Domestic Water Use Study

In Perth, Western Australia 1998-2001

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WATER CORPORATION

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Contents

1 Background and Methodology

1.1 Introduction

The Water Corporation of Western Australia supplies scheme water to approximately 1.7 million people throughout the state of Western Australia of whom about 1.4 million live in Perth, the state capital. With a mediterranean climate, Perth's weather is characterised by cool wet winters and hot dry summers. The average annual rainfall is 864 mm of which 744 mm falls between May and October and only 36 mm in the summer months of December, January and February. Most of the city lies on a coastal sand plain about 20 km wide between the Indian Ocean and the Darling Range. Below the plain, groundwater suitable for irrigation exists at depths varying from 2 m to 50 m and there are few restrictions in most areas to prevent householders sinking a bore for watering (garden, lawn and verge) purposes should they desire to supplement their scheme water supply.

In the 1999/00 financial year, Perth's total demand for scheme water was 241 GL, distributed as shown in Figure 1.1. Domestic water usage accounts for approximately 70% of Perth's total demand, of which 62% is used by single residential dwellings and 8% by multi-residential dwellings (e.g. townhouses, apartments and flats).

A good understanding of domestic water usage patterns and trends is essential for the Corporation to effectively plan for the present and future needs of its domestic and other customers. A detailed study of domestic water use in Perth was last undertaken in 1981/82, almost 20 years ago (Metropolitan Water Authority, 1985). In 1995 the Corporation completed the Perth Water Future Study (PWF) (Stokes et al., 1995) which committed the Corporation to a new Domestic Water Use Study (DWUS) that would provide a more current understanding of domestic water use patterns and trends.

A further incentive to update knowledge of domestic water use came from the Water and Rivers Commission (WRC), one of the Corporation's regulators. The WRC is responsible for the management and protection of Western Australia's water resources which includes allocating available water resources to uses such as public water supply. WRC's approval to develop new sources would be subject to the Corporation implementing a mutually acceptable water use efficiency program which sets realistic savings targets.

More specifically, objectives of the new DWUS were to:

- collect data on household water usage;
- identify water use patterns and trends; and
- develop a demand forecasting model and a water use efficiency program at a later stage.

This report addresses the first two study objectives. It briefly describes the study methodology, presents the more salient results of data analysis and summarises key findings. The information will be used by the Corporation to improve forecasting of future demand and develop water use efficiency programs that are soundly based.

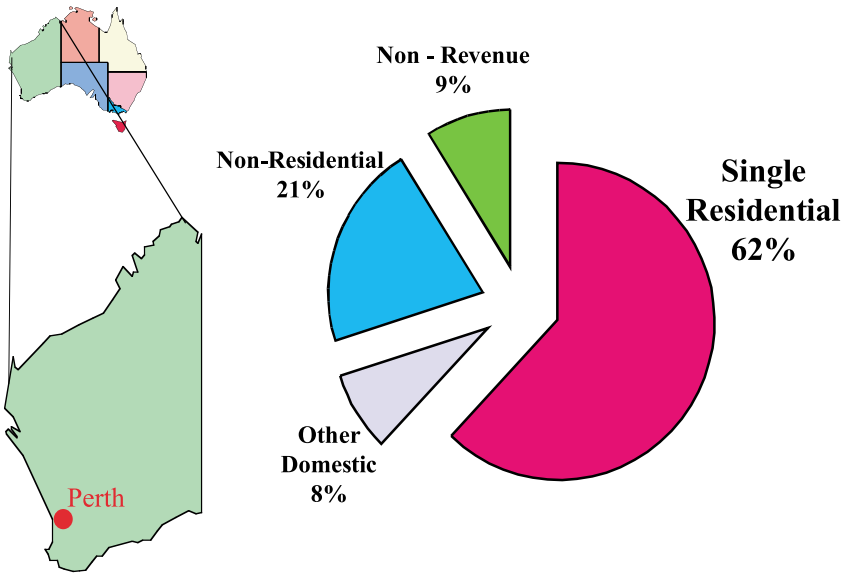


Figure 1.1 ~ Perth Metropolitan Water Use 1999/2000

1.2 Methodology

Detailed planning of the study started late in 1997 and a brief summary of the planning process is listed below.[1]

- Background literature search.
- Contacting other agencies[2] and consultants[3] in the world who had done similar work.
- Statistical analyses of data from about 1,000 households to determine the major variables affecting domestic water usage.
- Engaging with stakeholders (internal and external) to ensure their needs were captured.
- Determination of the data to be collected and the method of collection.
- Trials of meters used for the study.

Careful planning was required to ensure selection of appropriate households as well as the logistics of collecting and processing the data.

[1] A detailed description of the DWUS methodology was documented in an internal report by Coghlan *et al*. (1999). For a general overview of the methodology, refer to Coghlan and Higgs (2000).

[2] Including Australian Bureau of Statistics, Department of Mathematics (Murdoch University), CSIRO and Water & Rivers Commission.

[3] Montgomery Watson (Asia) and Aquacraft Inc.

1.2.1 Samples

A phased approach was adopted for the DWUS. Phase 1 included single residential households, followed by Phase 2 which focused on multi-residential households.

In Phase 1, household data was collected from 720 volunteer households across the Perth metropolitan area which comprised of:

- A Pilot Group of 120 households at which special metering equipment was installed to continuously monitor water use from November 1998 to June 2000.
- A Main Group of another 600 households at which total monthly water usage was recorded from November 1998 to February 2000.

All 720 households completed three questionnaire surveys covering demographics, appliance ownership and attitudes to water use.

The Pilot Group consisted of 3 sub-samples of 40 households drawn from low, medium and high income locations. The Main Group was a stratified sample and is statistically representative of the Perth metropolitan area. Data gathered from the Main Group were used to help validate the Pilot Group data on key variables.

In Phase 2, household data were collected from 297 volunteer multi-residential households[4] across the Perth metropolitan area which comprised of:

- A Pilot Group of 124 households[5] at which special metering equipment was installed to continuously monitor water use from September 2000 and November 2001.
- A Main Group of another 173 households which provided questionnaire data only.

Data from additional households in the Main Group were used to help validate the Pilot Group data on key variables.

1.2.2 Questionnaires

In Phase 1, data on household characteristics and attitudes were collected using three separate questionnaires. The first surveyed all 720 households at the time of recruitment and covered ownership of water-using appliances and demographics. Two additional questionnaire surveys, one at the end of each of the two summer periods in the study time frame (i.e. 1998/99 and 1999/00), covered attitudes to water use (CSIRO, 2002). All questionnaires were designed with input from the Corporation and administered by CSIRO's Australian Research Centre for Water in Society (ARCWIS).

In Phase 2, all multi-residential households were surveyed at the time of recruitment using a questionnaire covering ownership of water-using appliances, water use patterns and demographics. Again, ARCWIS assisted with survey design and conduct.

[4] These include duplexes, triplexes, townhouses/units in groups of more than 4 and some multi-storey residential households.

[5] The pilot group is made up of 26 duplexes, 26 triplexes, 39 townhouses/apartments in a group of 4 to 10 and 33 townhouses/flats/apartments in a group of more than 10.

1.2.3 Water Usage

All Pilot Group households had meters and data loggers (referred to as 'smart' meters) installed on their water services to continuously record water usage patterns. The 'smart' metering set up is shown schematically in Figure 1.2 and pictorially in Figure 1.3. Existing service meters at Main Group households (both Phases) were only read monthly by householders.

All water usage data were stored on a data logger which was downloaded every six weeks and validated for timing, total usage and data quality. The data was then further processed using special computer software called 'Trace Wizard'[6] to a format suitable for analysis of usage patterns.

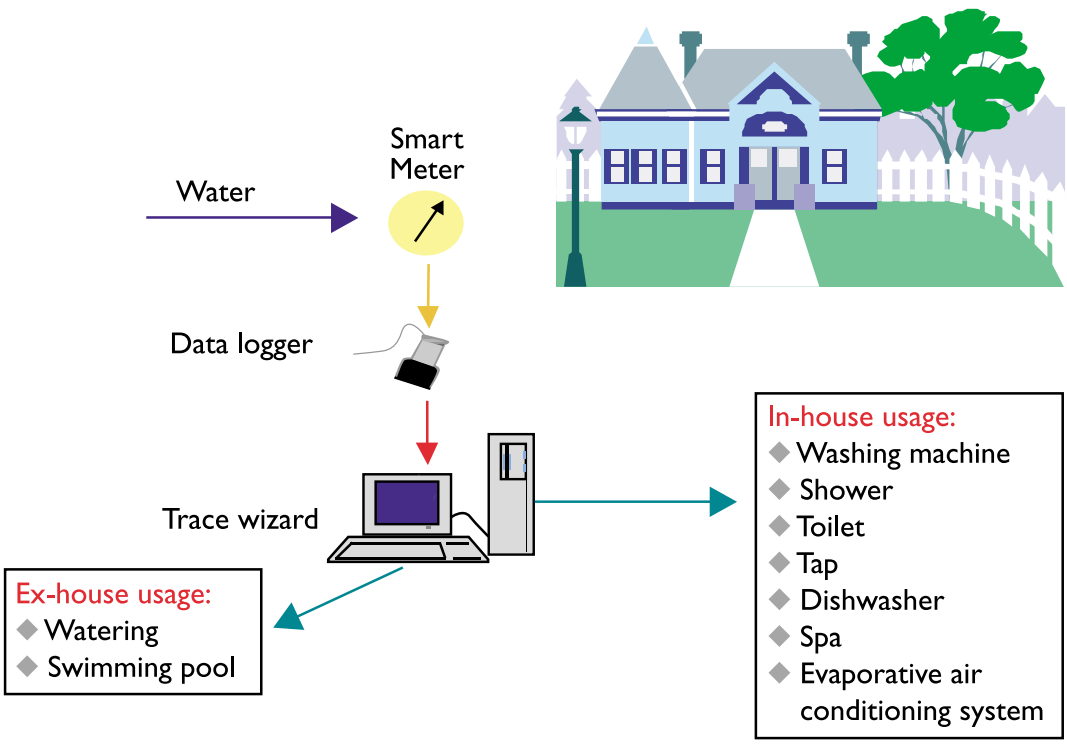


Figure 1.2 ~ 'Smart' Metered Household

[6] This program was developed by Aquacraft Inc. in the United States of America (www.aquacraft.com).

Figure 1.3 ~ 'Smart' Meter Arrangement

2 Sample Characteristics

2.1 Occupancy Rate

The average occupancy rates of the households sampled in the study are 3.35 persons for single residential households and 2.19 persons for multi-residential households. These figures are slightly higher than recent census figures for these dwelling types.

2.2 Ex-House Appliances

Tables 2.1 and 2.2 show the ownership levels for ex-house water-using appliances and reported frequency of watering for both the single residential and multi-residential households. It should be noted that only a day time sprinkler ban was in force at the time of the questionnaire survey.

Table 2.1 Ownership of Ex-house Water-Using Appliances

Household	Watering system using scheme water (%)				Private bore (%)	Swimming pool (%)
	Automatic reticulation	Manual reticulation	Hand watering	Other systems[7]		
Single residential	25	16	19	8	32	21
Multi-residential	38	8	40	14	N/A	N/A

Table 2.2 Reported Water Use Patterns

Households	Frequency of watering	%
Single residential	More than once a day/everyday	16
	Every second day/3 times a week	37
	Every third day/2 times a week	33
	Other (e.g. every 4 days)	14
Multi-residential	More than once a day/everyday	22
	Every second day/3 times a week	34
	Every third day/2 times a week	14
	Other (e.g. every 4 days)	30

[7] Other systems include single residential households without lawn and multi-residential households without lawn/garden.

2.3 In-House Appliances

2.3.1 Washing Machine

99% of single residential households owned a washing machine compared to only 92% for multi-residential households. 4% of the multi-residential households shared a communal washing machine and the rest did not have a washing machine on site at all. Table 2.3 summarises ownership levels and shows that automatic top loading washing machines are the most popular.

Table 2.3 Washing Machine Ownership

Type of residence	Washing machine type	%
Single residential	Automatic top loader	85
	Automatic front loader	8
	Twin tub/other types[8]	6
	No washing machine	1
	Total	**100**
Multi-residential	Automatic top loader	80
	Automatic front loader	9
	Twin tub/other types	3
	No washing machine[9]	8
	Total	**100**

2.3.2 Shower

Ownership levels for the different types of shower are shown in Table 2.4. Difficulties in obtaining accurate information from householders on the efficiency rating of their showers (ie A, AA etc) meant that the only meaningful distinction between shower types was whether one or more water-efficient showers (of any type) was owned or not.

Table 2.4 Shower Ownership

Type of residence	No of showers	Normal flow (%)	Water-efficient (%)	Mixed[10] (%)	Total (%)
Single residential	*1*	37	16	0	53
	2	26	8	8	42
	3 or more	2	1	2	5
Multi-residential	*1*	68	14	0	82
	2	11	2	2	15
	3 or more	2	1	1	4

[8] Includes owners who did not specify the type of washing machine owned.

[9] Includes households which used a communal washing machine.

[10] Mixed – households with more than one type of shower, e.g. one water efficient shower and one normal flow shower in the same house

2.3.3 Toilet

Table 2.5 shows ownership level of various toilet types. Owners were asked about the capacity of their dual flush toilet cisterns[11] but many could not reliably identify the type(s) of dual flush toilets installed in their houses. This identification problem was further compounded by the fact that some older dual flush toilets have 11/6 L capacity and this option was not specified in the questionnaire. For these reasons, no distinction has been made between the types of dual flush toilets installed.

The high ownership levels for dual flush toilets are a reflection of an amendment to By-Laws in 1993, which made it compulsory for all new toilet cisterns installed after 1993 to be of the 6/3 L dual flush type.

Table 2.5 Toilet Ownership

Type of residence	No of toilets	Single flush (%)	Dual flush (%)	Mixed[12] (%)	Total (%)
Single residential	*1*	25	24	0	49
	2	9	28	7	44
	3 or more	1	4	2	7
Multi-residential	*1*	12	43	0	55
	2	5	34	0	39
	3 or more	0	6	0	6

2.3.4 Other In-House Appliances

Ownership levels for dishwashers and evaporative air conditioners are shown below in Table 2.6.

Table 2.6 Ownership of Other Appliances

Appliance	Single residential	Multi-residential
Dishwasher (%)	29	9
Evaporative air conditioner (%)	24	34

[11] The capacity of the cisterns could either be 6/3 L or 9/4.5 L.

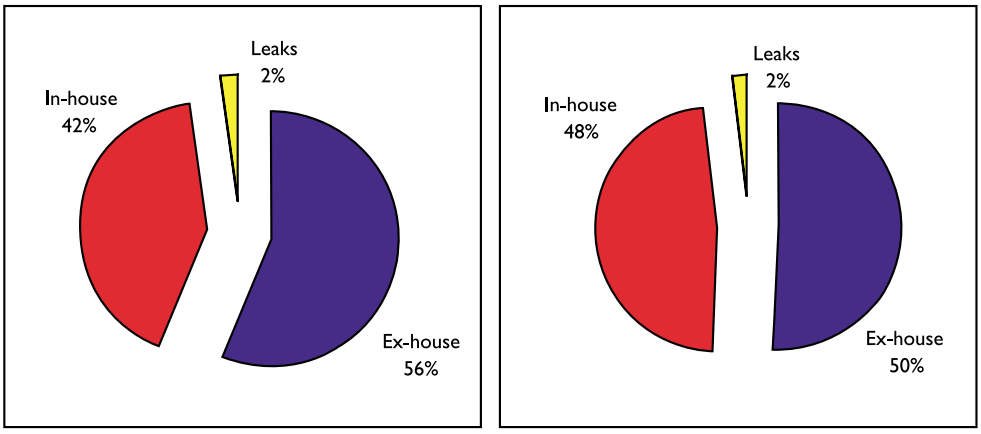
[12] Mixed – households with more than one type of toilet.

3 Total Water Usage

This section examines total water usage based mainly on data from pilot groups (both single residential and multi-residential) before reporting further on how this is used in-house and ex-house.

3.1 Annual Usage

The estimated average annual total usage by the single residential and multi-residential households in this study are 460 kL/house and 280 kL/house respectively[13]. Proportions of water used ex-house and in-house and actual quantities are presented in Figure 3.1 and Table 3.1 respectively.



(a) Single residential (b) Multi-residential

Figure 3.1 ~ Proportion of Total Water Usage

Table 3.1 Average Daily Usage

	Single residential	Multi-residential
Ex-house usage (L/house/day)	707	389
In-house usage (L/house/day)	523	365
Leaks (L/house/day)	29	14
Total usage (L/house/day)	1259	768

[13] These figures are for the total study sample, including households with bores. The single residential household sample consisted of eight households with bores (out of a total of 121 households). Information regarding ownership of bores was not available for the multi-residential households.

3.2 Monthly Usage

Figure 3.2 compares average monthly water usage by single residential and multi-residential households. It is very clear that single residential households use more water compared to the multi-residential households during summer months. This is most likely due to the larger areas of lawn and garden that single residential households maintain compared to multi-residential households.

During the winter months, average water usage of single residential household appears to be higher than that of the multi-residential households. However, on a per capita basis (see Section 5.2) the usage is fairly similar.

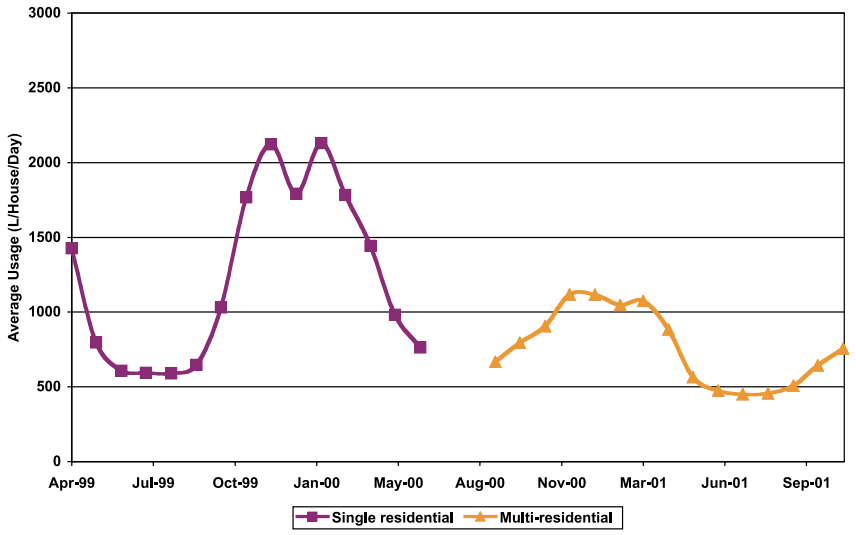


Figure 3.2 ~ Average Monthly Usage for Single/Multi-residential Households

Figure 3.3 shows the average monthly water usage (L/house/day) for both single and multi-residential households. Single residential households were divided into high, medium and low income households.

Multi-residential households, on the other hand, were divided into multi-storey households and single storey households. It is difficult to locate multi-storey households with individual meters because most have a master meter recording water usage for the entire complex. Therefore, only nine multi-storey households were recruited for this study. The water usage of these nine households was cross-checked using meter readings from households within the same complex. Multi-storey households have been isolated from most of the sample and their water usage patterns reported on separately.

For single residential households, there is a strong relationship between total usage and the socio-economic level of the area in which a household is located. The usage patterns during winter are essentially the same for all three sub-groups but there is considerable variation between them during the summer months. This is also a strong indication that the sub-groups have similar in-house usage patterns but very different ex-house demand patterns.

Less water is used by the multi-storey residential group, reflecting the fact that water usage by these households is mainly in-house due to the absence of lawn/garden.[14] Water usage for this group is further reduced by its lower average occupancy rate of 1.44 persons.

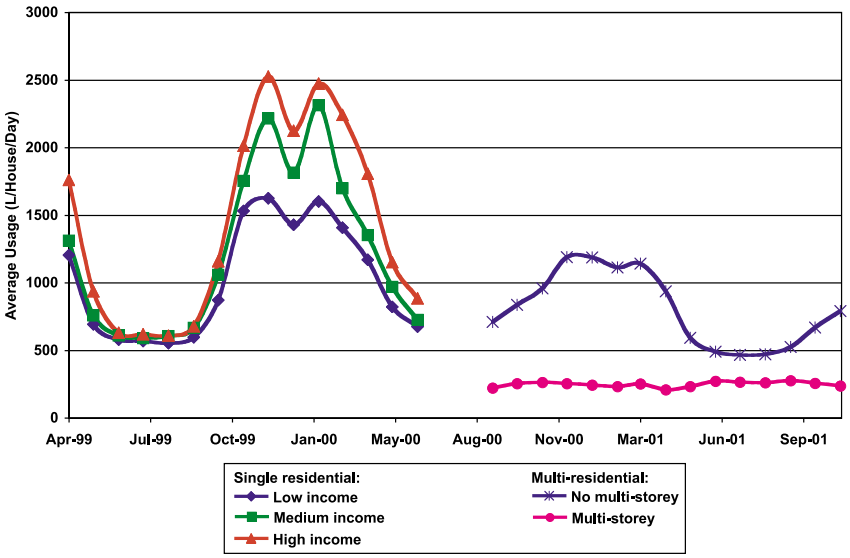


Figure 3.3 ~ Average Monthly Usage

3.3 Daily Profile

Figures 3.4 to 3.7 show the summer and winter daily profiles for total water usage. There was very little difference in the profiles for all the households during winter when most water usage is in-house.

[14] The only exception is households located on the ground floor which may have a limited lawn/garden area.

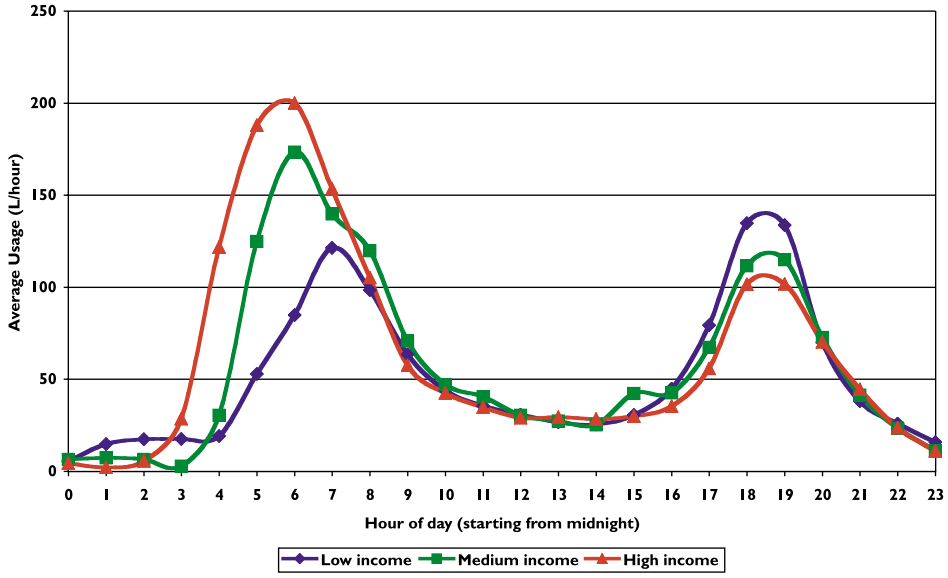


Figure 3.4 ~ Single Residential Summer Hourly Profile – Total Usage

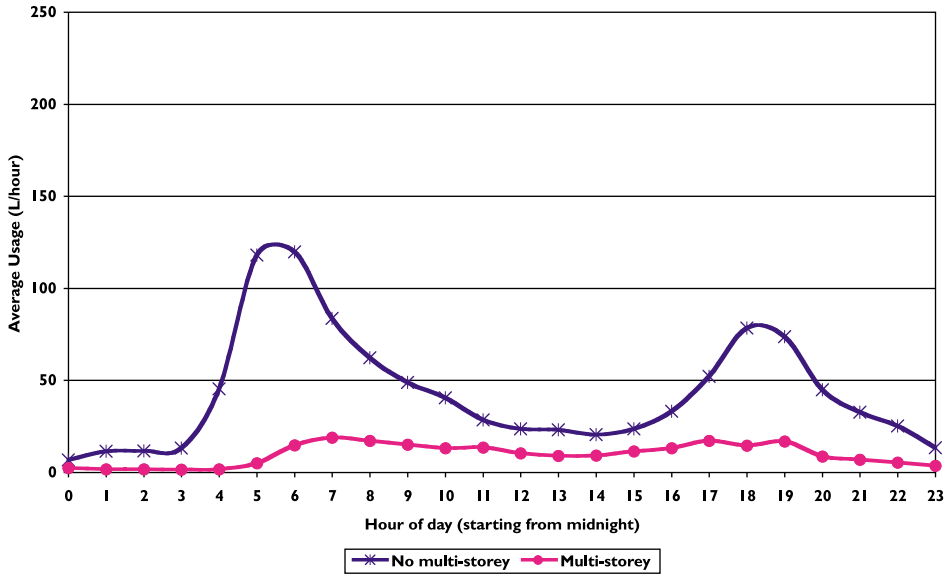


Figure 3.5 ~ Multi-residential Summer Hourly Profile – Total Usage

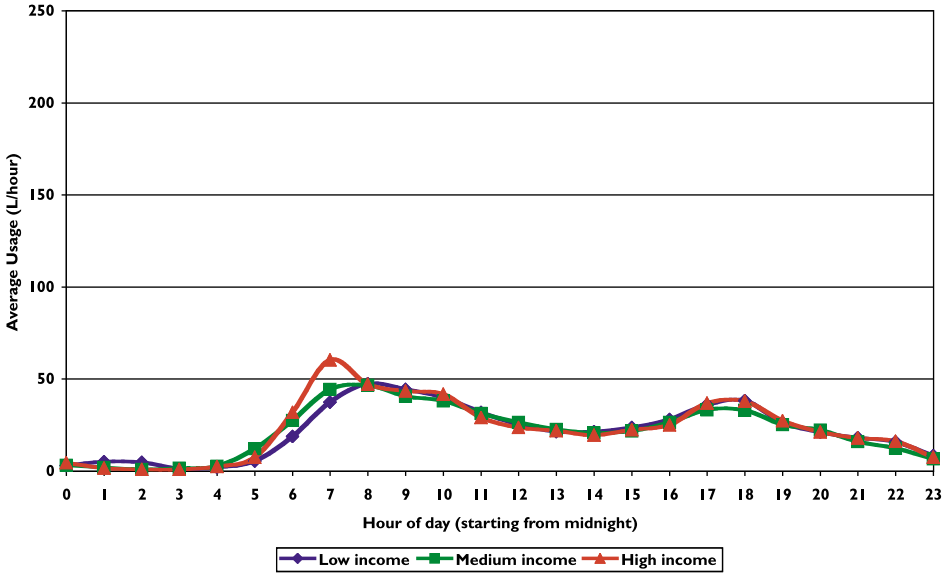


Figure 3.6 ~ Single Residential Winter Hourly Profile - Total Usage

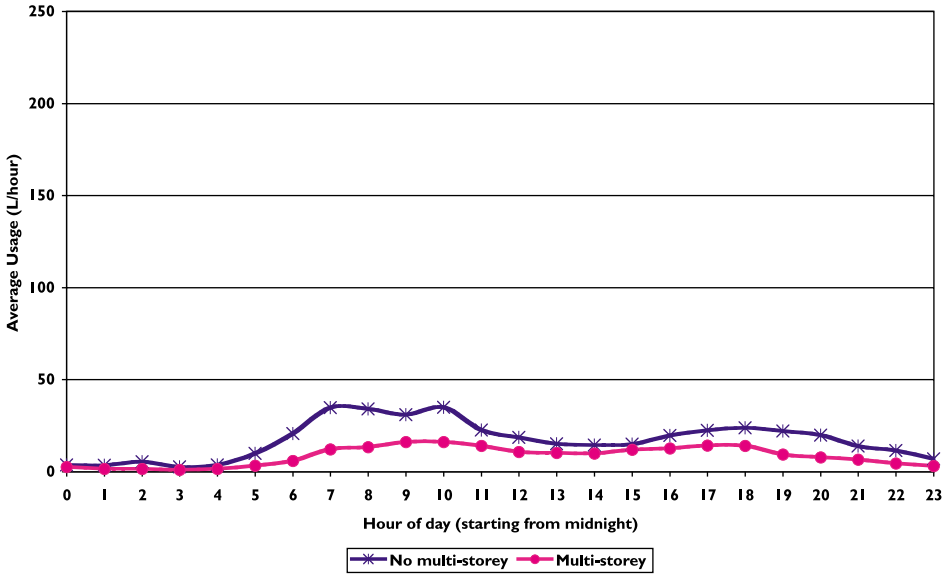


Figure 3.7 ~ Multi-residential Winter Hourly Profile – Total Usage

4 Ex-House Water Usage

Almost all ex-house water use is accounted for by lawn and garden watering, with a much smaller amount used for swimming pools (mainly for topping up purposes). Small tap uses have been identified but study methodology does not permit reliable identification as in-house or ex-house usage. As it is likely that the vast majority of small tap uses would be in-house, they have all been assigned to in-house usage.

For a multi-residential household, the average ex-house usage for watering only is 389 L/day (see Table 3.1). Study methodology did not permit a reliable estimate of water usage by swimming pools for individual multi-residential households. If available to these households, swimming pools are, in almost all cases, located in a common area. Such water use is normally through a separate and common water service to the whole complex which could not be monitored using the special meters developed for the study.

4.1 Single Residential

On average a single residential household used 707 L/day ex-house with 687 L/day (approximately 97%) used on the lawn and garden and 20 L/day (3%) for the swimming pool.

Figure 4.1 shows average daily ex-house usage by month for low, medium and high income households. The decrease in usage for January was due to unseasonal rainfall of over 100 mm.

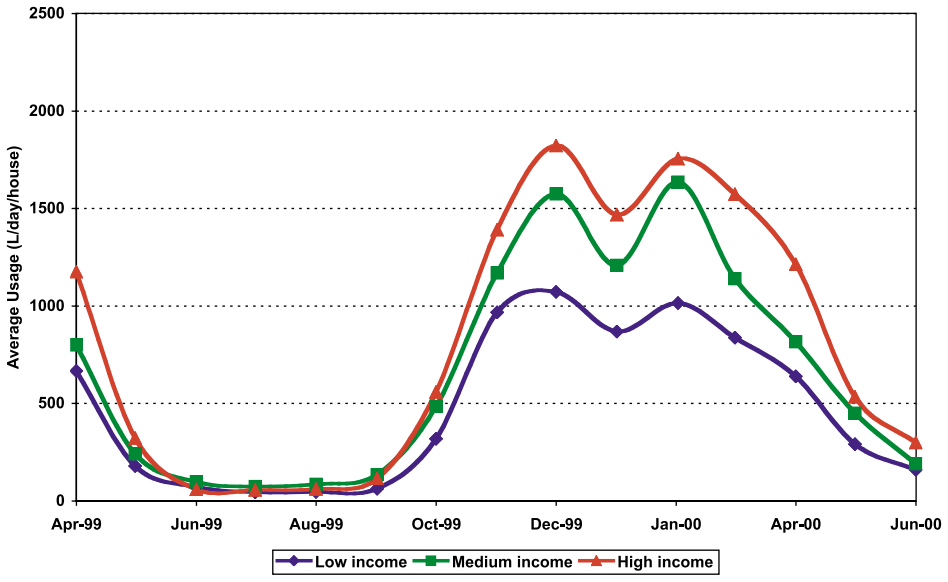


Figure 4.1 ~ Single Residential Average Daily Ex-house Usage (by Month)

Household income had a significant effect on ex-house water usage. High income households tended to use more water ex-house than lower income households. Differences in ex-house usage could also be due to ownership of automatic reticulation watering systems as higher income areas are more likely to have these systems than low income areas.

4.1.1 Automatic Reticulation System

Table 4.1 shows the average daily ex-house water usage by month for single residential households. It is clear that households with automatic reticulation systems used considerably more water when compared with households with no automatic reticulation systems, particularly during summer. Figure 4.2 shows the average daily ex-house usage by month for households with and without automatic reticulation systems.

Table 4.1 Single Residential Average Ex-house Scheme Water Usage

	Auto reticulation	No automatic reticulation
Average usage (L/house/day)	1058	537

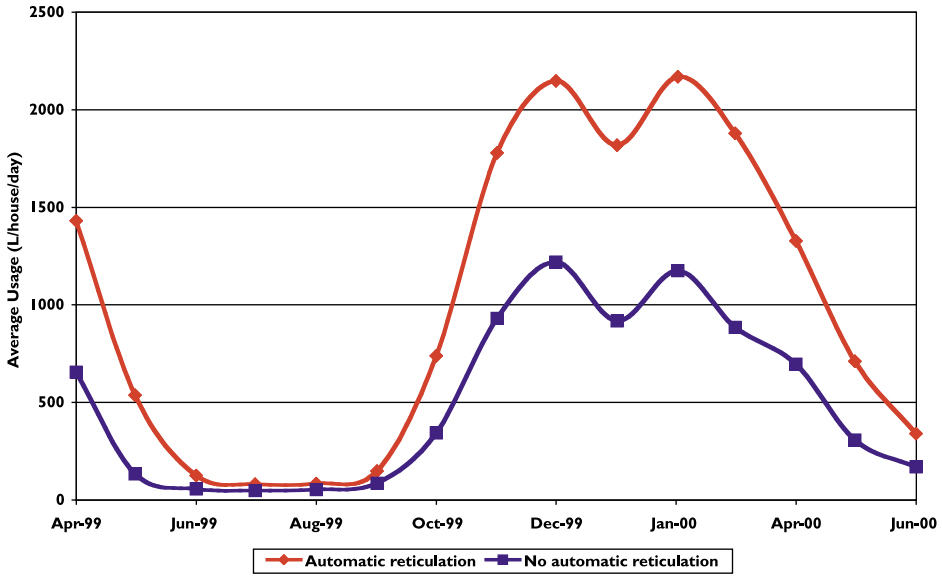


Figure 4.2 ~ Single Residential Ex-house Average Daily Scheme Water Usage (by month)

4.1.2 Houses with Bores

Figure 4.3 shows the scheme water usage by houses with and without bores. As would be expected, houses with bores use less scheme water for watering purposes than houses without a bore. Higher income households are more likely to have a bore than low income households. The influence of automatic reticulation systems on daily usages is again evident.

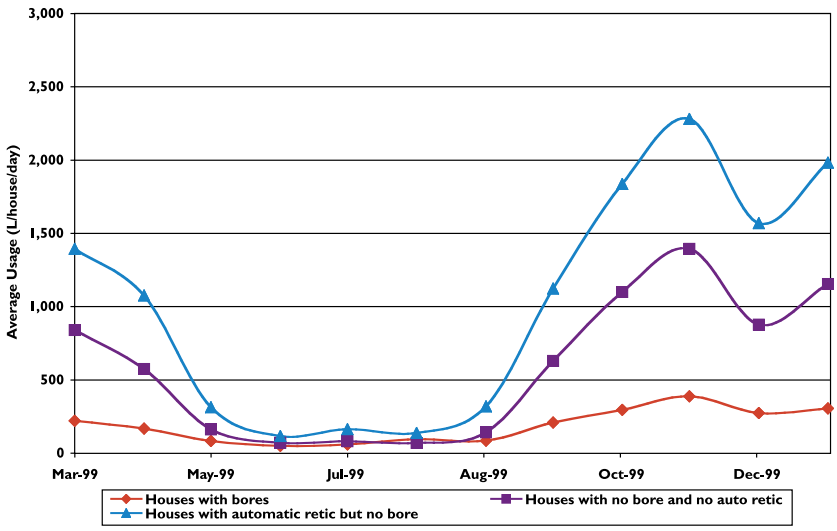


Figure 4.3 ~ Ex-house Scheme Water Usage For Houses With and Without Bores (Single Residential)

4.1.3 Effect of Lawn/Garden Area on Watering Usage

The irrigable area (garden, lawn and verge) of single residential households was estimated from aerial photographs to ascertain if there is any relationship between the areas requiring watering and water usage attributed to them. The relationship between water usage and irrigable area for the summer period (Dec. 1999 to Feb. 2000) is shown in Figure 4.4.

No strong relationship between irrigable area and ex-house water usage is evident. This was also the case when comparing houses with different income levels. A relationship could reasonably be expected if all households watered efficiently, so it is possible that many households are following inefficient irrigation practices.

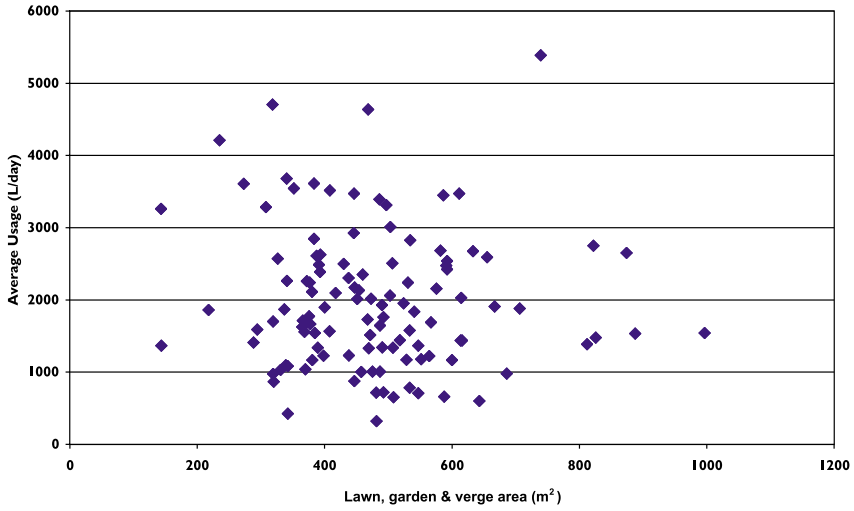


Figure 4.4 ~ Summer Watering Usage vs Irrigable Area

4.2 Multi-Residential

On average, a multi-residential household used 389 L/day ex-house for watering lawn and garden.

Figure 4.5 shows the average monthly ex-house usage for multi-residential households with only one storey and those with more than one storey. Ex-house water usage of the multi-storey households is close to zero. This is due to the fact that these households do not have a garden and any ex-house water usage is likely to be for minor uses such as watering pots. The ex-house water usage for multi-residential households was significantly lower than that of the single residential households. As with single residential households, seasonal variation in ex-house water usage occurred for single storey multi-residential households.

Table 4.3 shows the average water usage for multi-residential households. As with single residential households, owners of an automatic reticulation system used considerably more water ex-house than those without one.

Table 4.3 Multi-residential Average Ex-house Scheme Water Usage

	Auto reticulation	No automatic reticulation
Average usage (L/house/day)	515	279

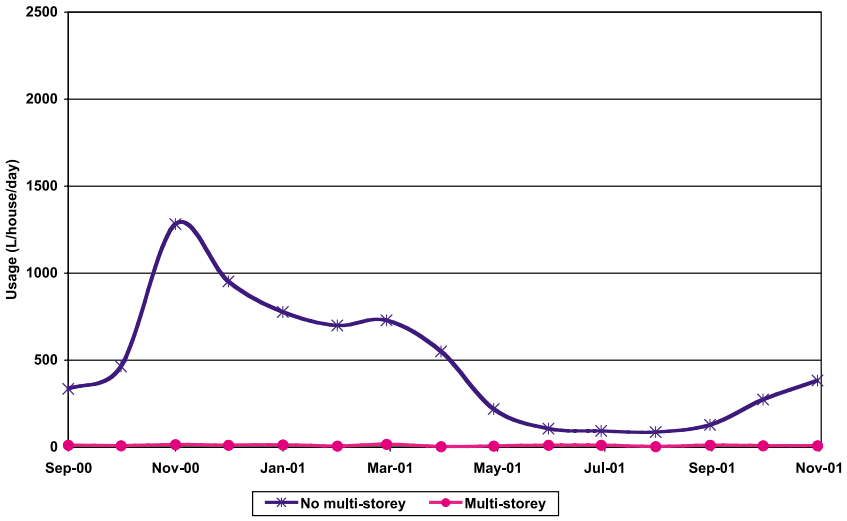


Figure 4.5 ~ Multi-residential Average Daily Ex-house Usage (by Month)

5 In-House Water Usage

This section describes the in-house water usage by the different household types.

5.1 Total In-House Usage

Figure 5.1 shows the average monthly in-house usage for single residential and multi-residential households while Figure 5.2 shows the average monthly in-house usage for the different types of households.

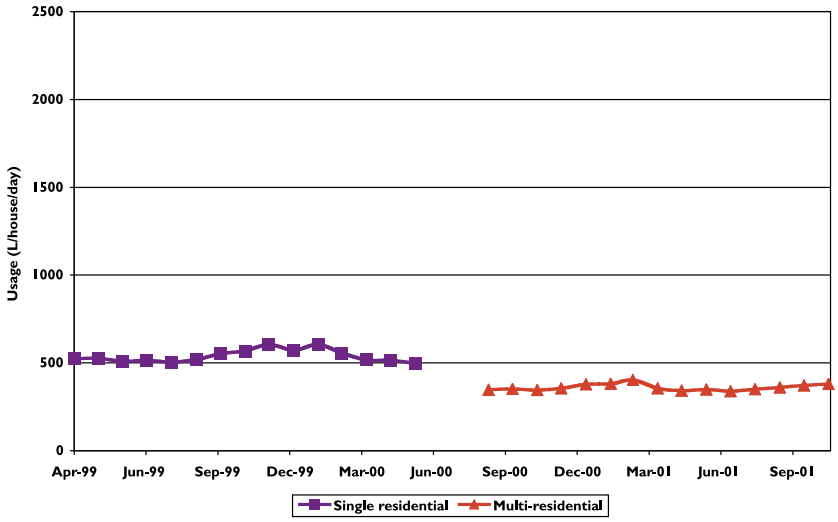


Figure 5.1 ~ Average Daily In-house Usage (by Month)

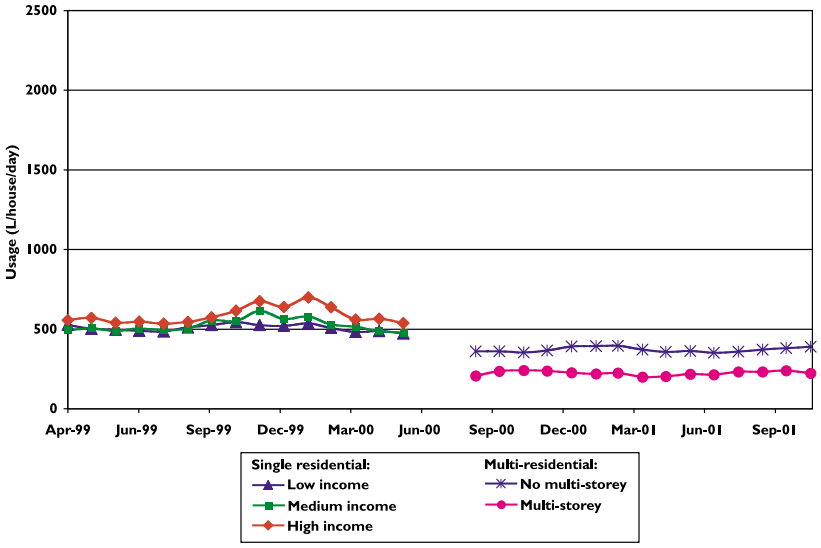
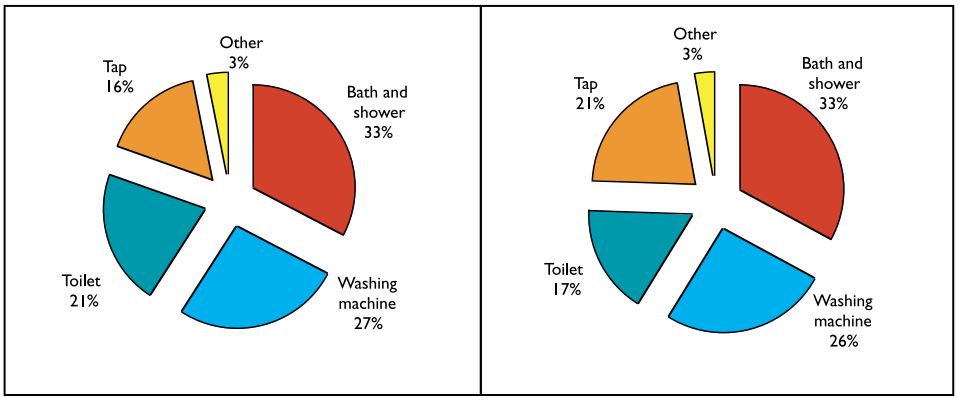


Figure 5.2 ~ Average Daily In-house Usage for Different Household Types (by Month)

It is evident from Figures 5.1 and 5.2 that there was very little seasonal variation in in-house water usage. For single residential households, high income households had a slightly higher usage compared to all other household types with the difference increasing a little during the summer period. This could be due to more frequent showering during summer and more frequent use of evaporative air conditioning systems. As for multi-residential households, it is clear that multi-storey households used the least amount of water.

5.2 Component Usage

Single residential households used more water in-house than multi-residential households. Single residential households used an average of about 520 L/house/day whereas multi-residential households used an average of about 360 L/house/day. The split of the components is as shown in Figure 5.3.



(a) Single residential (b) Multi-residential

Figure 5.3 ~ Proportion of In-house Usage

In-house usage is highly dependent on the occupancy rates for the different household types. Given that the average occupancy rate for single residential households in this study is 3.35 persons and 2.19 persons for the multi-residential households, the difference in water usage is understandable.

Table 5.1 shows total individual appliance usage and per capita usage. Total in-house usage does not vary much on a per capita basis between household types. The main difference is that single residential households used more water for toilets than multi-residential households, possibly due to lower ownership levels of dual flush toilets in single households. Multi-residential households, on the other hand, had more small tap usages with no apparent reason for this difference.

Table 5.1 Per Capita In-house Usage

	Single residential		Multi-residential	
Appliance	L/house/day	L/person/day	L/house/day	L/person/day
Bath and shower	171	51	121	55
Washing machine	139	42	94	43
Toilet	112	33	62	28
Tap	83	24	77	35
Other	18	5	11	5
Total in-house	***523***	***155***	***365***	***166***

5.3 Appliance Usage

One of the objectives of the study was to investigate the potential savings of water-efficient appliances,[15] so consumption by individual in-house appliances was estimated.

5.3.1 Shower

Table 5.2 shows the water consumption for each type of shower i.e. conventional normal flow and water-efficient shower roses.

In the case of the normal flow showers, there is no significant difference between water usage (L/shower) by the residents in either single or multi-residential households.

There is no significant difference between shower durations for a normal flow or water-efficient shower rose. The average shower lasts about 7 minutes (ranging from 6.7 to 7.3 minutes).

[15] For a preliminary investigation into water savings, refer to Loh *et al*. (2002).

Table 5.2 Shower Water Usage

Type of residence	Shower type	L/day	L/shower	Min/shower	L/min
Single residential	Normal flow	152	60	7	9
	Water-efficient	135	48	7	7
Multi-residential	Normal flow	113	64	7	9
	Water-efficient	110	58	7	8

As observed from Table 5.2, possible water savings of 1 to 2 L/minute can be achieved by changing to a water-efficient shower rose. So for a 7 minute shower, a water savings of 7 to 14 L can be achieved, amounting to a water savings of between 2.6 and 5.1 kL/person per annum.

5.3.2 Washing Machine

The water consumption for washing machines is as shown in Table 5.3.

Table 5.3 Washing Machine Usage

Type of residence	Washing machine type	L/fill	L/day	L/day/person
Single residential	Automatic top loader	39	145	43
	Automatic front loader	15	104	27
	Semi automatic/twin tub/other	37	22	9
Multi-residential	Automatic top loader	31	98	47
	Automatic front loader	13	80	35
	Semi automatic/twin tub/other	25	68	29

A front loading washing machine uses less water compared to a top loading washing machine, leading to savings of between 12 and 16 L/day/person or 4.4 to 5.8 kL/person per annum.

5.3.3 Toilet

Table 5.4 shows the water usage for different toilet types. Dual flush toilets come in different capacities with 6/3 L and 9/4.5 L being the most common. Although owners were asked about the capacity of the toilet, most could not reliably differentiate between the types of dual flush toilets. This problem was compounded by the fact that some older dual flush toilets have a 11/6 L capacity which was not specified in the questionnaire.

As an estimate, a dual flush toilet uses 2 to 3 L less per flush compared to a single flush toilet. Based on an average of 10 flushes per day per household, this amounts to a saving of between 7.3 and 11.0 kL/household per annum once a single flush toilet is changed to a dual flush toilet.

Table 5.4 Toilet Water Usage

Single residential	Dual flush toilet			Single flush
	Half	Full	Overall	
Average vol (L)	6	10	8	10
Average vol/day (L/day)	26	47	73	107
Average flushes/day	5	5	10	10
Multi-residential	**Dual flush toilet**			**Single flush**
	Half	Full	Overall	
Average vol (L)	5	9	7	10
Average vol/day (L/day)	24	33	58	92
Average flushes/day	5	4	9	10

6 Some Trends since 1981/82

As discussed earlier, a similar study was carried out in 1981/82. That study concentrated on single residential households, so the comparison here relates only to single residential households.

Rigorous comparison between the two studies is not possible due to different methodologies adopted. Diaries were used to record water use activities in the 1981/82 study so there are some differences in types of data collected (e.g. leaks and small tap usages ex-house). Since these usages account for only a small part of total water usage, a valid comparison of many study results can still be made.

6.1 Appliance Ownership

Table 6.1 shows the main changes in appliance ownership since 1981/82.

Table 6.1 Changes in Appliance Ownership

Appliance	Ownership in	
	1981/82 (%)	1998/00 (%)
Private bore	27	32
Below ground pool	11	21
Fixed reticulation off mains (scheme water for watering)	5	41
Automatic reticulation off mains (scheme water for watering)	2	25
Two or more showers	19	47
One or more water efficient showers	0	35
Two or more toilets	22	51
One or more dual flush toilets	1	65
Automatic washing machine	64	93
Non-automatic washing machines	30	6
Dishwasher	13	29

Ownership levels for all main appliances have increased since 1981/82. In terms of impact on water usage, the large increase in fixed reticulation systems is particularly relevant.

6.2 Total Usage

The total usage (L/house/day) for both studies is as shown in Table 6.2.

Table 6.2 Comparison of Water Use

	1981/82 Study		1998/00 Study	
	Usage (L/house/day)	%	Usage (L/house/day)	%
Ex-house	342	42	707	56
In-house	473	58	523	42
Leaks	Not available	-	29	2
Total	815	100	1259	100

Total average water usage per single residential household has increased by about 55% since 1981/82. In-house water usage has increased slightly, probably due to a slight increase in occupancy rates for the study samples (an average of 3.07 persons/house for the 1981/82 study compared to 3.35 persons/house for the 1998/00 study).

6.3 Ex-House Usage

Table 6.3 shows that watering is the major component of ex-house water usage recorded by the two studies. This component has more than doubled since the previous study due mainly to the increased popularity of automatic reticulation and/or fixed sprinkler systems.

Table 6.3 Comparison of Ex-house Water Usage (L/house/day)

	1981/82 Study		1998/00 Study	
	Usage (L/house/day)	%	Usage (L/house/day)	%
Watering	311	91	687	97
Swimming pool	13	4	20	3
Other[16]	18	5	0	0
Total	342	100	707	100

[16] This includes filling watering cans, washing hands etc. for the 1981/82 study. These were picked up by tap usages in the 1998/00 study.

The level of ownership of swimming pools has increased from 11% (from the 1981/82 Study) to 21% and the water usage has also increased from 13 L/house/day to 20L/house/day[17]. Nevertheless, the water usage for swimming pools does not represent a significant proportion of ex-house water usage.

6.4 In-House Usage

The volume of in-house usage is heavily dependent on household size. Indeed, the only significant influence on in-house usage is the number of people in the household.

As shown in Table 6.4, per capita in-house usage has remained constant since 1981/82 at about 155 L/person/day. However, its components have changed as indicated.

Figure 6.1 shows that the four major in-house appliances are the shower, washing machine, toilet and tap uses, accounting for 96% of total in-house usage. Since 1981/82, there have been significant changes in the distribution of in-house usage between these appliances.

Table 6.4 Comparison of In-house Water Usage

Household appliance	Usage/house (L/day)		Usage/person (L/day)	
	1981/82	1998/00	1981/82	1998/00
Shower	143	167	47	50
Bath	21	4	7	1
Toilet	150	112	49	33
Washing machine	83	139	27	42
Taps[18]	72	83	23	24
Other in-house[19]	3	18	1	5
Total	472	523	154	155

The ownership level of dual flush toilets has increased from 1% in 1981/82 to 65% in 1998/00 due to legislation making dual flush toilets compulsory for all new toilet installations. This has resulted in a significant drop in the proportion of total in-house water usage by the toilet from 32% in 1981/82 to only 21% in 1998/00.

Concurrently, washing machine usage has increased from 18% to 26%. Bath usage has declined considerably and shower usage has increased. However, the combined bath and shower component has remained fairly constant at around 32% - 35% of total in-house usage.

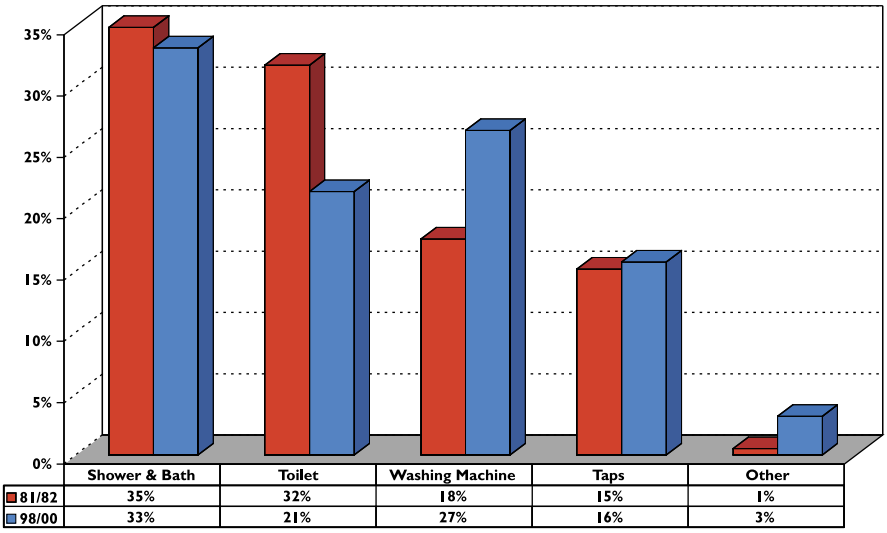
[17] Averaged over all study households.

[18] Tap usage includes a small amount of usage outdoors, e.g. washing cars, washing hands etc.

[19] 'Other-in-house' includes dishwashers, evaporative air conditioners and spas.

Since 1981/82, the ownership of automatic washing machines has increased from around 64% to around 93% for single residential households. In addition, the capacities of the washing machines have increased significantly. The combination of these two factors has resulted in increased water usage for washing machines.

There have also been small increases in other in-house appliances including dishwashers, evaporative air conditioners and spas. The increase in usage associated with these fixtures along with that attributable to washing machines equals the savings that have been achieved through the regulation of dual flush toilet cisterns and the promotion of water efficient showers.



	Shower & Bath	Toilet	Washing Machine	Taps	Other
81/82	35%	32%	18%	15%	1%
98/00	33%	21%	27%	16%	3%

Figure 6.1 ~ Comparison of In-house Water Usage (Percentage)

7 Summary of Findings

This section summarises the main findings of this study.

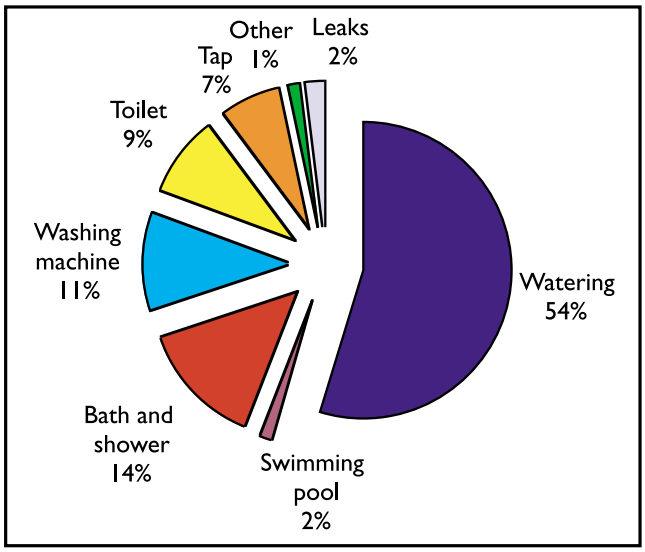
7.1 Single Residential Households

7.1.1 Total Water Usage

- The domestic sector accounts for about 70% of Perth's total demand.
- The rate of water usage during the winter period was essentially the same for all single residential households but higher income households use more water during summer.
- The average total usage per household was:

	L/house/day	% total use
Ex-house	707	56
In-house	523	42
Leaks	29	2
Total	1259	100

- The component usage per household is set out below:



Single Residential Household Water Usage

7.1.2 Ex-house

- Estimated average ex-house water usage was 707 L/house/day which includes 687 L/house/day for watering and 20 L/house/day for the swimming pool.
- Private bore ownership/access has increased from 27% in 1981 to 32% in 1998 – an increase of only 5%.
- Ownership of reticulation systems off the mains has increased considerably from only 5% in 1981 to over 41% in 1998. About 25% of households own a fully automatic system.
- A major influence on ex-house water usage is ownership of an automatic reticulation system or a bore.
- No strong relationship was established between irrigable area (ie lawn, garden and verge) and total ex-house water usage. Such a relationship could be reasonably expected so it is likely that many householders are watering inefficiently.
- Higher income households use more water with almost all of this used ex-house.
- Households with an automatic reticulation system used an average of 1058 L/house/day while households without an automatic reticulation system used an average of 537 L/house/day.

7.1.3 In-house

- Per capita usage at about 155L/person/day has remained about the same since 1981.
- Toilet usage has decreased from 32% to 21% of in-house usage due to increased ownership of dual flush toilets (from 1% in 1981/82 to 65% in 1998/00).
- Washing machine usage has increased from 18% to 27%. This is due to the increase in the ownership of automatic washing machines (from 64% to 93%) and in their capacity since 1981/82.
- There have been small increases in the ownership levels of other in-house appliances including dishwashers, evaporative air conditioners and spas.
- The increase in usage associated with these fixtures along with that attributable to washing machines equals the savings that have been achieved through the regulation of dual flush toilet cisterns.
- Average component usages for in-house use per household were:

Component	L/house/day	% in-house	% total use	L/person/day
Bath and shower	171	33	14	51
Washing machine	139	27	11	42
Toilet	112	21	9	33
Tap	83	16	7	24
Other	18	3	1	5
Total in-house	523	100	42	155

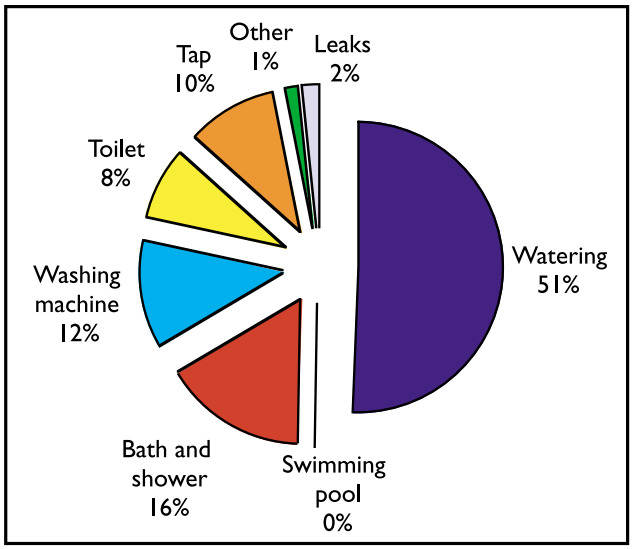
7.2 Multi-Residential Households

7.2.1 Total Water Usage

- There is no seasonal variation for multi-storey residential households, indicating that water usage is mainly in-house.
- Multi-residential households use less water compared to single residential households.
- The average total usage per household was:

	L/house/day	% total use
Ex-house	389	51
In-house	365	47
Leaks	14	2
Total	768	100

- The component usage per household is as follows:



Multi-residential Household Water Usage

7.2.2 Ex-house

- Estimated average ex-house water usage was 389 L/house/day for watering only.
- Ex-house usage of multi-storey households was negligible.
- Households with automatic reticulation systems used an average of 515 L/house/day whereas households without automatic reticulation system used an average of 279 L/house/day.

7.2.3 In-house

- Per capita usage is 166 L/person/day, which was not significantly different from that of single residential households.
- Bath and shower were the main water users in-house.
- Average component usages for in-house use per household were:

Component	L/house/day	% in-house	% total use	L/person/day
Bath and shower	121	33	16	55
Washing machine	94	26	12	43
Toilet	62	17	8	28
Tap	77	21	10	35
Other	11	3	1	5
Total in-house	365	100	47	166

7.3 Final Comment

It should be noted that a permanent daytime sprinkler ban (i.e. no watering between 9am and 6 pm) has been in place since 1 November 1994 in Perth and areas supplied by the integrated water supply system. Further, water restrictions limiting sprinkler uses to two days per week between 6 pm and 9 am were introduced in September 2001 to reduce the outside water use of Perth domestic customers. These restrictions remain in place at the time of publication of this report.

The State Government of Western Australia has released a State Water Strategy (2003). One of the aims of this widely publicised strategy is to improve water use efficiency throughout the state of Western Australia. Assuming community support in the adoption of various water conservation measures, the domestic water use patterns presented in this report are expected to change. For instance, the public has been offered attractive financial rebates to install water efficient shower heads, AAAA rated (or better) washing machines, rainwater tanks and garden bores. Ultimately, much will depend on community attitudes and a massive education campaign may be necessary to promote responsible water usage behaviour in order to ensure a sustainable water future.

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