WATER SERVICES ASSOCIATION
of Australia

Impact of Demographic Change and Urban Consolidation on Domestic Water Use

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Occasional Paper No. 15 - June 2005

Prepared by:

Centre for Population and Urban Research

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for

Water Services Association *of Australia*

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ISBN 1 920760 20 2

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Acknowledgement

The authors would like to thank staff at WSAA and Yarra Valley Water for the information concerning current patterns of water use which they provided. The modelling for this project was developed by Virginia Rapson.

Terminology

Water usage

1 kilolitre (KL) = 1,000 litres (L)

1 megalitre (ML) = 1,000,000 litres

1 gigalitre (GL) = 1,000,000,000 litres

L/D = litres per day

KL/D = kilolitres per day

KL/Y = kilolitres per year

GL/Y = gigalitres per year

Geography

SD = Statistical Division

A Statistical Division (SD) is a geographic entity used by the Australian Bureau of Statistics (ABS) for data collection. According to the ABS, each capital city SD is defined to contain the anticipated development of the city for a period of at least 20 years. This fixed SD boundary delimits an area which is stable for general statistical purposes. A boundary is only altered at infrequent intervals, for example every 15 to 20 years. The SD represents the city in a wider sense. The population projection data to 2031 used as a basis for the projected water consumption is based on Statistical Divisions, as is the other ABS data used in the modelling.

In the case of Brisbane, the Statistical Division takes in Brisbane City, Beaudesert Shire Part A, Caboolture Shire Part A, Gold Coast City Part A, Ipswich City (Part in BSD), Logan City, Pine Rivers Shire, Redcliffe City and Redland Shire.

In the case of Sydney, Sydney Water's area of operations differs from the area incorporated in the ABS's Sydney Statistical Division.

The Sydney Statistical Division comprises the statistical subdivisions of Gosford-Wyong, Outer Western Sydney, Central Northern Sydney, Northern Beaches, Eastern Suburbs, Blacktown, Fairfield-Liverpool, Outer South Western Sydney, St George Sutherland, Canterbury-Bankstown, Central Western Sydney, Lower Northern Sydney, Inner Western Sydney and Inner Sydney.

The Gosford-Wyong statistical subdivision does not lie in the area of operation of Sydney Water, however areas such as Wollongong, which are not included in the Sydney Statistical Division, do lie within Sydney Water's area of operation.

Foreword

by Ross Young, Executive Director, WSAA

The Water Services Association of Australia (WSAA) engaged the Centre for Population and Urban Research at Monash University to produce this Occasional Paper No. 15 on the Impact of Demographic Change and Urban Consolidation on Domestic Water Use.

In the past much public comment has accompanied the prospect of significant further urban consolidation in Australian cities. Many commentators have suggested that demographic changes would lead to smaller households and in turn, the inevitable result of smaller households would be denser dwelling styles with a resultant lower per capita demand for water (based on the premise that external water use would be dramatically reduced or eliminated).

The purpose of this study was to test the evidence of this rationale and the extent to which changes in housing type would compensate, at least in part, for the expected growth in population in our major cities.

Demographic change and urban consolidation are not the only influences that determine domestic water demand. As the Occasional Paper itself notes, domestic water demand is determined by a wide range of factors; including the price of the water, who pays the water bill (i.e. the consumer or the landlord), the affluence of the community, the efficiency of water using appliances, the existence and extent of water restrictions and climatic conditions, just to mention a few. This Occasional Paper focuses solely on the impact of demographic changes and urban consolidation on domestic water demand as previous studies have dealt with the above factors and the influence they have on household water demand.

Per capita consumption of water in Australian cities has been steadily declining over the last two decades and further reductions will continue into the future. Although some water utilities take into account changing household type when projecting future water consumption, the take home message from this study is that household numbers are growing faster than population and each Australian city will have greater demands placed on its water resources than anticipated if demand projections were based solely on population growth.

I commend water resource planners to take note of the analysis contained in this Occasional Paper.

Ross Young

1. Executive Summary

The purpose of this report is to estimate, in the absence of other changes, the impact of demographic change and urban consolidation (where an increased share of the dwelling stock is in the form of medium and high density housing) on domestic water consumption.

Information from the various water authorities was gathered on current (1998-99 to 2003-04) domestic water consumption levels for Melbourne, Sydney, Greater Brisbane*, Adelaide and Perth. This information included an estimate of the percentage of domestic water used outdoors in each city. Using this and other water usage data provided by Melbourne's Yarra Valley Water, consumption levels were determined for outdoor use by different garden sizes and for indoor use based on the average number of persons per household in each city. For the purpose of the study, it was assumed that there would be no change in these consumption levels over the 2001 to 2031 period.

Water consumption projections were based on four scenarios as follows:

- Scenario A assumes that per capita consumption remains stable at the 2001 rate for each city over the projection period. The 2001 per capita rates vary from between 82 KL/Y for Melbourne to 118 KL/Y for Perth.

* The Brisbane Statistical Division takes in Brisbane City, Beaudesert Shire Part A, Caboolture Shire Part A, Gold Coast City Part A, Ipswich City (Part in BSD), Logan City, Pine Rivers Shire, Redcliffe City and Redland Shire.

Executive Summary
Continued

- Scenario B is built around projections of household numbers by age and family type for each city. It assumes that these households will continue to occupy the same housing type as they did in 2001. The implication is that the proportion of the dwelling stock which is low-density housing will be maintained in each city.
- Scenario C examines the consequences for domestic water consumption should the dwellings constructed over the next thirty years echo the types of new dwellings built over the 1991 to 2001 decade. The projected households are assumed to adapt to the resulting dwelling stock (as is also the case under Scenario D).
- Scenario D explores the implications for domestic water consumption should the urban consolidation measures of State planning authorities be successful.

Projections for domestic water demand are detailed for each city. The following table summarises these projections.

Projected increase in water demand based on four scenarios - 2001 to 2031

	Scenarios			
	A	**B**	**C**	**D**
Sydney	33%	43%	38%	35%
Melbourne	33%	42%	40%	37%
Greater Brisbane	58%	73%	66%	62%
Adelaide	13%	20%	19%	18%
Perth	48%	62%	60%	53%

Population growth is the main driver of increases in domestic water consumption in each city. However, in each case, when household change is taken into account, projected water demand is considerably higher than is the case if demand projections are based just on population growth. This is because, as average household size decreases, average per capita water use within households increases. For example, in the case of Melbourne, the increase in water demand projected on the basis of population growth and a continuation of current per capita consumption levels is 33 per cent. Projections based on population growth, together with household change, indicate a 42 per cent increase in demand.

The changes in the dwelling stock over the projected period to 2031 considered in scenario C would reduce the projected domestic water consumption in each city relative to the consumption projected under scenario B, which only takes account of household change. This is largely because of the drop in the projected proportion of dwellings with large gardens – or any garden at all – consequent on an increased share of the housing stock being in the form of medium to high density dwellings. In the case of Melbourne, should the Victorian Government achieve its aspirations for urban consolidation, the projected growth in domestic water consumption between 2001 and 2031 will be 37 per cent. If the 1990s pattern of dwelling construction continues, domestic water consumption is projected to grow by 40 per cent over the same period.

This pattern is similar in the other cities, except for Adelaide where the impact on domestic water consumption due to changes in the dwelling stock is limited. This is because of the anticipated low rate of population growth, and thus dwelling construction, in the city. In the rapidly growing cities of Brisbane and Perth, urban consolidation (if the planning authorities' aspirations are met) will have a considerable impact on the dwelling stock and will lead to a lower domestic demand relative to the household change scenario. However, it will still leave domestic water demand at levels well above those that would be the case if per capita use in 2031 was the same as in 2001.

In the absence of any other changes, each city faces a much larger demand on its water supply system than would be anticipated if demand projections are based simply on population growth. For this reason, water utilities should examine the implications of population growth and household changes when projecting future water demand and re-assess their current projections in this context.

2. Impact of demographic change and urban consolidation on domestic water use

Domestic water demand is determined by a wide range of factors. These include the price at which water is sold, whether or not the consumer pays for water use at all (as in the case for renters who have been shown to use more water than home owners[1]), the relative affluence of the community (thus ability to install sophisticated watering systems or maintain a pool), and the efficiency of the appliances (such as washing machines) which each household possesses. Demand will also be influenced by whether or not water restrictions are in place. Should these restrictions limit outdoor use of water, they can have a major influence on lowering consumption levels.

This report does not deal with such issues. Nor does it deal with supply-side issues such as the impact of climate change or innovations in recycling. The focus of this report is on the demographic and urban consolidation factors, as they apply in Australia's major metropolitan locations, which will influence future domestic water consumption. In the case of the demographic factors, the most obvious is the number of people. As our cities grow in population, other things being equal, additional water will be needed. This impact can easily be estimated by multiplying current per capita demand by the projected additional population for each city. In this paper, the projection period is to 2031.

However, because most water for domestic consumption[2] is used in a household context, the amount needed will be shaped not only by population growth but by the living arrangements of the population. Thus the amount of water consumed will be affected by the rate of household growth. Each additional household means an extra dwelling. Each additional dwelling implies additional demand for water for indoor consumption, the amount varying with the number of persons in the household. If there is a garden, its maintenance will also require water, the volume of which will vary with the size and type of the garden. The number of people in the household will have little effect on the outdoor consumption of water.

The average number of persons per household does affect indoor consumption. In a society with an ageing population, as is the case in all of Australia's metropolises, the average household size is expected to become smaller because there will be more empty nests (couples, or singles, where the children have left home) and more lone person households as a result of the death of one partner in a couple household. Per capita use in a given household tends to decline with each additional household member.[3] This is because indoor water consumption partly derives from household usage and partly from personal usage. The impact of these factors on water use is assessed below on the basis of our projections of household formation in each of the five metropolitan areas.

Domestic water use will also be influenced by the pattern of dwelling construction. This is because of the very close correlation between detached houses and outdoor water usage for gardens. To the extent that households seek or are forced by economic circumstances or planning constraints on the spread of greenfield developments to seek houses on small lots (including dual occupancy developments), semi-detached houses or flats rather than detached houses on conventional sized blocks, this will diminish water usage.

In Sydney this process is already very marked (by Australian standards). Over the decade 1991 to 2001, the proportion of households living in Sydney who resided in detached houses fell from 68 to 63 per cent. The reason for this decline is that only 38 per cent of the extra dwellings added to Sydney over the period 1991 to 2001 were detached houses. Table 1 presents the number of extra dwellings added to each of the five metropolitan areas over the 1991 to 2001 decade by type of structure. As a result of these building patterns, the proportion of households living in detached houses in Melbourne fell from 77 per cent to 74 per cent over the same period, while in Adelaide this proportion was unchanged at 75 per cent over the decade.

[1] *Residential Water Use in Sydney, the Blue Mountains and Illawarra*, Independent Pricing and Regulatory Tribunal of New South Wales, Research Paper RP26, April 2004, p. 35

[2] The term 'domestic consumption' in this report refers to water consumption related to population needs and includes water consumed by persons in all residential situations, not just households.

[3] Yarra Valley Water customer accounts, average daily usage patterns

2. Impact of demographic change and urban consolidation on domestic water use *Continued*

Table 1: Increase in occupied dwellings 1991-2001 by dwelling structure as used in Scenario C, five metropolitan Statistical Divisions

	Houses	Semi detached	One-two storey flats	Three storey flats	Total	Number
Sydney	38%	25%	7%	30%	100%	218,834
Melbourne	58%	15%	17%	9%	100%	194,326
Greater Brisbane	68%	19%	4%	9%	100%	144,343
Adelaide	76%	0%	21%	3%	100%	50,896
Perth	76%	11%	10%	3%	100%	107,864

Source: ABS Census, Time series 2001

The projections below explore the implications of various scenarios regarding urban consolidation in each of Australia's metropolises for domestic water usage.

A model[4] was developed to project future water use based on current usage patterns over the last six years. As indicated above, the model does not attempt to take account of any behavioural changes which may affect water consumption. The reason for this is that the purpose of the analysis is to identify the impact of demographic and urban consolidation factors. Tables 2a and 2b show a comparison of water consumption patterns for the five metropolitan areas considered. These patterns were used as the consumption basis for the demand projections detailed below.

The figures in Table 2a are based in part on the information in *WSAAfacts* 2004 in regard to the last six years of metropolitan domestic water consumption. Estimates of amounts consumed indoors and outdoors were drawn from various sources including unpublished information on National Water Balance Sheets compiled by WSAA and information drawn from Yarra Valley Water in Melbourne. The information is internally consistent in that the internal and external consumption levels cited, when multiplied by the number of households in each city, are consistent with the total domestic consumption levels published in *WSAAfacts*.

The assumptions about consumption in Table 2a are approximations of actual levels. However, they accord fairly closely with WSAA figures on domestic consumption levels detailed in Table 2b.

[4] For a detailed description of the model, see the methodology section at the end of this paper.

2. Impact of demographic change and urban consolidation on domestic water use
Continued

Table 2a: Domestic water use in 2001 as derived from the assumptions used in the model and constrained to approximate average usage over the six years published in *WSAAfacts 2004*, five metropolitan Statistical Divisions

	Melbourne	Sydney**	Brisbane***	Adelaide	Perth
Household usage in model					
% ex-house	27%	30%	46%	39%	51%
Per capita indoors (L/D)	171	185	164	179	165
Per household – indoor and outdoor (L/D)	618	711	787	713	856
Total metropolitan annual water use (GL/Y)					
By households – indoor and outdoor	270	355	168	109	154
By persons not included as members of households*					
Visitors, persons with no household information	5	7	1	1	2
Not in private dwelling	3	4	2	1	1
Total household and other population*	278	366	171	112	157
Per capita usage (L/D)					
Total population	226	253	291	285	322
Members of households only	233	263	301	294	335
Per capita usage (KL/Y)					
Total population	82	92	106	104	118

* Includes people not counted as living in a household at the time of the 2001 Census (such as visitors, those recorded in non-private dwellings, and people counted without their living arrangements being recorded). If no information is recorded for households at the time of the Census the Australian Bureau of Statistics uses computer generated counts for persons by age and sex but not for other variables. This is more likely to occur in high rise buildings where there are entrance security measures which limit internal access to the building and its occupants.

** In the case of Sydney, Sydney Water's area of operations differs from the area incorporated in the ABS's Sydney Statistical Division.

The Sydney Statistical Division comprises the statistical subdivisions of Gosford-Wyong, Outer Western Sydney, Central Northern Sydney, Northern Beaches, Eastern Suburbs, Blacktown, Fairfield-Liverpool, Outer South Western Sydney, St George Sutherland, Canterbury-Bankstown, Central Western Sydney, Lower Northern Sydney, Inner Western Sydney and Inner Sydney.

The Gosford-Wyong statistical subdivision does not lie in the area of operation of Sydney Water, however areas such as Wollongong, which are not included in the Sydney Statistical Division, do lie within Sydney Water's area of operation.

*** The Brisbane Statistical Division (SD) takes in Brisbane City, Beaudesert Shire Part A, Caboolture Shire Part A, Gold Coast City Part A, Ipswich City (Part in BSD), Logan City, Pine Rivers Shire, Redcliffe City and Redland Shire. The 2001 Census reported that Brisbane City had a population of around 875,000 and the balance of the Brisbane SD (which takes in the other areas listed above) had a population of another 735,000 persons, to make a total of around 1,610,000 persons for the whole SD. The estimate of water use for Brisbane SD was derived partly from the Brisbane Water usage for Brisbane City, Logan and Ipswich, as reported in *WSAAfacts,* but adjustments have been made to allow for the fact that the balance of the Brisbane SD has a higher percentage of detached houses (87%) than Brisbane City (75%). Also 97 per cent of the flats of three or more storeys in the SD are in Brisbane City. It is therefore likely that usage per household is higher in the balance of the SD than in Brisbane City, partly because of higher average household size (2.8 compared with 2.5 for Brisbane City) and partly because of the higher percentage of detached houses in the dwelling stock.

Table 2b: WSAA estimates of domestic water use, five metropolitan Statistical Divisions

	Melbourne	Sydney	Brisbane ^	Adelaide	Perth
% ex-house	25%	27%	47%	40%	54%
Per household – indoor and outdoor (L/D)	616	685	709	712	822
Total household and other population (GL/Y)	287	379	165	116	160

^ The Brisbane SD data is based on the water usage reported by WSAA for Brisbane City, Logan and Ipswich. The total GL/Y has been derived by extrapolation.

Source: Derived from The Australian Urban Water Industry, WSAA*facts* 2004 *and other unpublished information supplied by WSAA*

2. Impact of demographic change and urban consolidation on domestic water use *Continued*

Melbourne Case Study

In order to explain the methodology used for the five metropolitan Statistical Divisions (SDs) examined, the paper first provides details relating to the assumptions employed for Melbourne. Following this exposition, the projections for the other metropolitan SDs are provided.

Table 3 provides projections for domestic water use in Melbourne which isolate the impact of population growth, household growth, and building patterns. These will be discussed in turn below.

Continued over page

Table 3: Projected total domestic water use (GL/Y) for Melbourne showing the influence of growth in population, change in household formation and urban consolidation

	Projected		Projected water demand (GL/Y) for an increasing population based on current patterns of usage			
			Scenario A	Scenario B	Scenario C	Scenario D
Year	Number of persons	Number of households	projected population growth (stable per capita use)	projected population growth and household change	projected population growth, household change, continuation 1991-2001 dwelling construction pattern	projected population growth, household change, urban consolidation
2001	3,367,174	1,196,161	278	278	278	278
2011	3,872,892	1,446,401	319	328	325	323
2021	4,206,532	1,640,500	347	364	360	355
2031	4,483,359	1,806,690	370	395	389	380
Change 2001-2031	1,116,185	610,529	92	117	111	102
% change	33	51	33	42	40	37

- Projected population derived from Australian Bureau of Statistics Population Projections to 2051, Series II. Projected households are derived from applying the living arrangement propensities for persons by sex and ten year age groups current at the time of the Census 2001 to the projected populations for 2011, 2021 and 2031.
- Scenario A assumes that per capita consumption remains stable at the 2001 rate of 82 KL/Y over the projection period.
- Scenario B assumes that households by age and family type will continue to occupy the same housing type as they did in 2001. This requires that cities continue to grow in area to accommodate high levels of detached housing.
- Scenario C assumes that new dwellings added to the dwelling stock in future will echo the types of new dwellings built over the 1991 to 2001 decade.
- Scenario D reflects any urban consolidation measures incorporated in the current urban strategies of Government.
- This table does not incorporate any changes which may occur in the future as to the propensities of persons in each age group to live in different living arrangements. Nor does it incorporate any behavioural changes in water consumption.
- All scenarios include an allowance for water consumed by persons whose family type is unknown (e.g. domestic visitors) and persons not residing in private dwellings but do not include an allowance for water consumed by overseas visitors.

Table 4: Assumed daily water usage (L) for Melbourne as used in Table 3 calculation

Water usage is held constant over time period

In-house	Daily use (L)	Garden use	Daily use (L)
One person	220	Large	230
Second person (80% of person 1)	176	Medium (60% of large garden)	138
Other persons (50% of person 1)	110	Small (25% of large garden)	58

Note: In Table 3 persons not included as household members have been deemed to be consuming the same amount of water (110L/D) as 'Other persons' in households.

Source: Derived from information on household median water usage supplied on customer accounts by Yarra Valley Water as shown at http://www.yvw.com.au/for-home/account/about-account/watersmart_account.html and data sourced from Yarra Valley Water Appliance Stock and Usage Patterns Survey, 2003

Melbourne Case Study
Continued

The starting point of the projection is the domestic consumption of water in 2001 (Table 2a). It is based on estimates of indoor and outdoor water usage by household and dwelling type for 2001. Table 4 indicates the consumption levels assumed for indoor and outdoor use in Melbourne by persons in each household and by size of garden. The major source for this water usage breakdown is household survey data on water consumption collected by Yarra Valley Water[5] which was adapted for utilisation in this study.[6] The total domestic use for Melbourne in 2001, as generated by the modelling and shown in Table 3, is 278 gigalitres per year. This figure is consistent with the average utilisation of water for domestic purposes over the six year period to 2003-04 as derived from *WSAAfacts*.[7] The starting assumption for water use is varied for the other four metropolitan SDs (as shown earlier in Table 2) according to information provided in *WSAAfacts* and other relevant reports of domestic water consumption.[8]

As can be seen, Table 3 provides four scenarios for future domestic water use for Melbourne. The first (Scenario A) is a simple extrapolation of domestic water use should per capita consumption remain unchanged (at the estimated 82 KL/Y current per capita consumption) to the year 2031. Should this be the case, water consumption will increase by the same percentage level as population growth. In Melbourne's case, the population is projected to increase from 3.4 million to 4.5 million (33 per cent) by 2031. On this scenario, domestic water consumption will increase from 278 GL/Y to 370 GL/Y in 2031.

In reality, water use will be affected by any change in the number and size of households relative to population, as well as any changes in dwelling type. The basis for estimates of impacts of these factors is now explored, beginning with household change.

Household change

In an ageing society, as indicated above, household numbers are expected to increase at a greater rate than population growth. These household numbers were calculated by applying current propensities for persons of different age groups to live in particular household types (couple with children, couple without children, lone parent, lone person and group households, and others).[9] For each city, these propensities were derived from the patterns current at the time of 2001 Census. Table 5 shows the outcome for Melbourne. It indicates that the growth in the number of households by 2031 will be 51 per cent, well above the 33 per cent growth in population. The reason for this outcome is that an ageing population generates smaller households because children leave home and couple households become lone person households when one partner dies. This can be seen in Table 5 where the pro-

Table 5: Projected number of persons, number of households by lone person and other households, and average household size, and change 2001 to 2031, Melbourne

Year	Number of persons	Number of Households	Lone person households	Other households	Average household size*
2001	3,367,174	1,196,161	277,778	918,383	2.65
2011	3,872,892	1,446,401	340,987	1,105,414	2.51
2021	4,206,532	1,640,500	401,276	1,239,224	2.4
2031	4,483,359	1,806,690	463,161	1,343,529	2.31
Increase 2001-2031	1,116,185	610,529	185,383	425,146	
% increase	33	51	67	46	

* Note that multiplying the average household size by the number of households will not produce the number of persons because a proportion of the population does not live in households.

5 See http://www.yvw.com.au/for-home/account/about-account/watersmart_account.html.

6 The goal was to replicate WSAA information on Residential GL/Y, Household L/D, Per capita L/D indoor usage and the percentage of household water used outdoors as closely as possible by adjusting the indoor usage of person 1 (in the model, person 2 uses 80% of the amount of water used by person 1 and subsequent persons use 50% of the amount used by person 1). Outdoor usage was also adjusted by the amount used in a large garden (a medium garden uses 60% of a large garden and a small garden uses 25% of a large garden). At the same time the indoor use of person 1 in each of the five metro-politan areas was constrained to 210-240 L/D. Data supplied on Yarra Valley Water accounts for median use for different household and garden sizes were used as a starting point for these assumptions and sourced from Yarra Valley Water Appliance Stock and Usage Patterns Survey, 2003.

7 The Australian Urban Water Industry, *WSAAfacts 2004*

8 See, for example, Michael Loh, Peter Coghlan, *Domestic Water Use Study in Perth, Western Australia, 1998-2001*, Water Corporation 2003; *Residential Water Use in Sydney, the Blue Mountains and Illawarra*, op.cit.

9 The current propensities may not reflect future living arrangements accurately, but to change them involves conjecture on future social patterns.

Melbourne Case Study
Continued

jected number of lone person households in Melbourne increases by 67 per cent, compared with the overall rate of household growth of 51 per cent. One consequence is that the average household size in Melbourne drops from 2.65 in 2001 to 2.31 in 2031.

The model also takes account of dwelling type preferences for each age group and family type as of 2001. This is projected forward for each of the three decades. Because persons, particularly older persons, had a relatively high propensity to occupy detached houses with gardens in 2001, this assumption does generate a slight increase in the proportion of households who occupy detached houses over the 2001 to 2031 period. Even though this does affect domestic water use relative to the base population Scenario A somewhat, the overall impact on water consumption is marginal.

The implication of these household projections for domestic water use is shown in Scenario B of Table 3. Domestic water use grows by 42 per cent rather than 33 per cent in the population growth scenario, but falls short of the projected 51 per cent growth in the number of households.

Under Scenario B, outdoor use will grow about the same pace as the number of households because there is little change in the proportion of dwellings with gardens (Table 6). The explanation for the projected 42 per cent rate of growth is related to indoor use patterns. Total water use indoors does not grow as fast as the growth in total household numbers because of the projected decline in household size. On the other hand, this effect is counteracted to a degree because of the contraction of household size – there are more households of one or two members, and thus the per capita consumption of the persons in each household will be higher.

In addition, as the population ages, the numbers of persons living outside households (as in institutional care) increase. It is assumed that their water consumption is relatively low (equivalent to a third person in a household).

Nonetheless, the effect of household change is to add a significant additional component to metropolitan domestic demand over the projected period (other things being equal).

Implications of urban consolidation

In most Australian metropolises, the respective State planning authorities propose to implement policies aimed at increasing urban consolidation. Also, particularly for Sydney, geographical barriers limit the spread of detached housing estates on the fringe. To the extent that these factors result in an increasing proportion of apartments (particularly in multi-storey blocks) in the dwelling stock, then the average household use of water should decline because of the absence of outdoor gardens. Urban consolidation policies could also result in a reduction in the size of gardens surrounding detached houses, should the planning regulations, and/or geographical constraints, lead to smaller block sizes in new estates. The trend towards larger houses which cover a greater proportion of the site will also reduce garden size.

Two different urban consolidation scenarios are provided. The first, shown in Scenario C of Table 3, assumes that the pattern of dwelling construction in the decade 1991 to 2001 in each of the five cities will be maintained over the next three decades. In the cases of Melbourne, Sydney and Brisbane, the overall proportion of detached dwellings will decline and the share of medium and high density dwellings will increase. Under Scenario C, the changes in Adelaide and Perth are not so marked.

Table 6, Scenario C, presents the outcome of this assumption for Melbourne. It shows that the overall proportion of houses in the dwelling stock drops from 75 per cent in 2001 to 69 per cent in 2031. On the other hand, the proportion of the dwelling stock which is composed of semi-detached dwellings increases from 10 to 12 per cent, one-to-two storey flats increase from 9 per cent to 12 per cent and three-storey-or-higher flats increase from 5 to 6 per cent.

The consequence for Melbourne under Scenario C (see Table 3) is that domestic water consumption grows by 40 per cent between 2001 and 2031. This is slightly lower than the 42 per cent projected growth under Scenario B. The reason for the lower figure is primarily that the proportion of dwellings with gardens declines because of the increase in the share of medium and high density dwellings.

Melbourne Case Study
Continued

The second urban consolidation scenario (Scenario D) projects the implications for domestic water consumption should the Melbourne 2030 planning scheme achieve its aspiration to promote the construction of apartments in Activity Centres and reduce the proportion of the new dwelling stock built on greenfield estates.

Melbourne 2030 will permit the construction of multi-storey flats and apartments across some 119 nodes of commercial and transport activity across Melbourne. Should the urban consolidation aspiration be achieved, the proportion of dwellings which are houses as of 2011, 2021 and 2031 will drop much more sharply than in Scenario C. In the latter, by 2031 the share of houses in the dwelling stock was projected to fall to 69 per cent. However, in Scenario D this share is projected to fall to 64 per cent of the dwelling stock. Because of the assumption that the Activity Centre policy will succeed, the share of the dwellings which are three-storey flats or higher is projected to be 12 per cent by 2031, compared with 6 per cent in Scenario C.

Under Scenario D it is anticipated that the proportion of houses with large gardens will decline and that the proportion of one-to-two storey flats with gardens will also diminish. This is because, under the consolidation scenario, block sizes for detached houses will tend to be smaller, and, in the case of one-to-two storey flats, more will be two-storey and thus lack their own garden. In regard to flats of three storeys or higher, it is assumed that, under all scenarios, individual dwellings do not have a garden.

Table 6: Assumptions about dwelling and garden characteristics used in Scenarios B, C and D, Melbourne

Built environment factors influencing outdoor usage	Year	Scenario B Continuation 2001 current housing pattern	Scenario C Continuation building pattern 1991-2001	Scenario D Urban consolidation policies
% dwellings which are houses	2001	75%	75%	75%
	2011	75%	72%	71%
	2021	75%	70%	67%
	2031	75%	69%	64%
% houses with large garden	2001	65%	65%	65%
(other houses assumed to have	2011	65%	65%	62%
medium size garden)	2021	65%	65%	60%
	2031	65%	65%	59%
% dwellings which are semi-detached	2001	10%	10%	10%
(assumed to have medium size garden)	2011	10%	11%	12%
	2021	10%	12%	13%
	2031	10%	12%	14%
% dwellings which are 1-2 storey flats	2001	9%	9%	9%
	2011	9%	10%	10%
	2021	9%	11%	10%
	2031	9%	12%	10%
% 1-2 storey flats with garden	2001	65%	65%	65%
(assumed to be small garden)	2011	65%	63%	60%
	2021	65%	61%	55%
	2031	65%	59%	50%
% dwellings which are 3+ storey flats	2001	5%	5%	5%
	2011	4%	5%	6%
	2021	4%	6%	9%
	2031	4%	6%	12%

Melbourne Case Study
Continued

The impact of these assumptions is shown for Melbourne in Table 6 under Scenario D. For example, in the case of houses, the proportion with a large garden is 65 per cent in 2001 but falls to 59 per cent in 2031. There are no accurate statistics on this issue. The assumption used in this report is that large gardens in Australia's cities are found where block sizes are over 600 square metres. In recent years, however, lot sizes on the frontier in Melbourne[10] (and other cities in Australia) have trended below 600 square metres at the same time as the size of houses in terms of site coverage has increased.

The implication of these changes in dwelling characteristics under the urban consolidation Scenario D for water consumption is that total domestic water consumption increases by 37 per cent between 2001 and 2031, instead of the 40 per cent under Scenario C and 42 per cent under Scenario B. Thus it is projected that urban consolidation will reduce water consumption, mainly because the additional multi-storey flats will not add to outdoor water use. Another less significant contributor to reducing water consumption in the consolidation scenario is the decreased garden sizes associated with new detached houses.

In practice, the effect of changes in dwelling structure between 2001 and 2031 on water use is likely to lie somewhere between the projections under Scenario B and Scenario D. The outcome may well be closer to the 40 per cent projected growth rate (that assumes that the 1991 to 2001 pattern of dwelling construction will be maintained), because the Melbourne 2030 planning template is aspirational rather than prescriptive. The Urban Growth Boundary is flexible, in that the Victorian Government has made it clear that if land on the fringe falls short of a 15 year supply benchmark, then further land will be allocated for such development. Likewise, in regard to Activity Centres, developers will have the statutory right to construct apartments in these centres, but this is only likely to occur if they can find willing customers. Our analysis elsewhere concluded that relatively few households would wish to make a move into apartment living in an Activity Centre.[11]

Summary

In the case of Melbourne, the impact of population growth is fundamental in shaping projected domestic water consumption. The city will have to provide for a major increase in water for its domestic users if there are no changes in per capita and household water usage. The ageing of the city's population and the consequence growth in household numbers adds a further component to the projected water consumption; increasing it to 42 per cent. If the urban consolidation policies articulated by the Victorian Government are successful, they will reduce the growth in the domestic consumption of water to an increase of 37 per cent on the present usage. This is close to, but still above, the 33 per cent growth anticipated if the only factor shaping demand was population growth.

Even under the unlikely Scenario D circumstance, there will be an increase in demand for water for domestic purposes over the 2001 to 2031 period of 102 GL/Y. WSAA estimates that domestic consumption accounts for about 55 per cent of total water usage in Melbourne. It is likely that, as population grows, there will also be growth in demand from industry, commerce and government. The estimated yield of Melbourne's water supply system is 566 GL/Y and on average Melbourne uses 480 GL/Y.[12] The projected increase in domestic demand of 102 GL/Y will alone take consumption to 582 GL/Y, which is above the currently available water supply for Melbourne. In the absence of new sources of supply, and if current reliability of supply service standards is to be maintained, there will have to be major cut backs in per capita water use, as the Victorian Government has already flagged.

10 Bob Birrell, Kevin O'Connor, Virginia Rapson and Ernest Healy, *Melbourne 2030: Planning Rhetoric Versus Urban Reality*, Monash University ePress, 2005, Chapter 3, p.5 and Chapter 5, pp. 27-28

11 ibid., Chapter 4, pp. 6-16

12 Nancy. F. Millis, 'Urban water cycle', in CEDA, *Water and the Australian Economy*, Growth no. 52, March 2004, p. 55

Sydney Case Study

The per capita water usage in Sydney is higher than for Melbourne for both indoor and outdoor water use (see Table 2a).[13] The data is for the average usage of the last six years. Current water usage is lower than the six-year average because of the recent restrictions on outdoor water use in Sydney.

Sydney's population is projected to grow by 1.3 million between 2001 and 2031[14]. This represents a growth of 33 per cent, which almost identical to the increase projected for Melbourne. The population based scenario and the three other scenarios for Sydney are shown in Table 7.

Scenario B, which reflects changes in household composition, indicates that domestic water consumption will be considerably higher (43 per cent) than in Scenario A (33 per cent), as shown in Table 7. The pattern is very similar to that of Melbourne. Though household size in Sydney (2.71) is marginally higher than in Melbourne (2.65) as of 2001, and remains so until 2031, the rate of change in the direction of smaller households is identical.

Sydney is notable, however, in the impact of the two consolidation scenarios. They imply much sharper trends towards medium and high density dwellings.

Table 7: Projected domestic water use (GL/Y) for Sydney showing the influence of growth in population, change in household formation and urban consolidation

	Projected		Projected water demand (GL/Y) for an increasing population based on current patterns of usage			
			Scenario A	Scenario B	Scenario C	Scenario D
Year	Number of persons	Number of households	projected population growth (stable per capita use)	projected population growth and household change	projected population growth, household change, continuation 1991-2001 dwelling construction pattern	projected population growth, household change, urban consolidation
2001	3,961,391	1,366,325	366	366	366	368
2011	4,539,267	1,652,308	420	433	425	425
2021	4,924,659	1,871,715	455	481	468	465
2031	5,253,148	2,065,470	486	522	504	498
Change 2001-2031	1,291,757	699,145	119	156	138	130
% change	33	51	33	43	38	35

- Projected population derived from Australian Bureau of Statistics Population Projections to 2051, Series II.
- Projected households are derived from applying the living arrangement propensities for persons by sex and ten year age groups current at the time of the Census 2001 to the projected populations for 2011, 2021 and 2031.
- Scenario A assumes that per capita consumption remains stable at the 2001 rate of 92 KL/Y over the projection period.
- Scenario B assumes that households by age and family type will continue to occupy the same housing type as they did in 2001. This requires that cities continue to grow in area to accommodate high levels of detached housing.
- Scenario C assumes that new dwellings added to the dwelling stock in future will echo the types of new dwellings built over the 1991 to 2001 decade.
- Scenario D reflects any urban consolidation measures incorporated in the current urban strategies of Government.
- This table does not incorporate any changes which may occur in the future as to the propensities of persons in each age group to live in different living arrangements. Nor does it incorporate any behavioural changes in water consumption.
- All scenarios include an allowance for water consumed by persons whose family type is unknown (e.g. domestic visitors) and persons not residing in private dwellings but do not include an allowance for water consumed by overseas visitors.

[13] It is not clear why this is the case but one reason may be the high proportion of unmetered dwellings (units and apartments) in Sydney which is related to higher water use (reported by the Auditor General's Report Performance Audit, *Planning for Sydney's Water Needs*, May 2005). Another factor could be that most tenants in Sydney do not pay a volumetric charge for water, whereas in Victoria tenants pay the volumetric component of the water bill (WSAA, personal communication).

[14] As previously outlined, this population projection is based on the ABS Sydney SD, which does not correspond to Sydney Water's operational boundary. For instance, the Sydney SD includes the local government areas of Gosford and Wyong (which are outside of Sydney Water's operational boundary), but excludes the Illawarra AD which is serviced by Sydney Water. For this reason comparisons with population projections in this paper based on the Sydney SD, are problematic.

Sydney Case Study
Continued

Under Scenario C, which projects the water consumption where the construction pattern of the decade 1991 to 2001 is maintained, domestic water consumption drops more than in Melbourne (40 per cent) to 38 per cent. As indicated in Table 10, the proportion of houses in the dwelling stock drops from 65 per cent in 2001 to 56 per cent in 2031.

Under Scenario D where it has been assumed that there is a continued decline in the proportion of houses constructed in each of the three decades to 2031, the proportion of the dwelling stock in the form of houses drops from 65 per cent in 2001 to 53 per cent in 2031. It is also assumed in this scenario that the major point of growth in the dwelling stock is in dwellings that are buildings of three storeys or higher. These are projected to grow from 16 per cent of the dwelling stock in 2001 to 24 per cent in 2031. Under this scenario and Scenario C, the proportion of houses with large gardens also declines. The effect of these assumptions is that the increase in domestic water use in Sydney under Scenario D falls by a further three percentage points, relative to Scenario C, to 35 per cent.

Even under Scenario D, the total projected growth for domestic use by 2031 is 130 GL/Y. Sydney already faces supply problems because the system yield from the existing water storage is around 600 GL/Y. This figure approximates the actual use of water in Sydney for domestic use (around 62 per cent) and other uses (27 per cent) (plus losses of 11 per cent).[15] In other words, in the absence of severe reductions in per capita water use by domestic (and other) consumers, major new sources of supply will be required well before 2031.

Further urban consolidation is inevitable in Sydney regardless of government policy on the matter because there are severe geographical constraints on the extension of the suburban frontier in Sydney. These reflect the presence of National Parks, the Blue Mountains and the Nepean-Hawkesbury drainage system. There is simply much less space for detached housing estates on the urban frontier than is the case with the other State capital cities. It may well be that Scenario D represents a likely outcome for Sydney.

The assumptions underlying the projections in Table 7 are shown in Tables 8, 9 and 10.

Table 8: Assumed daily water usage (L) used in Table 7 calculation, Sydney

Water usage is held constant over time period

In-house	Daily use (L)	Garden use	Daily use (L)
One person	240	Large	340
Second person	192	Medium	204
Other persons	120	Small	85

Note: In Table 7 persons not included as household members have been deemed to be consuming the same amount of water (120L/D) as 'Other persons' in households.

Table 9: Projected number of persons, number of households by lone person and other households, and average household size, and change 2001 to 2031, Sydney

Year	Number of persons	Number of Households	Lone person households	Other households	Average household size*
2001	3,961,391	1,366,325	305,676	1,060,649	2.71
2011	4,539,267	1,652,308	373,179	1,279,130	2.56
2021	4,924,659	1,871,715	438,958	1,432,757	2.44
2031	5,253,148	2,065,470	509,154	1,556,316	2.36
Increase 2001-2031	1,291,757	699,145	203,478	495,667	
% increase	33	51	67	47	

* Note that multiplying the average household size by the number of households will not produce the number of persons because a proportion of the population does not live in households.

[15] Auditor General's Report Performance Audit, *Planning for Sydney's Water Needs*, May 2005, p. 14, p. 20. While Sydney Water's Annual Report indicates that 11.7 per cent of water released from its reservoirs is 'unaccounted for', its 'real losses' are estimated at 9.3 per cent (*Sydney Morning Herald*, 31 May 2005, p. 7).

Sydney Case Study
Continued

Table 10: Assumptions about dwelling and garden characteristics used in Scenarios B, C and D, Sydney

Built environment factors influencing outdoor usage	Year	Scenario B Continuation 2001 current housing pattern	Scenario C Continuation building pattern 1991-2001	Scenario D Urban consolidation policies
% dwellings which are houses	2001	65%	65%	65%
	2011	65%	60%	59%
	2021	65%	57%	56%
	2031	66%	56%	53%
% houses with large garden	2001	60%	60%	60%
(other houses assumed to have	2011	60%	57%	57%
medium size garden)	2021	60%	55%	55%
	2031	60%	53%	53%
% dwellings which are semi-detached	2001	11%	11%	11%
(assumed to have medium size garden)	2011	11%	14%	13%
	2021	11%	15%	14%
	2031	11%	16%	14%
% dwellings which are 1-2 storey flats	2001	7%	7%	7%
	2011	6%	7%	7%
	2021	7%	7%	7%
	2031	7%	7%	8%
% 1-2 storey flats with garden	2001	55%	55%	55%
(assumed to be small garden)	2011	55%	53%	50%
	2021	55%	51%	45%
	2031	55%	49%	40%
% dwellings which are 3+ storey flats	2001	16%	16%	16%
	2011	16%	18%	19%
	2021	15%	20%	22%
	2031	15%	21%	24%

Greater Brisbane Case Study

As shown in Table 2a, the average household use of water in Greater Brisbane is high relative to Sydney and Melbourne because of the high use of water outdoors. The share of Greater Brisbane's housing stock which is in the form of detached houses is high (81 per cent) compared with Sydney (65 per cent) and Melbourne (75 per cent). (Note that this refers to the Statistical Division of Brisbane, not just the Brisbane City area.)

Because Greater Brisbane's population is projected to grow by 58 per cent from 2001 to 2031, should the current consumption pattern persist, domestic water consumption will also grow rapidly. Table 11 provides the projections under the same set of scenarios as displayed above for Melbourne and Sydney. (The assumptions underlying the Greater Brisbane projections are shown in Tables 12, 13 and 14.) Scenario B indicates that the effect of household change (other things being equal) will be to push up the growth in domestic water use from the 58 per cent of Scenario A to 73 per cent. However, under Scenario C, growth will be lower because the proportion of additional dwellings in the Brisbane Statistical Division over the decade 1991-2001 which were detached houses fell to 69 per cent – a level well below the 81 per cent figure for the 2001 dwelling stock. Should this construction pattern continue, the overall growth in domestic water consumption in the Brisbane SD will be 66 per cent by 2031.

It is possible that the share of detached houses will contract further because the Queensland Government is currently proposing to encourage further urban consolidation. In Scenario D, it is assumed that the effect will be to reduce the proportion of the dwelling stock in the form of detached houses to 71 per cent (compared with 75 per cent in Scenario C), as well as result in the proportion of higher density dwellings and smaller garden size (as detailed in Table 14). The consequence is that the growth in domestic water consumption in the Brisbane SD will be 62 per cent.

Table 11: Projected domestic water use (GL/Y) for Greater Brisbane showing the influence of growth in population, change in household formation and urban consolidation

	Projected		Projected water demand (GL/Y) for an increasing population based on current patterns of usage			
			Scenario A	Scenario B	Scenario C	Scenario D
Year	Number of persons	Number of households	projected population growth (stable per capita use)	projected population growth and household change	projected population growth, household change, continuation 1991-2001 dwelling construction pattern	projected population growth, household change, urban consolidation
2001	1,609,084	584,659	171	171	171	171
2011	1,971,551	754,757	209	217	213	211
2021	2,272,367	912,904	241	258	250	245
2031	2,547,735	1,061,859	271	295	284	276
Change 2001-2031	938,651	477,200	100	125	113	105
% change	58	82	58	73	66	62

- Projected population derived from Australian Bureau of Statistics Population Projections to 2051, Series II. Projected households are derived from applying the living arrangement propensities for persons by sex and ten year age groups current at the time of the Census 2001 to the projected populations for 2011, 2021 and 2031.
- Scenario A assumes that per capita consumption remains stable at the 2001 rate of 106 KL/Y over the projection period.
- Scenario B assumes that households by age and family type will continue to occupy the same housing type as they did in 2001. This requires that cities continue to grow in area to accommodate high levels of detached housing.
- Scenario C assumes that new dwellings added to the dwelling stock in future will echo the types of new dwellings built over the 1991 to 2001 decade.
- Scenario D reflects any urban consolidation measures incorporated in the current urban strategies of Government.
- This table does not incorporate any changes which may occur in the future as to the propensities of persons in each age group to live in different living arrangements. Nor does it incorporate any behavioural changes in water consumption.
- All scenarios include an allowance for water consumed by persons whose family type is unknown (e.g. domestic visitors) and persons not residing in private dwellings but do not include an allowance for water consumed by overseas visitors.

Greater Brisbane Case Study
Continued

Table 12: Assumed daily water usage (L) used in Table 11 calculation, Greater Brisbane

Water usage is held constant over time period

In-house	Daily use (L)	Garden use	Daily use (L)
One person	210	Large	450
Second person	168	Medium	270
Other persons	105	Small	113

Note: In Table 11 persons not included as household members have been deemed to be consuming the same amount of water (105L/D) as 'Other persons' in households.

Table 13: Projected number of persons, number of households by lone person and other households, and average household size, and change 2001 to 2031, Greater Brisbane

Year	Number of persons	Number of Households	Lone person households	Other households	Average household size*
2001	1,609,084	584,659	133,646	451,013	2.62
2011	1,971,551	754,757	175,940	578,817	2.48
2021	2,272,367	912,904	223,550	689,354	2.35
2031	2,547,735	1,061,859	274,234	787,625	2.26
Increase 2001-2031	938,651	477,200	140,588	336,612	
% increase	58	82	105	75	

* Note that multiplying the average household size by the number of households will not produce the number of persons because a proportion of the population does not live in households.

Table 14: Assumptions about dwelling and garden characteristics used in Scenarios B, C and D, Greater Brisbane

Built environment factors influencing outdoor usage	Year	Scenario B Continuation 2001 current housing pattern	Scenario C Continuation building pattern 1991-2001	Scenario D Urban consolidation policies
% dwellings which are houses	2001	81%	81%	81%
	2011	81%	78%	77%
	2021	81%	76%	74%
	2031	81%	75%	71%
% houses with large garden (other houses assumed to have medium size garden)	2001	80%	80%	80%
	2011	80%	74%	71%
	2021	80%	70%	64%
	2031	80%	66%	60%
% dwellings which are semi-detached (assumed to have medium size garden)	2001	7%	7%	7%
	2011	6%	9%	9%
	2021	7%	11%	11%
	2031	7%	12%	13%
% dwellings which are 1-2 storey flats	2001	6%	6%	6%
	2011	6%	6%	6%
	2021	6%	6%	6%
	2031	6%	5%	7%
% 1-2 storey flats with garden (assumed to be small garden)	2001	90%	90%	90%
	2011	90%	88%	85%
	2021	90%	86%	80%
	2031	90%	84%	75%
% dwellings which are 3+ storey flats	2001	5%	5%	5%
	2011	5%	6%	6%
	2021	5%	6%	7%
	2031	5%	7%	8%

Adelaide Case Study

Water consumption levels in Adelaide per household are relatively high because of the extensive use of water outdoors. However, by contrast with the other metropolitan areas considered in this report, Adelaide faces low increases in demand for water because of the relatively low rate of projected population growth.

Population growth is expected to be around 13 per cent by 2031. However, household growth in Adelaide is expected to be much faster relative to population growth than is the case in the other metropolises because of the high average age of Adelaide's population. For example, Table 15 shows that the number of households will grow almost twice as fast as population in Adelaide. By comparison, in Sydney the number of households grows only around one and a half times as fast as the population.

The implication of this household growth for water use can be seen under Scenario B which indicates that, as a consequence of household change, domestic water consumption will grow by 20 per cent. In Adelaide the effects of changes in dwelling type shown in Scenarios C and D are very limited. Even under the urban consolidation Scenario D, domestic water use grows by 18 per cent. One reason is that the recent pattern of dwelling construction in Adelaide approximates the existing dwelling stock. Another more important factor is, because population growth is low, the extent of anticipated new dwelling construction is also low. Thus, even though it has been assumed in Scenario D that the share of detached houses constructed over the next three decades will fall sharply from 76 per cent of the 1991-2001 decade to 50 per cent by the decade 2021-2031, this assumption has only a minor impact on domestic water use in Adelaide.

The assumptions underlying the projections in Table 15 are shown in Tables 16, 17 and 18.

Table 15: Projected domestic water use (GL/Y) for Adelaide showing the influence of growth in population, change in household formation and urban consolidation

	Projected		Projected water demand (GL/Y) for an increasing population based on current patterns of usage			
			Scenario A	Scenario B	Scenario C	Scenario D
Year	Number of persons	Number of households	projected population growth (stable per capita use)	projected population growth and household change	projected population growth, household change, continuation 1991-2001 dwelling construction pattern	projected population growth, household change, urban consolidation
2001	1,073,728	419,999	112	112	112	112
2011	1,161,109	471,617	121	123	123	123
2021	1,196,970	505,053	124	130	129	128
2031	1,211,901	526,336	126	134	132	132
Change 2001-2031	138,173	106,337	14	22	21	20
% change	13	25	13	20	19	18

- Projected population derived from Australian Bureau of Statistics Population Projections to 2051, Series II. Projected households are derived from applying the living arrangement propensities for persons by sex and ten year age groups current at the time of the Census 2001 to the projected populations for 2011, 2021 and 2031.
- Scenario A assumes that per capita consumption remains stable at the 2001 rate of 104 KL/Y over the projection period.
- Scenario B assumes that households by age and family type will continue to occupy the same housing type as they did in 2001. This requires that cities continue to grow in area to accommodate high levels of detached housing.
- Scenario C assumes that new dwellings added to the dwelling stock in future will echo the types of new dwellings built over the 1991 to 2001 decade.
- Scenario D reflects any urban consolidation measures incorporated in the current urban strategies of Government.
- This table does not incorporate any changes which may occur in the future as to the propensities of persons in each age group to live in different living arrangements. Nor does it incorporate any behavioural changes in water consumption.
- All scenarios include an allowance for water consumed by persons whose family type is unknown (e.g. domestic visitors) and persons not residing in private dwellings but do not include an allowance for water consumed by overseas visitors.

Adelaide Case Study
Continued

Table 16: Assumed daily water usage (L) used in Table 15 calculation, Adelaide

Water usage is held constant over time period

In-house	Daily use (L)	Garden use	Daily use (L)
One person	225	Large	360
Second person	180	Medium	216
Other persons	113	Small	90

Note: In Table 15 persons not included as household members have been deemed to be consuming the same amount of water (113L/D) as 'Other persons' in households.

Table 17: Projected number of persons, number of households by lone person and other households, and average household size, and change 2001 to 2031, Adelaide

Year	Number of persons	Number of Households	Lone person households	Other households	Average household size*
2001	1,073,728	419,999	117,202	302,797	2.42
2011	1,161,109	471,617	133,899	337,718	2.32
2021	1,196,970	505,053	148,478	356,575	2.23
2031	1,211,901	526,336	161,998	364,338	2.16
Increase 2001-2031	138,173	106,337	44,796	61,541	
% increase	13	25	38	20	

* Note that multiplying the average household size by the number of households will not produce the number of persons because a proportion of the population does not live in households.

Table 18: Assumptions about dwelling and garden characteristics used in Scenarios B, C and D, Adelaide

Built environment factors influencing outdoor usage	Year	Scenario B Continuation 2001 current housing pattern	Scenario C Continuation building pattern 1991-2001	Scenario D Urban consolidation policies
% dwellings which are houses	2001	76%	76%	76%
	2011	76%	76%	75%
	2021	75%	76%	74%
	2031	74%	76%	73%
% houses with large garden	2001	75%	75%	75%
(other houses assumed to have	2011	75%	73%	73%
medium size garden)	2021	75%	72%	72%
	2031	75%	72%	71%
% dwellings which are semi-detached	2001	13%	13%	13%
(assumed to have medium size garden)	2011	13%	12%	13%
	2021	13%	11%	13%
	2031	14%	11%	14%
% dwellings which are 1-2 storey flats	2001	9%	9%	9%
	2011	9%	10%	10%
	2021	9%	11%	10%
	2031	10%	12%	10%
% 1-2 storey flats with garden	2001	65%	65%	65%
(assumed to be small garden)	2011	65%	63%	60%
	2021	65%	61%	55%
	2031	65%	59%	50%
% dwellings which are 3+ storey flats	2001	1%	1%	1%
	2011	1%	1%	2%
	2021	1%	1%	2%
	2031	1%	1%	2%

Perth Case Study

The implications of population growth in Perth for water availability are serious because the existing sources of the supply derived from nearby catchments are close to being fully utilised and inflows into Perth's storages have reduced significantly over the last 30 years.[16] Yet, the city's population is projected to grow by 48 per cent by the year 2031. Perth residents are also heavy water consumers. As indicated in Tables 2a and b, the average household use is more than 800 L/D, of which more than half is consumed by outdoor use.

As with the other metropolitan areas, it is assumed in the scenarios in Table 19 that current domestic water use patterns will be maintained. Should this be the case, under Scenario A, where domestic per capita water use remains stable, there will be a 48 per cent increase in domestic use of water. Under Scenario B, which takes account of changes in household patterns, domestic water use will increase by 62 per cent. As with the other cities, this increase is largely attributable to the effect of an ageing population and the accompanying decline in average household size.

Should the 1991-2001 pattern of dwelling construction by dwelling type be maintained, as shown in Scenario C, the increased demand will only be a little less (60 per cent) than under Scenario B. The reason is that development in Perth over this decade was predominately low density detached housing. There is scope for significant reduction in water use, should urban consolidation policies be pursued in Perth. In Scenario D it is assumed that, by the third decade 2021-2031, the proportion of total dwellings constructed which are detached houses will fall to 55 per cent from the 76 per cent level of the 1991-2001 decade. Under this scenario the proportion of houses with large gardens also falls (see Table 22). Under these circumstances, the growth in domestic water consumption will be lower, at 53 per cent.

The assumptions underlying the projections in Table 19 are shown in Tables 20, 21 and 22.

Table 19: Projected domestic water use (GL/Y) for Perth showing the influence of growth in population, change in household formation and urban consolidation

	Projected		Projected water demand (GL/Y) for an increasing population			
			Scenario A	Scenario B	Scenario C	Scenario D
Year	Number of persons	Number of households	projected population growth (stable per capita use)	projected population growth and household change	projected population growth, household change, continuation 1991-2001 dwelling construction pattern	projected population growth, household change, urban consolidation
2001	1,336,245	493,469	157	157	157	157
2011	1,601,585	627,376	188	195	195	191
2021	1,802,556	741,587	212	227	225	218
2031	1,979,208	844,071	233	254	252	240
Change 2001-2031	642,963	350,602	76	97	95	83
% change	48	71	48	62	60	53

- Projected population derived from Australian Bureau of Statistics Population Projections to 2051, Series II. Projected households are derived from applying the living arrangement propensities for persons by sex and ten year age groups current at the time of the Census 2001 to the projected populations for 2011, 2021 and 2031.
- Scenario A assumes that per capita consumption remains stable at the 2001 rate of 118 KL/Y over the projection period.
- Scenario B assumes that households by age and family type will continue to occupy the same housing type as they did in 2001. This requires that cities continue to grow in area to accommodate high levels of detached housing.
- Scenario C assumes that new dwellings added to the dwelling stock in future will echo the types of new dwellings built over the 1991 to 2001 decade.
- Scenario D reflects any urban consolidation measures incorporated in the current urban strategies of Government.
- This table does not incorporate any changes which may occur in the future as to the propensities of persons in each age group to live in different living arrangements. Nor does it incorporate any behavioural changes in water consumption.
- All scenarios include an allowance for water consumed by persons whose family type is unknown (e.g. domestic visitors) and persons not residing in private dwellings but do not include an allowance for water consumed by overseas visitors.

[16] The reduction in runoff into surface water storages experienced in Perth is such that the stream flows for the last eight years (including 2004) have been 64 per cent down on those up to 1974 (WSAA, personal communication).

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Continued

Table 20: Assumed daily water usage (L) used in Table 19 calculation, Perth

Water usage is held constant over time period

In-house	Daily use (L)	Garden use	Daily use (L)
One person	210	Large	520
Second person	168	Medium	312
Other persons	105	Small	130

Note: In Table 19 persons not included as household members have been deemed to be consuming the same amount of water (105L/D) as 'Other persons' in households.

Table 21: Projected number of persons, number of households by lone person and other households, and average household size, and change 2001 to 2031, Perth

Year	Number of persons	Number of Households	Lone person households	Other households	Average household size*
2001	1,336,245	493,469	122,342	371,127	2.55
2011	1,601,585	627,376	159,180	468,196	2.4
2021	1,802,556	741,587	196,951	544,637	2.28
2031	1,979,208	844,071	235,681	608,390	2.19
Increase 2001-2031	642,963	350,602	113,339	237,263	
% increase	48	71	93	64	

* Note that multiplying the average household size by the number of households will not produce the number of persons because a proportion of the population does not live in households.

Table 22: Assumptions about dwelling and garden characteristics used in Scenarios B, C and D, Perth

Built environment factors influencing outdoor usage	Year	Scenario B Continuation 2001 current housing pattern	Scenario C Continuation building pattern 1991-2001	Scenario D Urban consolidation policies
% dwellings which are houses	2001	78%	78%	78%
	2011	78%	78%	77%
	2021	77%	78%	75%
	2031	77%	77%	72%
% houses with large garden	2001	90%	90%	90%
(other houses assumed to have	2011	90%	88%	80%
medium size garden)	2021	90%	86%	74%
	2031	90%	84%	70%
% dwellings which are semi-detached	2001	13%	13%	13%
(assumed to have medium size garden)	2011	13%	12%	13%
	2021	13%	12%	14%
	2031	13%	12%	14%
% dwellings which are 1-2 storey flats	2001	4%	4%	4%
	2011	6%	6%	6%
	2021	6%	6%	7%
	2031	7%	7%	8%
% 1-2 storey flats with garden	2001	80%	80%	80%
(assumed to be small garden)	2011	80%	78%	75%
	2021	80%	76%	70%
	2031	80%	74%	65%
% dwellings which are 3+ storey flats	2001	3%	3%	3%
	2011	3%	3%	4%
	2021	3%	3%	4%
	2031	3%	3%	5%

3. Conclusion

Table 23 provides a summary of the projected growth in domestic water consumption in each of the five cities under the four scenarios described in the previous chapter. The table highlights the underlying importance of population growth as the prime determinant of the projected growth in water consumption in each city.

The summary also makes clear the very important impact of household change (other things being unchanged) in the projected growth in domestic water consumption. As discussed above, the main determinant of the relatively high rates of household growth (by comparison with population growth) is due to the ageing of Australia's metropolitan populations. In the absence of any other changes, each city faces a much larger demand on its water supply system than would be anticipated if demand projections are based simply on population growth.

Should the respective cities achieve their stated urban consolidation objectives, this would have a significant impact on reducing the projected domestic water consumption growth relative to the household change scenario. The outlook for these consolidation policies is uncertain. A more modest, and probably more achievable, outcome for urban consolidation, as indicated in Scenario C, suggests that the reduction in water consumption due to urban consolidation, though significant, will still leave the anticipated consumption level well above what it would be if per capita consumption remains at the current level for each city.

Table 23: Projected total domestic water use (GL/Y) for five metropolitan areas showing the influence of growth in population, change in household formation and urban consolidation

	Projected		Projected water demand (GL/Y) for an increasing population			
			Scenario A	Scenario B	Scenario C	Scenario D
Year	Number of persons	Number of households	projected population growth (stable per capita use)	projected population growth and household change	projected population growth, household change, continuation 1991-2001 dwelling construction pattern	projected population growth, household change, urban consolidation
Melbourne						
2001	3,367,174	1,196,161	278	278	278	278
Increase 2001-2031	1,116,185	610,529	92	117	111	102
% increase	33%	51%	33%	42%	40%	37%
Sydney						
2001	3,961,391	1,366,325	366	366	366	368
Increase 2001-2031	1,291,757	699,145	119	156	138	130
% increase	33%	51%	33%	43%	38%	35%
Greater Brisbane						
2001	1,609,084	584,659	171	171	171	171
Increase 2001-2031	938,651	477,200	100	125	113	105
% increase	58%	82%	58%	73%	66%	62%
Adelaide						
2001	1,073,728	419,999	112	112	112	112
Increase 2001-2031	138,173	106,337	14	22	21	20
% increase	13%	25%	13%	20%	19%	18%
Perth						
2001	1,336,245	493,469	157	157	157	157
Increase 2001-2031	642,963	350,602	76	97	95	83
% increase	48%	71%	48%	62%	60%	53%

4. Methodology

Assumptions and model inputs

Customised 2001 Census data[17] was used as a starting point for the projected household formation patterns for each Statistical Division. Tables were prepared that showed the propensity of persons of each age group (by sex) to live in certain family and household types in 2001. A separate indicator was included which marked one person in each household as the household reference person so a count of households could be prepared. For example, 47 per cent of males aged 35-44 counted in Greater Brisbane were the reference person in a couple-family-with-children household. Six per cent of women aged 35-44 in Greater Brisbane were the reference person in a lone parent household and 49 per cent were a non-reference person in a couple-family-with-children household.

The propensity of persons of certain age groups to live in certain family types has assumed to be constant from 2001 to 2031. This has been done to keep the model simple. In reality, it can be expected that there will be changes in these propensities over the projected time period but the model does not attempt to incorporate any view of what those changes might be.

These propensities were then applied to the Australian Bureau of Statistics population projections[18] based on Series B assumptions of net overseas migration of 100,000 per year and total fertility rate from 2011 at 1.6. Tables were prepared that presented the effect of both the growing size and the ageing of the population on the number of households and the average size of these households.

From the 2001 Census matrix, tables were also prepared for each capital city Statistical Division that showed the propensity of households of different types and age group to live in dwellings of different structures. For example, again for Brisbane, 96 per cent of couple-family-with-children households with a reference person aged 35-44 lived in a detached house but only 57 per cent of lone person households in the same age group lived in a detached house. These propensities to live in detached houses, semi-detached houses and flats were applied to the households of different type (couple with or without children, lone parent and so on) by age group for 2011, 2021 and 2031 for each city. These calculations provided the data on the housing choices which were the basis of Scenario B. This assumes that people of certain age and household type will continue to choose the same dwelling type as they did in 2001 and the new dwellings added to the housing stock will reflect these choices.

Both Scenario C and Scenario D force changes on the type of housing available for the projected households. Scenario C assumes that future building patterns will replicate the changes seen in each city over the 1991 to 2001 period and that the projected households will be forced to choose a dwelling from the stock generated by this building pattern, rather than the households influencing the type of new dwellings being built.

The building pattern for each city has been calculated using the Time Series tables from the 2001 Census which report the number of occupied dwellings for 1991 and 2001 by dwelling type. As can be seen in Table 1, the change in the type of dwelling stock over this decade is different for each city, with Melbourne and (particularly) Sydney both showing a move towards more medium and high density housing in their dwelling stock.

In Scenario D the move away from detached housing towards to medium and high density housing has been modelled on the aspirations of the State governments to consolidate their urban areas. As in Scenario C, the projected households are forced to choose from the dwelling stock available under the consolidation process. In both Scenario C and D, the model incorporates the growth in the proportion of gardens which are smaller in size, reflecting the decreased lot sizes which will be part of the move to urban consolidation.

Water usage data proved problematic as published figures varied markedly in the manner in which they were calculated and presented. A useful insight was obtained initially from the data supplied on the accounts sent to customers of Melbourne's Yarra Valley Water. This data itemises in-house and ex-house water use separately, and are provided to customers as indicators of median water usage by households in the region by number of persons in the household and size of the garden. The data indicates that a one person household has a higher per capita indoors use of water than a multiple person household. This is because there is a basic requirement of water for household tasks (dish and clothes washing, cleaning) which is separate from direct personal usage (showering, toilet). With more persons per household, the amount of water for household tasks reduces on a per capita basis.

In the model the indoors usage of the first person in each household has been constrained to vary between 210 and 240 litres per day, with the second person using 80 per cent of the first person and all other persons using 50 per cent of the first person. This gives an indoor per capita use for the five major metropolitan areas varying from 164 to 185 litres per day. The ex-house usage for each city was designed to approximate the usage reported by WSAA for the last six years. (In practice the percentage used in the modelling varied from one to three percentage points either side of the percentage reported by WSAA.) The water usage by household size and garden size was kept constant for each city over the time period of the projections. No changes deriving from more efficient water appliances or behavioural changes in the use of water were incorporated in the model.

These water usages were applied to the projected households by size for each of the scenarios provided in the tables.

[17] Australian Bureau of Statistics, Census of Population and Housing 2001, customised matrix reporting population by sex, ten year age group, family type, dwelling structure, tenure and reference person status for each Statistical Division

[18] Australian Bureau of Statistics, Population Projections (5 year age group and sex) to 2051 for Capital City Statistical Division, Series B, downloaded from Ausstats. For further information, see *Population Projections Australia, 2002-2101*, Catalogue No. 3222.0, 2003.