysis for Sydney, Hunter and Gosford combined. The household characteristics are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Data source: 2015 Household Survey.

Figure 5.4 Differences in usage between low income households and the other income groups (kL pa)



Note: Analysis for Sydney, Hunter and Gosford combined. The household characteristics are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

Table 5.1 Predicted usage by income group, all dwelling types (kL pa)

	Co-efficient	Low income		Lower middle income		Higher middle income		High income	
	kL pa	Average value	kL pa	Average value	kL pa	Average value	kL pa	Average value	kL pa
Adults	*34.3*	1.58	54	2.04	70	2.48	85	2.84	97
Children	*12.9*	0.21	3	0.42	5	0.72	9	0.70	9
Bedrooms	*5.9*	2.61	15	3.01	18	3.38	20	3.68	22
Dishwasher use per week	*1.6*	0.98	2	1.93	3	2.84	5	3.68	6
Washing machine use per week	*8.4*	2.56	21	3.19	27	4.02	34	4.27	36
Toilets	*6.1*	1.56	9	1.87	11	2.13	13	2.56	15
Use a water saving device	*-9.2*	74%	-7	74%	-7	76%	-7	78%	-7
Have a pool	*24.1*	5%	1	12%	3	19%	4	24%	6
Plot size	*31.6*	0.71	22	0.72	23	0.75	24	0.73	23
No plot size	*10.7*	56%	6	44%	5	36%	4	28%	3
Use an alternative water source	*-15.9*	25%	-4	27%	-4	28%	-5	34%	-5
Have taken steps to reduce usage	*-7.3*	72%	-5	74%	-5	68%	-5	70%	-5
Use a sprinkler	*29.1*	13%	4	21%	6	24%	7	31%	9
Water garden in winter per week	*8.9*	0.34	3	0.40	4	0.37	3	0.42	4
Area-specific variable for Hunter	*-4.8*	13%	-1	13%	-1	13%	-1	13%	-1
Area-specific variable for Gosford	*-31.4*	4%	-1	4%	-1	4%	-1	4%	-1
Constant	*8.5*	1	9	1	9	1	9	1	9
Total predicted usage			**132**		**164**		**198**		**219**
Actual usage			**134**		**158**		**199**		**215**

Note: To predict the usage that is associated with each variable, we multiply the coefficient by the value of the corresponding characteristic. We then sum to amounts to give the total usage. Analysis for Sydney, Hunter and Gosford combined. The household characteristics are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

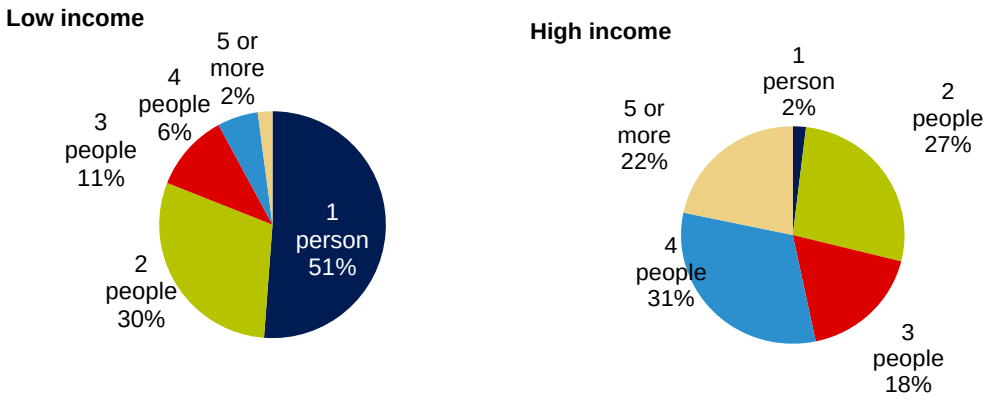
Source: 2015 Household Survey.

5.4 Reasons for wide variations in usage within income groups

In section 5.3 we considered the drivers of usage for the 'average' household in each income group. But within each income group there is a wide range of usage (Figure 5.2). The reason for this is that there is also a wide range of the characteristics that drive usage within each income group. The most important of these drivers is the number of people in the household, and this varies widely for each income group. For example:

- About 80% of low income households had only one or two people, but 8% had four or more people.
- More than half of high income households had four or more people, but almost 30% had only one or two people (Figure 5.5).

Figure 5.5 Distribution of people per household for low income and high income households (% of households)



Note: Analysis for Sydney, Hunter and Gosford combined. Data are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

In addition, some low income households have or do things that are associated with high levels of usage, such as having a pool, using sprinkler, and/or living in a house with four or more bedrooms. These households are likely to use fairly large amounts of water. On the other hand, many high income households do not have a pool or a garden and/or live in a dwelling unit that has only one or two bedrooms (Table 5.5). These households are likely to use relatively little water.

Table 5.2 Range of characteristics for low income and high income households

	Low income	High income
Number of adults		
1 adult	55%	2%
2 adults	34%	50%
3 adults	9%	20%
4 or more adults	2%	29%
Number of children		
no children	87%	63%
1 child	8%	14%
2 children	3%	17%
3 or more children	2%	6%
Number of bedrooms		
0 to 2	44%	17%
3	40%	26%
4 or more	17%	57%
Times per week a washing machine is used		
up to 2 times	60%	1%
3 to 4	22%	25%
4 to 5 or more	18%	64%
Times per week a dishwasher is used		
up to 2 times	56%	29%
3 to 4	21%	23%
4 to 5 or more	20%	46%
Households that		
have a pool	5%	25%
use a sprinkler	13%	31%
have a garden	57%	73%

Note: Analysis for Sydney, Hunter and Gosford combined. The household characteristics are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey,* September 2016).

Source: 2015 Household Survey.

6 Do houses discharge more wastewater into the sewerage system than flats?

An issue to consider for future price reviews is whether or not households in individually metered dwellings (houses)[30] discharge more wastewater into the sewerage system than those in multi-premise dwellings (such as flats).

We used the household survey data and the results of Frontier's regression analysis to shed some light on this issue. We focused on estimating the average **indoor** usage of households in each type of dwelling, as most of this water is discharged into the sewerage system.

The sections below discuss our findings on the difference in average total usage between households in houses and flats, and explain how we estimated the difference in average **indoor** usage in houses and flats, and the resulting estimates.

6.1 Difference in average total usage between houses and flats

Our survey found that, on average, households in houses use more water than households in flats (about 183 kL pa compared to about 138 kL pa in flats). However, some of this additional water is used outdoors – eg, to water the garden or top up a swimming pool. This outdoor water does not flow into the sewerage system.

To get a rough indication of how much water is used outdoors by households in houses, we compared the average usage of these households that:

- do and do not have a swimming pool, and
- do and do not frequently water their garden.[31]

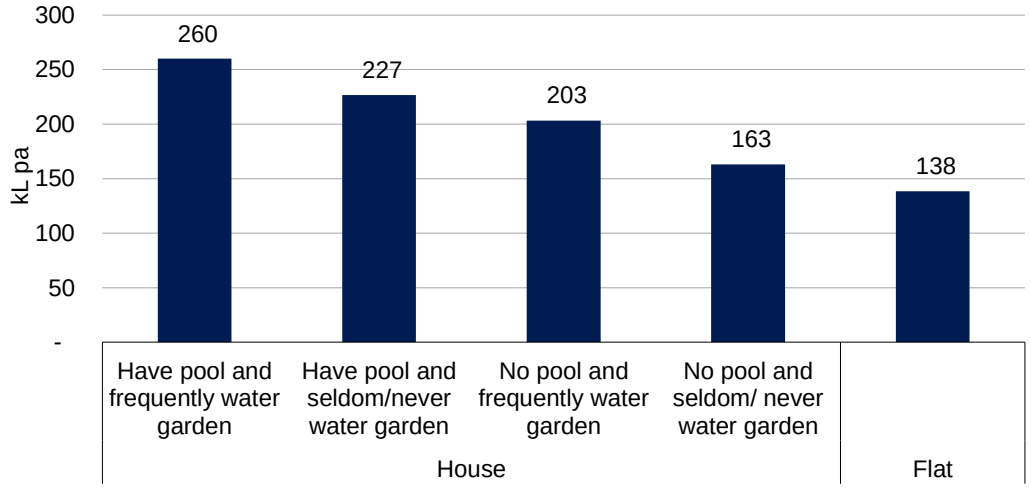
30 'Houses' means free standing houses as well as dwelling units such as terrace houses, villa units and townhouses with individual meters.

31 'Frequently water the garden' means use a sprinkler or hosepipe to water the garden at least once a week in summer.

We found that, compared with the amount used by households with no pool that seldom or never water their garden (163 kL pa), the amount used by households

- with a pool that frequently water their garden was 97 kL pa, or 60% higher
- with a pool that seldom or never water their garden was 64 kL pa, or 39% higher, and
- with no pool that frequently water their garden was 40 kL pa, or 25% higher (Figure 6.1)

Figure 6.1 Average household water usage, by dwelling type, pool ownership and garden watering behaviour (kL pa)



Note: Houses means individually metered dwellings that are not flats. Analysis for Sydney, Hunter and Gosford combined. The household characteristics are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

However, we think it is unlikely that **all** of this difference in usage is due to differences in outdoor use. Other factors are likely to be involved. For example, households in houses with a swimming pool tend to be larger than households in houses with no pool (an average of 3.4 people per household compared with 2.8). They also tend to have bigger houses (an average of 4.2 bedrooms compared with 3.4). Therefore, households with a pool are likely to use more water both indoors and outdoors than those with no pool. Therefore, we did further analysis.

6.2 How we estimated average indoor usage of houses and flats

Ideally, we would have liked to measure indoor and outdoor usage in flats and houses by developing a separate regression model for each of these groups of households. However, we could not do this for flats because we do not know how much water each surveyed household that lives in a flat actually used. Almost all households that live in flats share a water meter, and this means that we only have information about the average usage by all units on that meter (see Box 2.3). This average usage includes private as well as communal usage, for example for a communal garden or pool. Our survey did not collect information about communal usage.

The problem with knowing only what the average usage is for all units on a shared meter is that we cannot link their household characteristics to their water usage. In turn, this means that we cannot use regression analysis to directly estimate indoor and outdoor usage by households that live in flats.

To get around this problem, we used the results of Frontier's regression model to estimate how much water households use indoors and outdoors, on average, depending on whether they live in a house or a flat. To do this we:

- identified the average characteristics of households that live in houses and flats respectively
- used the regression coefficients to estimate the usage that is associated with each of these characteristic
- identified each of characteristics as representing either indoor or outdoor usage,[32] and
- summed indoor, outdoor and total usage.

We used the outcomes of this analysis to estimate indoor usage in flats as a proportion of that in houses using two different methods. First, we simply compared the indoor usage volumes predicted by the regression model. Second, we applied the predicted ratio of indoor to outdoor usage to the actual average usage in houses and flats, after including an allowance for watering communal gardens in flats.

6.3 Findings on estimated average indoor usage of houses and flats

We found that the indoor water usage of households in flats is probably between two-thirds and four-fifths that of households in houses. The main reason for this is that there are fewer people per household in flats.

[32] Some of the characteristics could be split between indoor and outdoor usage, for example the area adjustments and having taken steps to reduce usage. However, the usage associated with these variables is small and their allocation to both indoor and outdoor usage would have very little impact on the outcome.

6.3.1 Comparing predicted indoor usage in houses and flats

Using our first method, we estimated that, on average, households in houses use about 156 kL pa indoors while households in flats use about 105 kL pa. This suggests households in flats use about two-thirds (67%) as much water indoors as those in houses. We also found that the main drivers of this is difference is that on average households in flats have fewer people and use their washing machines less frequently than those in houses. Flats also tend to have fewer bedrooms and toilets than houses. (See Table 6.1 and Figure 6.2).

In relation to outdoor usage, our first method estimated that on average:

- households in houses use about 31 kLpa outdoors, which represents 17% of their total usage of 187 kL pa, and
- households in flats use about 7 kL pa outdoors, which represents 6% of their total usage of 111 kL pa (Table 6.1.).

However, we consider that this method probably underestimates outdoor usage for flats because the household characteristics do not capture much information about their outdoor usage. For example, 35% of households in flats said they have a communal garden, but neither the survey nor the model captured any information about watering these gardens. In addition, some households with a communal pool may have said that they did not have a pool because they do not regard the pool as 'theirs'.[33]

6.3.2 Applying the ratio of indoor-outdoor usage to actual usage

For our second method, we estimated the outdoor usage for communal purposes in flats based on assumptions about the average amount of water used to water communal gardens per household in flats.[34] Given our survey finding that 35% of households in flats had a communal garden, we assumed that:

- for about 70% of flats with communal gardens, the garden is watered with a sprinkler (ie, for 25% of all households in flats), and
- communal gardens are watered as frequently in winter as are private gardens for houses.

Using these assumptions, the model predicts that households in flats use about 15k L pa outdoors, which represents 13% of total usage (Table 6.1.).

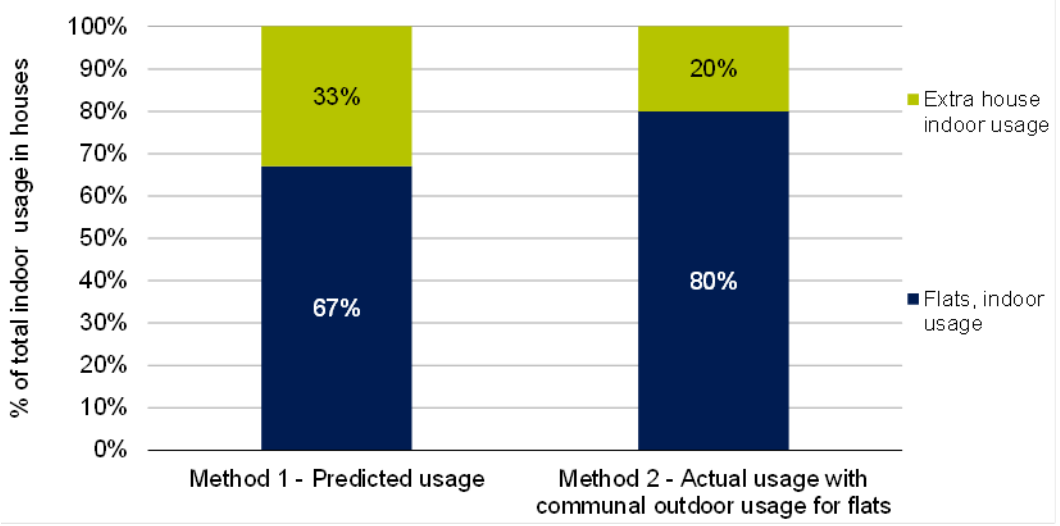
---

[33] The underestimation of outdoor usage for flats is probably one of the reasons why the average actual usage is higher than our predicted usage (138 kL pa compared with 111 kL pa). (See Table 6.1.).

[34] We did not include an allowance for communal pools because the impact would most likely be very small. We did not have any information about the prevalence of such pools.

We then applied the indoor-outdoor usage ratios for houses (83 to 17) and flats (87 to 13) to the actual average usage for households in each dwelling type. This analysis found that, on average, households in houses use about 152kL pa indoors while households in flats use about 121 kL pa indoors. In percentage terms, households in flats use around 80% as much water indoors as those in houses (Table 6.2 and Figure 6.2).

Figure 6.2 Indoor usage by dwelling type (% of total usage)



Note: Houses means individually metered dwellings that are not flats. Analysis for Sydney, Hunter and Gosford combined. The household characteristics are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas, as Sydney residents make up a higher proportion of the population (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

Table 6.1 Predicted indoor and outdoor usage by dwelling type (kL pa)

	Co-efficient	Houses		Flats		Flats, adjusted outdoor usage[a]	
	kL pa	Average value	kL pa	Average value	kL pa	Average value	kL pa
Western Sydney	*-0.2*	29%	-0.1	7%	0	7%	0
Hunter	*-4.8*	16%	-0.8	4%	0	4%	0
Gosford	*-31.4*	4%	-1.4	1%	0	1%	0
Per adult (16 years or older)	*34.3*	2.34	80	1.66	57	1.66	57
Per child	*12.9*	0.54	7	0.36	5	0.36	5
Per bedroom	*5.9*	3.53	21	1.88	11	1.88	11
Per time a dishwasher is used in a week	*1.6*	2.54	4	1.12	2	1.12	2
Per time a washing machine is used in a week	*8.4*	3.82	32	2.27	19	2.27	19
Per toilet	*6.1*	2.14	13	1.43	9	1.43	9
Use a water saving device	*-9.2*	80%	-7	59%	-5	59%	-5
Constant	*8.5*	1.00	9	1.00	9	1.00	9
Total indoor usage			**156**		**105**		**105**
Have a pool	*24.1*	17%	4.2	3%	1	3%	1
Plot size, per sq km	*31.6*	0.73	23	0.00	0	0.00	0
No information on plot size	*10.7*	25%	2.6	100%	11	100%	11
Use an alternative water source	*-15.9*	34%	-5.4	10%	-2	10%	-2
Have taken steps to reduce usage	*-7.3*	76%	-5.5	57%	-4	57%	-4
Use a sprinkler	*29.1*	27%	8.0	1%	0	25%[b]	7
Per time per week the garden is watered in winter	*8.9*	0.47	4	0.09	1	0.26[b]	2
Total outdoor usage			**31**		**7[a]**		**15**
Total usage			**187**		**111**		**120**
Percentage outdoor usage			17%		6%		13%
Actual usage			183		138		138

a This approach makes an allowance for outdoor usage for communal purposes. The household characteristics from the survey did not provide information about usage for communal purposes.

b IPART assumption, to capture outdoor usage for watering communal gardens.

Note: Houses means individually metered dwellings that are not flats. To predict the usage that is associated with each variable, we multiply the coefficient by the value of the corresponding characteristic. We then sum to amounts to give the total usage. Analysis for Sydney, Hunter and Gosford combined. The household characteristics are weighted to represent the wider metropolitan population. This means that respondents in Sydney receive a higher weight than respondents in the other survey areas (see IPART, *IPART 2015 Household Survey — About the survey*, September 2016).

Source: 2015 Household Survey.

6 Do houses discharge more wastewater into the sewerage system than flats?

Table 6.2 Indoor and outdoor usage scaled up to total actual usage, adjusted for communal outdoor usage in flats

	Houses kL pa	Flats[a] kL pa	Usage in flats as a proportion of usage in houses
Indoor usage	152	121	80%
Outdoor usage	30	18[a]	60%
Total actual usage	183	138	75%
Percentage outdoor usage	17%	13%	

a Usage in flats makes an allowance for outdoor usage for communal purposes. The household characteristics from the survey did not provide information about usage for communal purposes.

Note: Analysis for Sydney, Hunter and Gosford combined. The analysis includes only individually metered household in dwelling types other than flats. Data for tenants that do not pay the water usage charge and household that did not provide income data are excluded. The data are not weighted.

Source: 2015 Household Survey.