



Urban Form Analysis

Canberra's sustainability performance
technical report



ACT Planning &
Land Authority



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Executive summary

As part of ACTPLA's sustainable future program, the urban form analysis project has measured and compared the social and environmental performance of seven case study areas.

These were four Canberra suburbs – Reid, Kingston, Gungahlin and Weston, and three overseas residential developments that are sustainability exemplars - Kronsberg in Hannover and Vauban in Freiburg, Germany plus Dockside Green in Victoria, Canada.

The case study areas are 15 to 22 hectares, and in Canberra census districts within the suburbs were used. The Canberra places were chosen because they are representative of the changing planning trends over time for suburban living and demonstrate different types of urban forms and patterns.

Sustainability performance was measured with a range of indicators covering four main themes:

1. Land use – compact layout and efficient land use
2. Resource use – efficient energy and water use
3. Diversity – housing choice and socio-demographic mix
4. Connectivity – movement and amenity.

The summarised results are shown in the table below.

Canberra and international case study areas							
Indicators	Reid ACT	Kingston ACT	Gungahlin ACT	Weston ACT	Hannover Kronsberg	Freiburg Vauban	Dockside Green
People per hectare of urban area	48	47	33	13	85	134	288
Land-take per person (m ²)	206	214	303	796	117	75	35
Public open space per person (m ²)	14	9	13	204	27	34	14
Road per person (m ²)	32	71	36	70	11	3	4
Water use per person (kL)	86	66	76	111	51	29	37
CO ₂ emissions per person (tonnes/yr)	5.4	3.6	3.6	6.4	0.9	0.5	0.2
Low income households (%)	9	2	12	0	37	10	10

Key insights from the comparison with international examples are:

1. Land use
The overseas examples have two to ten times more land-efficient neighbourhood design than the Kingston case study area, the most land-efficient of the Canberra studies. Freiburg Vauban and Dockside Green reduce the land used for transport by having perimeter roads and minimising car traffic in development.
2. Resource use – energy and water
District scale co-generation power plants and low-energy building design for low operational energy use, reduces carbon emissions from dwellings to a level significantly below the Canberra examples. And in the overseas examples, publicly visible stormwater management and rainwater retention infrastructure was applied across all scales of the developments (block, street, section, estate).
3. Diversity
Hannover Kronsberg showcases diversity in design by offering a mix of housing types, tenures and sizes, thus achieving a balanced social mix. Freiburg Vauban is dominated by two to four storey row-houses and apartments for families with children. Dockside Green achieves a narrower social mix with four to ten storey buildings with one and two bedroom apartments.
4. Connectivity
Car dependency in the international areas is reduced by providing rapid public transport in combination with neighbourhoods that have walkable distances to local essential services and quality design of the public realm, where pedestrian friendly spaces are linked and buildings have a diversity of forms and sizes.

A comparison of the four Canberra areas showed:

- There is no 'average' Canberra suburb, with each area reflecting the planning philosophy at the time.
- None of the four areas performs outstandingly across all performance indicators.
- The Kingston case study area is the most land-efficient.
- Higher density areas in Kingston and Reid use less land, water and energy per person to provide housing, open space, pedestrian networks and other amenities.
- The predominant and built-in use of electricity from the grid to heat apartment buildings in Kingston and Reid results in comparatively high greenhouse gas emissions, as well as potentially decreasing living affordability as power costs rise.
- All study areas lack diversity in terms of design and social mix, mix of dwelling types, tenures and household types.

To improve the sustainability of Canberra's neighbourhoods, the following goals need to be considered throughout planning, design and implementation.

1. Land use
 - Reduce the land-take per person by minimising building footprints, paved road corridors and impervious surfaces in open spaces.
 - Encourage compact building designs with smaller building footprints, in low density residential areas in particular.
 - Use road verges more efficiently as a shared community zone that has high visual amenity to attract people's use of them.

2. Resource use
 - Provide sustainable infrastructure on a district scale, such as waste recovery, power co-generation, and renewable energy provision.
 - Improve the thermal performance of buildings and reduce reliance on electricity from the grid to heat the dwelling.
 - Provide for rainwater harvesting and stormwater management infrastructure across all scales (block, street, section and estate).
 - Conserve natural resources in open spaces and improve urban ecological functions.
 - Use road verges as safe, convenient and interactive spines of green open space.
3. Diversity
 - Ensure social diversity and equity in the community by providing small and internally differentiated neighbourhood areas instead of larger undifferentiated ones.
 - Create a suitable mix of semi-public, public and private open space on a street/section scale to support diverse community activities.
 - Provide a mix of housing types, sizes and tenures in development at section scale.
4. Connectivity
 - Provide connections for pedestrians and cyclists to essential facilities such as public transport, places of employment, community facilities and local shops.
 - Promote connection of smaller private spaces to multi-faceted public spaces to encourage stewardship and community interaction.
 - Provide pedestrians and cyclists with well designed public spaces and paths that provide safe and pleasant places for the community.

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A. Places – comparing different patterns of subdivision

Parts of four of Canberra's residential suburbs were compared using a range of sustainability indicators. This analysis improves our understanding of existing places with different urban form patterns and their sustainability performance. The findings give a current baseline and enable more informed decisions about how to develop Canberra in the future.

The chosen areas are census collector districts and are 15 to 22 hectares in size. They reflect the diversity of Canberra's urban form and show how areas have been designed and developed differently over time.

- | | |
|--------|--|
| Type A | <i>Reid, Canberra central</i> — Historic low to recent medium density residential development. |
| Type B | <i>Kingston, Canberra central</i> — Historic low to recent medium high density mixed-use development. |
| Type C | <i>Gungahlin (near Yerrabi Pond), Gungahlin</i> — Recent greenfield low to medium density residential development. |
| Type D | <i>Weston, Weston Creek</i> — low density residential development from the 1960s and 1970s (was greenfield). |

The Canberra case study areas were also compared with three international developments that are 'showcases' in terms of urban sustainability:

- | | |
|--------|---|
| Type E | <i>Hannover Kronsberg, Germany</i> <ul style="list-style-type: none">○ an area of 80 hectares with 3000 dwellings and nearly 7000 residents○ building heights of four to five storeys along a light rail corridor○ high quality open spaces and affordable living options. |
| Type F | <i>Freiburg Vauban, Germany</i> <ul style="list-style-type: none">○ an area of 41 hectares with 1800 dwellings and 5000 residents○ three to four storey apartments or row houses○ 70 per cent of households have chosen to live without a car. |
| Type G | <i>Dockside Green in Victoria, Canada</i> <ul style="list-style-type: none">○ an area of six hectares with 1100 dwellings and 2200 residents○ designed to be a carbon neutral○ mix between medium and high rise buildings achieves a high density in a modest site area with a high ratio of public open space. |

B. Performance indicators – measuring sustainability

The case study areas were analysed and compared according to performance indicators related to four main themes:

1. **Land use** – compact layout and efficient land use
 - How many people are accommodated in different urban areas?
Key indicator: population density (people per hectare of urban area)
 - How many people are accommodated on average in a dwelling?
Key indicator: Occupancy rate (people per dwelling)
 - How efficient is the use of land to develop buildings, roads and open space?
Key indicator: land-take (m² per person)
2. **Natural resource use** – efficient energy and water use
 - What is the impact on climate change from operating buildings?
Key indicator: annual residential greenhouse gas emissions (tonnes of CO₂ per person)
 - What is the average consumption of electricity and gas per person?
Key indicator: annual residential energy use (gigajoules per person)
 - How much potable water is used by private households?
Key indicator: annual residential potable water use (kilolitres per person)
 - How does the amount of open space affect water retention or run off?
Key indicator: ratio of pervious to impervious surfaces
3. **Diversity** – housing choice and socio-demographic mix
 - What type of housing options are available including type, tenure and size?
Key indicators: dwelling types (percentage of each in overall dwellings)
tenure types (percentage of each in overall dwellings)
dwelling sizes by number of bedrooms (percentage of each in overall dwellings)
 - What is the social mix of the residential population including age, household composition and income?
Key indicators: population by age cohort (percentage of overall population)
single, couple and family households (percentage of overall households)
low income households (percentage of overall households)
4. **Connectivity** - movement and amenity
 - How easy is it for people to access and use various means of transport?
Key indicator: nearest rapid bus stop in kilometres of walking distance
 - What is the availability of green open space and community facilities?
Key indicator: nearest green open space in kilometres walking distance
 - How readily can people access retail facilities?
Key indicator: nearest local shop in kilometres walking distance

C. Findings – How Canberra performs

1. Land use

Density of people and dwellings

Table 1 shows a comparison of different density indicators for each area of the study.

Canberra and international case study areas							
Density Indicator	Reid ACT	Kingston ACT	Gungahlin ACT	Weston ACT	Hannover Kronsberg	Freiburg Vauban	Dockside Green
People per hectare of urban area	48	47	33	13	85	134	288
Dwellings per hectare of urban area	36	36	13	5	38	44	144
Dwellings per hectare of developable land	60	83	20	10	73	79	302
Occupancy rates	1.3	1.3	2.7	2.4	2.3	3.1	2.0

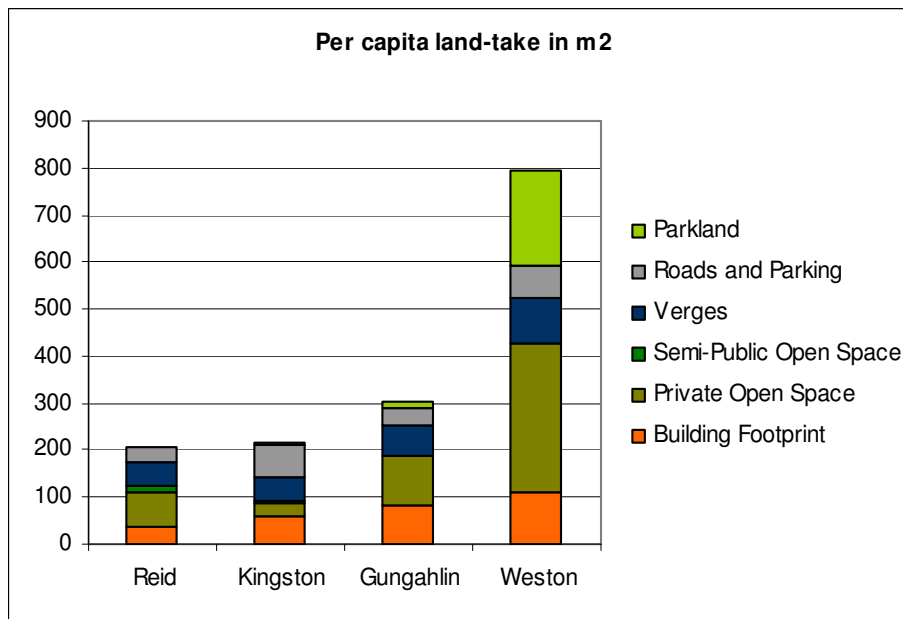
- Reid and Kingston have higher densities and are closer to the city centre.
- Reid and Kingston dwellings are predominantly one and two-bedroom apartments with fewer occupants than those in Gungahlin and Weston, which are bigger homes at lower density.
- Population densities of the international examples are considerably higher than Canberra.
- Hannover Kronsberg and Freiburg Vauban implemented densities that are considered the maximum 'socially acceptable' with two to four storey row-houses and walk-up apartments for families.
- Dockside Green provides predominantly one and two bedroom apartments in buildings ranging from four to ten stories.

Density of buildings and spaces

Table 2 and Figure 1 compare the amount of land that is used per person for buildings, roads and open space in the study areas.

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Land-take per capita in m ²	Canberra and international case study areas						
	Reid ACT	Kingston ACT	Gungahlin ACT	Weston ACT	Hannover Kronsberg	Freiburg Vauban	Dockside Green
Building footprint	38	38	83	112	18	15	9
Private open spaces	73	28	105	315	27	19	4
Semi-public open spaces	14	7	0	0	15	7	3
Road verges	49	48	66	95	34	4	3
Roads	32	71	36	70	11	3	4
Parkland	0	2	13	204	11	27	11
Overall in m²	206	214	303	796	117	75	35

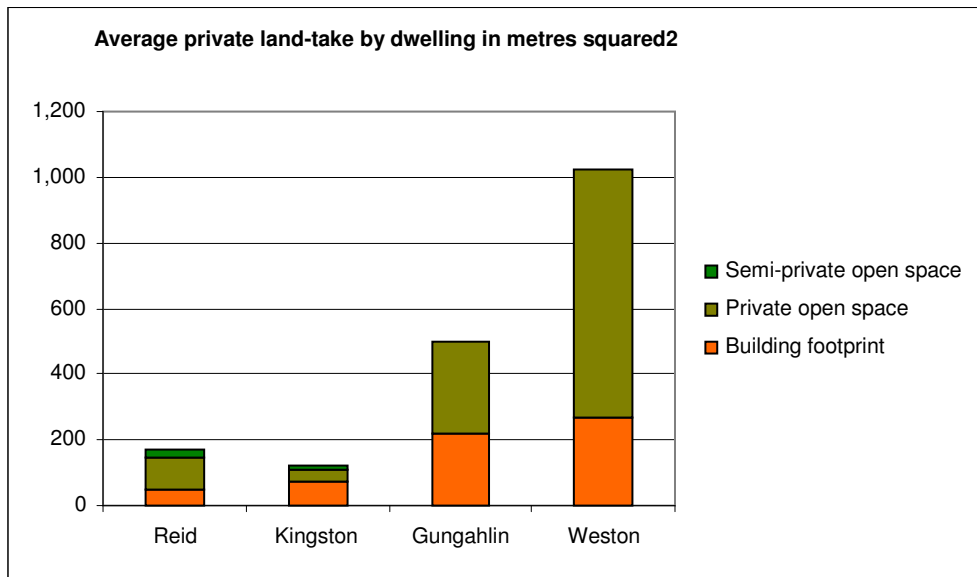


Data: ACTPLA 2010

- The amount of land used per person for buildings, open space and roads is highest in Weston and lowest in Reid and Kingston.
- The private land use per person (incorporating the building footprint, private and semi-private open spaces per resident) is highest in Weston, followed by Gungahlin and Reid.
- Weston has more than 20 times the public open space available per person than Kingston but there are longer distances to local services, a dependency on cars and less housing choice.
- Reid and Gungahlin show more efficient road pattern and parking design than Kingston and Weston.
- The international developments were found to have two to ten times more land-efficient neighbourhood design than the Kingston case study, the most land-efficient of the Canberra studies.

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Figure 2 shows the amount of private land per dwelling including the building footprint, private and semi-public open spaces (e.g. shared courtyards of apartment buildings).

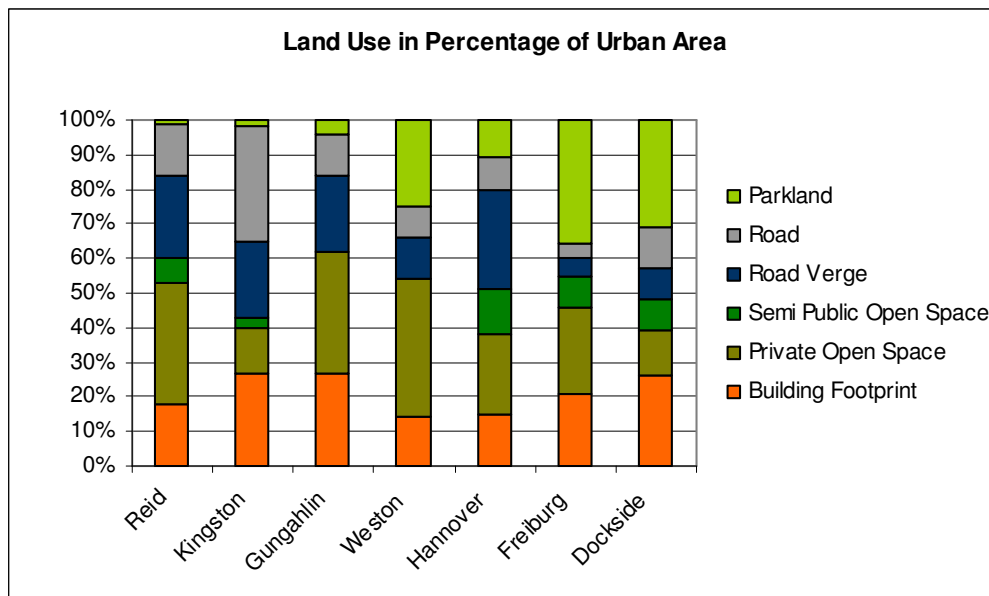


Data: ACTPLA 2010

- In Gungahlin and in Weston the mainly single residential building blocks take up considerably more private land than in Reid and Kingston.
- The average building footprint per dwelling is 270 m² for the Weston case study area and 215 m² in Gungahlin.
- Weston has the largest average private open space at 760 m².
- Gungahlin has much smaller average private yards of 280 m² per dwelling.

Land use and density

Figure 3 shows the land use pattern in each of the case study areas for various population densities.



Data: ACTPLA 2010

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- In all case study areas, the building footprints account for less than one third of the total land use of the urban area.
- In the Canberra areas, a higher proportion of land is dedicated to private, semi-public and public open spaces, creating the residential areas with lowest density.
- The road and public surface parking represents about one third of the urban area in higher densities (Kingston) and nine per cent in lower densities (Weston).
- In the Canberra areas, road verges take up 12 to 24 percent of the urban area.
- Freiburg Vauban and Dockside Green have an efficient road pattern with perimeter collector roads and traffic-calmed residential areas and maximise green open space.
- Hannover Kronsberg applies the concept 'city as a habitat' by using road verges as decentralised green corridors.

2. Natural resources

Combining energy and water

Table 3 shows energy consumption, carbon emissions and water use in residential areas.

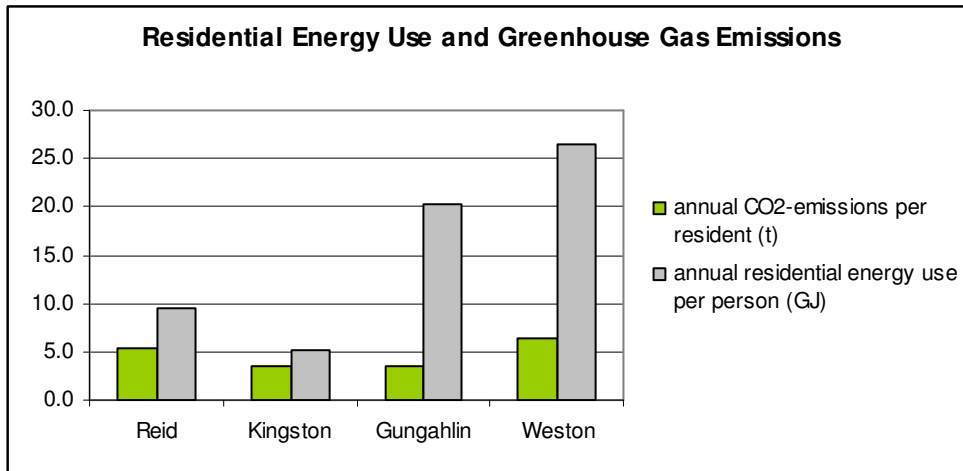
Canberra and international case study areas							
Building Performance	Reid ACT	Kingston ACT	Gungahlin ACT	Weston ACT	Hannover Kronsberg	Freiburg Vauban	Dockside Green
CO ₂ Emissions per person (t/a)	5.4	3.6	3.6	6.4	0.9	0.5	0.2
CO ₂ Emissions per dwelling (t/a)	7.3	4.7	9.5	15.4	2.0	1.5	0.4
Energy use per person (GJ/a)	10	5	20	26	16	9	7
Water use per person (kL/a)	86	66	76	111	51	29	37

The international case studies have significantly lower carbon emissions and water use, despite greater heating requirements in those colder climate zones. Key features of all the international case studies are:

- Lowest energy building standards with quality assurance, monitoring and skills qualification measures.
- Decentralised district heating with gas or biomass-boosted cogeneration plants to provide heat and electrical power.
- Renewable energy sources are used – solar collectors for warm water and hydronic heating and photovoltaic and wind turbine facilities for producing electricity.
- Innovative technology such as solar passive houses, solar district heating, waste recovery, onsite sewage treatment and water re-use, rainwater retention areas and water harvesting.

Energy

Figure 4 shows the residential energy use in comparison to greenhouse gas emissions per person.

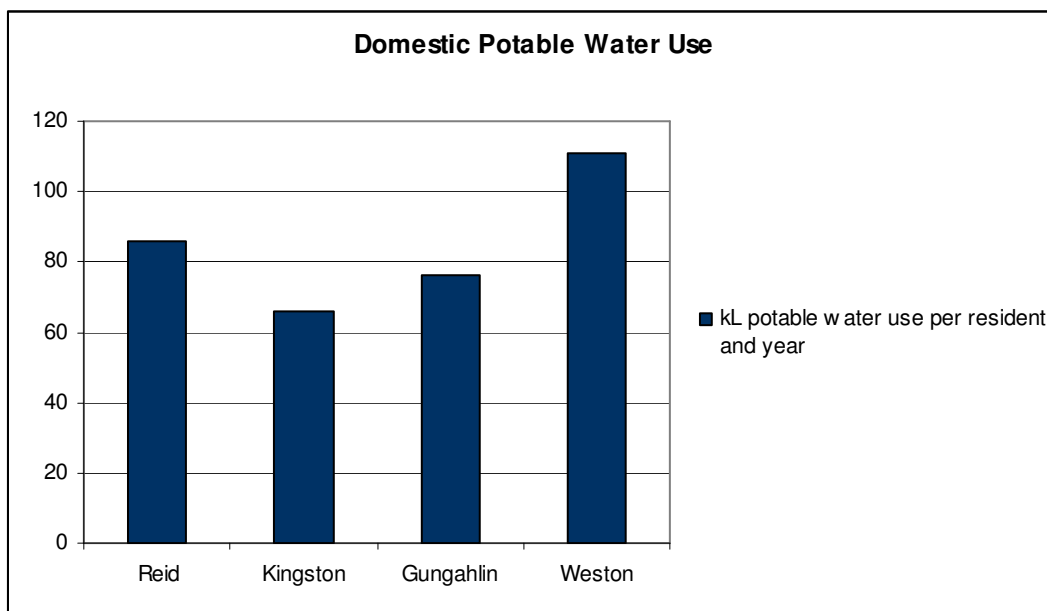


Data: ActewAGL 2009, Kinesis 2010

- Weston showed the highest CO2 emissions and energy consumption per person due to the low density residential buildings which are older and less energy efficient.
- Kingston and Gungahlin have the lowest CO2 emissions per person followed by Reid.
- Gungahlin residents produce less CO2 emissions due to the predominant use of natural gas for space heating.
- The predominant use of electricity for space heating, hot water and reverse-cycle air conditioning in apartments in Reid and Kingston increases their greenhouse gas emissions.

Water use

Figure 5 compares the mains water use per person per year.



Data: ActewAGL 2009

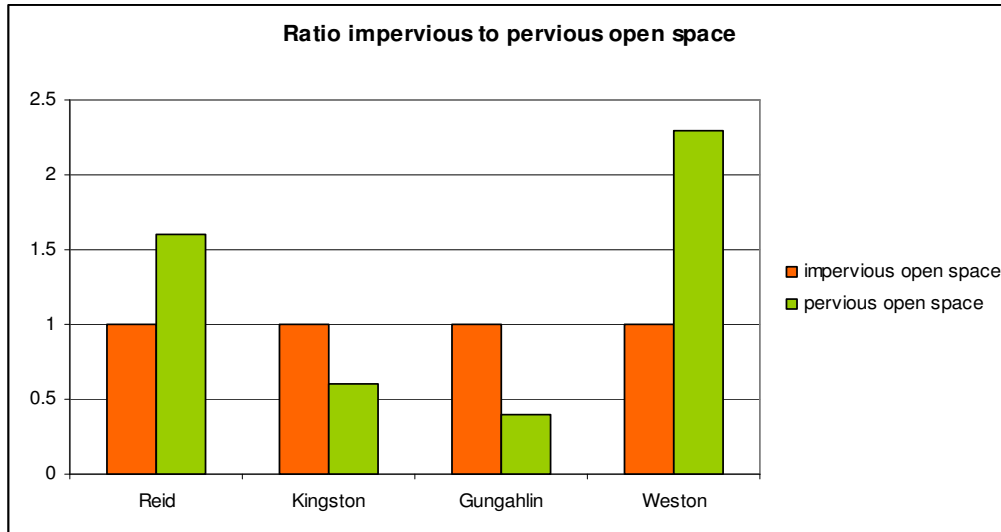
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- The water use rates in Reid and Weston are likely to be the result of garden watering requirements in private open space.
- Water-sensitive urban design and landscape practices considerably influence the outcomes for water use per person.

Water recharge

The ability of water to soak into the ground is desirable and necessary for plants to grow.

Figure 6 shows the ratio of pervious surfaces per unit of impervious surface.



Data: CSIRO Remote Sensing 2009

- Pervious ground surfaces allow for rainwater to penetrate the soil and reduce stormwater run-off. This is usually easier to provide in lower density residential areas with greater amounts of open space.
- Weston performs best with more than double the ratio of pervious to impervious open space.
- Kingston and Gungahlin both perform similarly due mainly to impervious, sealed surfaces.

Open space

Open or 'green' spaces were compared by assessing both the quantity of public and private open spaces and the area of overall tree canopy (cover) within public and private open spaces.

- Weston had 70 percent green open spaces with generous front and back yards. The tree canopy covers 37 percent of the area.
- Reid had 64 per cent green open space with wide street verges, generous backyards on single-dwelling blocks and semi-public open spaces for apartment blocks. The tree canopy was 36 percent of the urban area.
- Kingston had 37 percent green open space due to the commercial zones and extended parking requirements. The tree canopy was 20 per cent of the urban area.
- Gungahlin has only 30 percent green open spaces and 9 percent tree canopy. These results are due to the lack of mature trees in this newer suburb, combined with smaller block sizes and low water-use yards with paved not planted surfaces.

3. Diversity

Table 5 gives an overview of the types of dwellings, tenures and the composition of households.

Indicators	Reid	Kingston	Gungahlin	Weston
Predominant dwelling type	90% apartment	94% apartment	75% detached	96% detached
Predominant dwelling size	60% 2BR	73% 2BR	64% 4BR+	63% 4BR+
Predominant households	55% singles	40% singles	51% families	43% families
Predominant tenure type	76% rented	73% rented	70% owners	96% owners
Low income households	9%	2%	12%	0%
High income households	9%	50%	22%	42%
0-19 age cohort	12%	6%	32%	16%
40+ age cohort	39%	26%	25%	61%

Each area was found to have a narrow range of dwelling type and size. This has an impact on the socio-demographic mix of the residents.

- Reid and Kingston showed mainly two-bedroom apartment buildings rented by singles, couples without children or group households.
- Reid and Kingston both have fewer families with children, indicated by the low numbers of people below 19 years of age.
- Kingston caters more for high income households, whereas Reid is more affordable with social housing and apartments for medium income households.
- Gungahlin represents an affordable housing option for young, low to medium income families buying their first home. It has a balanced mix of youth and families.
- Weston offers mainly detached four bedroom houses, and the majority of the population was 40 years and older with medium to high income households.

4. Connectivity

The analysis of each of the four study areas compared a number of quantitative indicators:

- walking distance from the centre of the study area to various local amenities,
- length of bicycle and pedestrian networks,
- number of intersections per hectare of urban area.

The main findings were:

- Kingston was the only area with a major transport node accessible by foot in less than 400 metres.
- The proximity of schools and shops is closer for Reid and Kingston residents.
- Access to open space is very good for all areas.
- Weston provides the highest density of bike paths but also longer distances to travel.
- Reid has the most generous pedestrian path network and shortest distances to local services.
- Gungahlin residents have a better provision of paths than Kingston but further to walk to access services.

E. Suggestions for improved sustainability

Achieving the following goals throughout planning, design and implementation could substantially improve the sustainability of Canberra's neighbourhoods.

1. Land use

- Reduce the land-take per person by minimising building footprints, paved road corridors and impervious open spaces.
- Encourage compact building designs with smaller building footprints in particular in low residential areas.
- Use road verges more efficiently as an evenly distributed shared community zone of high visual amenity that attracts people to use them.

2. Resource use

- Provide sustainable infrastructure on a district scale such as waste recovery, co-generation or renewable energy sources.
- Improve the thermal performance of buildings and reduce the reliance on electricity from the grid to heat the dwelling.
- Provide for cross-scale rainwater harvesting and stormwater management.
- Conserve natural resources in open spaces and improve urban ecological functions.
- Use road verges as safe, convenient and interactive spines of green open space.

3. Diversity

- Ensure social diversity and equity in the community by providing small and internally differentiated neighbourhood areas instead of larger undifferentiated ones.
- Create a suitable mix of semi-public, public and private open space on a street/section scale to support diverse activities of the community.
- Provide a mix of housing types, sizes and tenures in a finer grain (section scale).

4. Connectivity

- Apply the proximity principle in subdivision design and provide connections for pedestrians and cyclists to important services such as public transport, places of employment, community facilities and local shops.
- Connect smaller private spaces to multi-faceted public spaces that encourage stewardship and community interaction.
- Provide pedestrians and cyclists with well designed public spaces and paths that provide safe and pleasant places for the community.

References to data sources

Cycle and pedestrian paths: TaMS asset management data (2010)

Land use: Cadastral Series spatial data (ACTPLA 2009)

Population and dwellings: most recent ABS Census data (2006)

Public transport networks: TaMS Transport for Canberra (2010)

Resource use (electricity, gas, water): Household consumption data (ActewAGL 2009)

Tree canopy cover and pervious/impervious groundcover: GIS Remote Sensing (CSIRO 2009)

Walking and cycling mapping: CSIRO Integrated Sustainability Assessment Platform (2010)