Liveability: environmental quality

This section reports on the following environmental indicators, which are defined in Newton et al. (1998).

Environmental Indicator	
HS 2.6	Population serviced by treated wastewater
HS 3.1	Stock of heritage and cultural assets
HS 4.10	Perceived daytime density
HS 7.5	Proportion of population sensitive to pollutants
HS 7.14	Exposure to indoor air
HS 9.1	Exposure to traffic noise
HS 9.2	Exposure to aircraft noise
HS 9.7	Air traffic density

Negative externalities in urban environments

A wide variety of urban activities produce what economists call 'negative externalities'. These are undesirable conditions, generally of an environmental nature, generated by local industry, traffic, neighbours or such like. Complaints about environmental concerns are commonly directed to state Environmental Protection Agencies or Authorities (EPAs) as well as local governments. Data presented in Figure 67 summarises the complaints per 1000 population received annually by each state EPA. Overall, the trend suggests an increase in the level of environmental complaints across Australia. It should be noted that noise complaints will also include many non-industrial situations, such as noise from residential properties; for example, police responded to 95 000 noise incidents among the 1.4 million non-urgent responses made in New South Wales in 1999 (P. Maganov, pers. comm. 2000).

The spectrum of complaints appears to vary from state to state (Figure 68), although a significant proportion of this variation may be due to which agency records what and how (see comments in the Data Gaps section).

Indoor air quality

An earlier section has dealt with personal exposure to ambient (outdoor) air pollution (discussed in Atmosphere report). The reality is, however, that urban populations spend 96%

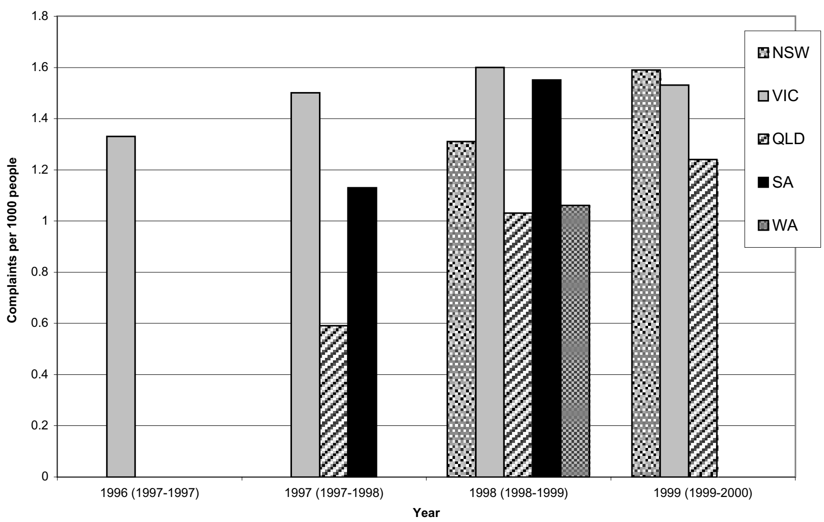

Figure 67: Environmental complaints in Australian states, 1996–2000.

Sources: Personal communications from New South Wales, Victorian, Queensland and Western Australian EPAs; EPA SA (1999).

of each day, on average, in a range of 'enclosed environments' such as the home (new, established, mobile), the workplace (non-industrial, industrial), school, shops, recreational buildings and transit vehicles.

Figure 69 demonstrates the complexity of how pollutants arise and are distributed in one of these indoor environments—a typical office building. Air pollutants are present within buildings due to three overarching sources:

- outdoor air that is used to ventilate the buildings introduces outdoor air pollutants,
- virtually all manufactured products that we construct, furnish and use within our buildings act as emission sources for a diverse range of air pollutants, often the same as those outdoors but limited in their dispersion by the enclosed nature of building environments, and
- the behaviour of occupants (e.g. smoking).

It is important to realise that outdoor pollutants will enter all types of buildings and transport. The level of indoor air pollution depends on the level of outdoor pollution, the level and type of ventilation used, and the nature of pollutant losses to indoor surfaces (e.g. ozone decays rapidly on indoor surfaces, while carbon monoxide does not decay at all). Indoor air pollutants emitted from manufactured products will add to pollution originating outdoors, to an extent depending on the level of the product emissions, their persistence over time, and the losses by ventilation or contact with indoor surfaces (Brown 1998a, 1999a, 1999b, 2000, Brown et al. 2000, Brown and Cheng 2000). It is commonly found that indoor pollutant sources, where present, dominate in their impact on indoor air quality compared to outdoor air pollutants, as shown in Table 51. The important questions therefore relate to concentrations of these pollutant sources in buildings, and how many and what sectors of the population are exposed to the pollutants at levels considered to be hazardous. National indicators for the levels of pollutants found in buildings are currently unavailable, although protocols for determining such indicators have been developed (Brown and Robinson 1997), but are yet to be applied. Questions about the impact of outdoor air pollutants need to consider those urban environments where greatest pollutant levels occur (e.g. near busy roads and city centres)—issues which are considered in the SoE Atmosphere Theme Report.

The types of pollutants and their sources and concentrations in Australian buildings can be summarised as follows (after Brown 1997):

Home—formaldehyde and VOCs from new building materials in new or renovated buildings (<6 months old); formaldehyde in mobile buildings with high loading of wood-

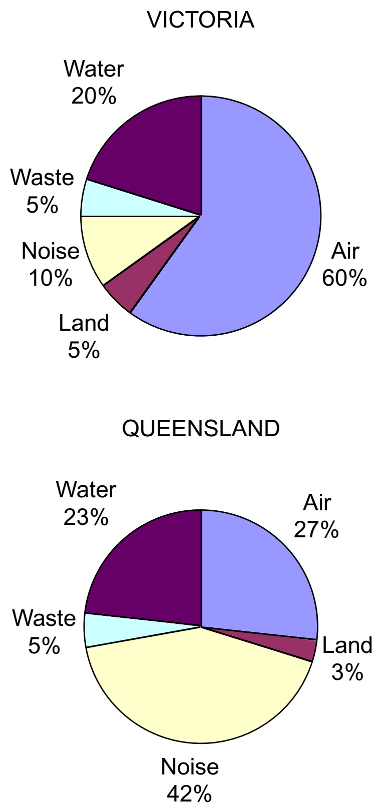

Figure 68: Environmental complaints in Victoria and Queensland, 1998–1999.[A]

[A] Complaints averaged over 1998 and 1999.

Source: Personal communications from Victorian and Queensland EPAs.

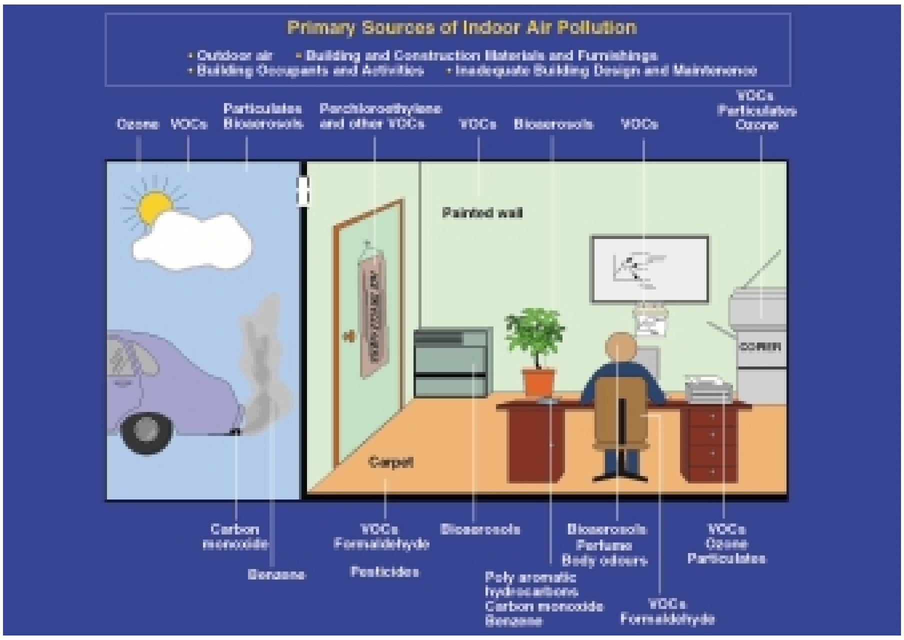

Figure 69: Primary sources of indoor air pollution in a typical office building.

Source: CSIRO Building, Construction and Engineering.

Table 51: Indoor and outdoor air pollutant levels for some Australian buildings.

Pollutant	Health goal ([mu]g/m^3 at 0°C, 101 kPa)	Typical indoor air concentrations ([mu]g/m^3)			Typical outdoor air concentration ([mu]g/m^3)
		New house/ office	Established house	Established office	
Formaldehyde	130 (NHMRC)	100–800	20–120	40–120	10–20
Total VOCs	500 (NHMRC)	5 000–20 000	200–300	100–300	20–100
Nitrogen dioxide	225 (NEPM)				
• no unflued gas heater		—	10–35	—	10–50
• unflued gas heater		—	60–1 500	—	(300 peak)
Fine particles (PM10)	50 (NEPM)				
• smoking		—	>90	100–300	5–30
• non-smoking		40–60	5–40	10–40	
Dust mite allergens (per gram of house dust)	2–10 (g/g (WHO)	<0.1	10–60 coastal <1 inland	<2 (data limited)	<0.1

Sources: Brown (1996, 1997, 1998b, 2000), Mannins (2000).

based panels; house dust mite allergen exposure from carpets and bedding (except central Australia); environmental tobacco smoke from occupants who smoke; combustion products (nitrogen dioxide, carbon monoxide, formaldehyde) from unflued gas heaters and stoves; auto-exhausts (benzene, 1,3-butadiene, respirable particles, carbon monoxide) if dwelling has an attached garage; asbestos from friable building materials, such as insulation products.

Work—formaldehyde and volatile organic compounds (VOCs) from new building materials in new or renovated buildings (<6 months old); formaldehyde in mobile buildings with high loading of wood-based panels; office equipment emissions (VOCs, ozone, respirable particles) and cleaning product residues in non-industrial workplaces and schools; auto-exhausts (benzene, 1,3-butadiene, respirable particles, carbon monoxide) if there is an enclosed carpark or if close to busy roads; *Legionella* bacteria associated with water cooling towers; asbestos from friable building materials such as insulation products.

Shopping—miscellaneous emissions from consumables, cooking etc.; auto-exhausts (benzene, 1,3-butadiene, respirable particles, carbon monoxide) if enclosed carpark or if close to busy roads.

Recreation buildings—environmental tobacco smoke from occupants who smoke; auto-exhausts (benzene, 1,3-butadiene, respirable particles, carbon monoxide) if there is an enclosed carpark or if close to busy roads.

Transit—auto-exhausts (benzene, 1,3-butadiene, respirable particles, carbon monoxide) if in slow-moving traffic.

The times spent in each of these environments (time budgets) can be estimated from ABS statistics (ABS 1998i). Table 52 shows that people typically spend almost all of their daily budget in enclosed environments—96% in 1997—and little time (4%) outdoors. This is consistent with survey findings in other developed countries.

Table 52: Time budget for total Australian population (persons 15 years and older). [HS Indicator 7.14]

Environment (ABS data source in parentheses)	1992		1997	
	Minutes/day	Percentage of day	Minutes/day	Percentage of day
Home (personal care + domestic activities + child care + voluntary work; excluding associated travel)	775	54	820	57
Work (employment + education; excluding associated travel)	205	14	199	14
Shopping (purchasing goods and services; excluding associated travel)	30	2.1	29	2
Recreation (social and community interaction + recreation and leisure; excluding associated travel)	299	21	262	18
Transit (associated travels from all items)	70	5	73	5
Outdoor (domestic activities—grounds and animal care + social and community interest—attending sports events + recreation and leisure—sport and outdoor activity)	59	4.1	54	3.8

Source: ABS (1998i).

The time spent in transit—70 minutes per day on average—is of particular concern from the perspective of exposure to auto-exhausts (benzene, 1,3-butadiene, respirable particles, carbon monoxide) when in slow-moving traffic. Duffy and Nelson (1996) found that car occupants were exposed to much greater levels of these pollutants when travelling in urban traffic. A target level for this indicator needs to consider the pollutant levels experienced, so that the population exposure distribution (pollutant level multiplied by time exposed) can be assessed and health risks can be estimated. For example, various studies have found that benzene concentrations within vehicles in urban traffic are 20–150 $\mu g/m^3$, which is much higher than the outdoor benzene exposure level recommended by UK Health and Safety of 3 $\mu g/m^3$ as an annual average.

Populations sensitive to air pollutants

It is generally considered that certain sections of the population are more likely to suffer adverse health effects from air pollutants. These are:

- the very young, since their immune systems are not fully developed and since they will experience a larger body dose than adults;
- the very old, since they may be more frail and have existing illnesses (this is already an issue in air pollution research, with fine particles in urban air having been linked to mortality rates); and
- people with existing respiratory illnesses, such as asthma, emphysema, bronchitis and hayfever.

Key trends are also problematic. For example, the Australian population is ageing so that the proportion of very old people is increasing. Also, studies have shown that the prevalence of asthma in the population has increased, particularly in schoolchildren (e.g. the prevalence of a history of asthma among seven-year olds in Melbourne increased from 19.1% in 1964 to 46% in 1990, an increase of 141%). Also, Australia has the second-highest reported death rate from asthma in the world, with the death rate from 1980 to 1990 in the 0–19 age group increasing by 50% (Robertson et al. 1991).

Based on all respiratory illnesses, it is seen that approximately one-third of the population may be sensitive to air pollutants, a proportion that increased by approximately 10% between 1990 and 1995 (Table 53). Of particular concern are the incidences of long-term conditions, such as:

- the proportion of asthmatics, which is 11.3% of the total population (an increase of about 30% in the above period), and the highest occurrence of asthma in the younger population;
- the high proportion of older Australians with bronchitis and/or emphysema; and
- the large increase in sinusitis, also most common in older Australians.

Table 53: Occurrence of long-term and all respiratory conditions in Australian population. [HS Indicator 7.5]

Respiratory condition	1989–1990		1995	Percentage of population age groups in 1995				
	'000s	Percentage of population	'000s	Total	<5 years	5–14 years	65–74 years	>75 years
Hayfever	1 753	10.3	2 515	13.9	2.0	8.8	12.2	11.0
Asthma	1 444	8.5	2 041	11.3	10.7	19.2	8.9	7.5
Sinusitis	727	4.3	1 859	10.3	1.3	4.9	11.5	9.1
Bronchitis/emphysema	587	3.5	778	4.3	3.0	2.8	8.8	10.4
All respiratory conditions	5 867	34.5	6 749	37.4	34.3	37.8	35.3	33.6

Source: ABS (1998j).

The 1995 National Health Survey also observed that asthma was more prevalent in 0–4 and 5–9 year olds from households with smokers (13% and 22%, respectively) than in household with no smokers (9% and 18%, respectively). Passive exposure to tobacco smoke has been linked to several illnesses in young children (Hill et al. 1998). For example, passive smoking is one of the major risk factors for sudden infant death syndrome; children of smokers are 60% more likely to have serious chest infections (bronchitis, croup, pneumonia), especially in the first year of life; and 9% of childhood asthma has been attributed to passive smoking.

Thus, the proportion of children living in households with smokers is a significant indicator for a population at risk from indoor air exposure to this pollutant. Over half a million children aged 0–4 have been estimated to fit into this category of the population at risk (data from ABS Australian Health Surveys, 1989–1990 and 1995).

High-risk environments

The daily pathways of human activity will dictate the levels and duration of exposure by individuals to the spectrum of urban air pollution (Newton 1997). Technologies are available to measure 24-hour exposure of individuals to various criteria pollutants via body sensors as well as track where individuals spend their time (e.g. via GPS). Only by linking these two data streams can we begin to understand the air quality landscape of our human settlements. In the meantime, we do know that there are several 'environments' which convey risk to human health from prolonged exposure. These are buildings where smoking is permitted; buildings which contain asbestos; buildings with unflued gas heaters; mobile homes; new or renovated buildings; and buildings which harbour dust mites.

Buildings without smoking prohibition

An increasing number of Australian buildings have undertaken tobacco smoke-free operation over the last 10–15 years, either voluntarily or in response to legislation. However, it is difficult to determine how many buildings are affected here since this information is seldom determined systematically. The Anti-Cancer Council of Victoria (1995) summarised organisations that became smoke-free as follows: Commonwealth Department of Health buildings (1986); all Commonwealth Public Service buildings (1988); Telecom, Australia Post, ICI, CSIRO, BHP, AMP, Westpac, 3M, Price Waterhouse, IBM, hospitals, state health departments, TAB betting offices in several states, Australian Army offices/halls/mess facilities (late 1980s to early 1990s); survey of New South Wales restaurants found less than 2% had total ban and 22% had a partial ban (1990); total ban in major fast-food chains Pizza Hut Australia, Hungry Jack's, Kentucky Fried Chicken and McDonald's (1992–1994). More recent restrictions include a total ban on smoking in indoor hospitality venues in the ACT (1994), SA and WA (1999), with restrictions likely in Victoria, NSW and Tasmania in 2000.

The Anti-Cancer Council of Victoria (1995) also summarised survey results from several states, and found that an increasing proportion of Australians are able to work in buildings with smoking prohibition. This information is most complete for Victoria, where nearly 90% of workers have been in workplaces with smoking prohibitions since 1992. The position in other States is less clear, and needs to be determined in terms of a national indicator.

Unflued gas heaters in residences and schools

Based on data obtained from the ABS Housing Survey of 1994, Ferrari et al. (1988) and Volkemer et al. (1995) among others, it is estimated that approximately 600 000 unflued gas heaters are in use in Australia, mostly in New South Wales, which represents 30% of all gas heaters. Note that the converse is that 70% of gas heaters are flued (i.e. the gas combustion products are vented outdoors and do not contaminate indoor air).

Residents in mobile buildings

It has been found that mobile buildings such as caravans, mobile homes and mobile offices generally have high concentrations of formaldehyde which may exceed health-based exposure goals for occupants. This is considered to result from the high usage of wood-based panels and the low air infiltration rates encountered with such buildings (Brown 1997). The numbers of these residences, or the numbers of people residing in them, is considered an environmental indicator of this population's exposure to high levels of formaldehyde gas.

ABS census data for 1986, 1991 and 1996 indicates that in each period approximately 90 000 mobile residences have been occupied nationally, with no evidence that this number is changing over time. Nearly two-thirds of these are in Queensland and New South Wales, suggesting an influence of climate on these occupancies. The total number of occupants in the 1996 census was 161 400, or 0.9% of the population. While this is a small proportion of Australia's population, it still represents a substantial number of people potentially exposed to high levels of formaldehyde.

Residents in new or renovated buildings

It has been found that building occupants are exposed to much higher levels of VOCs and formaldehyde in the first 6–12 months after construction or renovation of buildings, due to the large range of high-emission materials used in construction (e.g. paints, adhesives, sealants, carpets, wood-based panels, furniture). The health significance of these levels of exposure is an area of current research, with possible roles being considered for asthma, eye/nose/throat irritation, headache, nausea, lethargy, and general comfort and well-being (Brown et al. 1992, Brown 1999c).

New building construction is a common activity in Australia, and the number of new buildings constructed is considered an environmental indicator for occupant exposure to VOCs and formaldehyde, as presented in Table 54. The majority of new building construction is residential buildings where occupants will be located for large proportions of time. There were approximately 150 000 new buildings constructed per year throughout the 1990s. The number of people housed in these buildings is difficult to estimate because of the different types of dwellings, but would be expected to exceed 0.4 million. (The 1996 census recorded that 17.1 million people occupied 6.5 million dwellings.)

Table 54: Number of new buildings (thousands) in Australia.

Year	New houses	New other residential buildings	Alterations/ additions	Conversions to residential buildings	Non-residential buildings	Total
1991–1992	111	39	n.d.	1.3	n.d.	152
1993–1994	130	54	n.d.	4.1	n.d.	189
1995–1996	87	35	n.d.	2.0	n.d.	125
1997–1998	107	45	0.8	2.6	0.6	156
1998–1999	107	45	0.7	2.5	0.5	156

n.d. – no data available.

Source: ABS (1999h).

Allergen exposure in Australian dwellings

Australia experiences one of the highest incidences of asthma in the world, and the incidence continues to rise. It also has one of the highest levels of house dust mite allergen in indoor materials (bedding, furniture, carpets), and this allergen has been linked to asthma prevalence and severity in children. Generally, 80% of all asthmatics are allergic to dust mite allergen. The high level of the allergen in dwellings arises from the temperate climate along the coast where most of the population lives. Allergen avoidance by the population at large is highly desirable, though currently unachievable.

Occupant satisfaction with indoor air quality

Research has shown that large numbers of occupants of commercial buildings experience detriment to their health and well-being due to poor indoor air quality, with significant national costs from health care and lost productivity (USEPA 1989, Fisk and Rosenfeld 1997). In recent years, a number of occupant surveys have been undertaken which have found levels of dissatisfaction ranging from 25 to 60% (Bakke et al. 1996, Christensen 1996, Sundell 1996). Studies in Australia have been limited in scope and application, but suggest that high levels of occupant dissatisfaction are common. For example, 62% of occupants of 228 low-rise offices in suburban Melbourne and 72% of occupants of 511 Commonwealth Government offices found the building air unacceptably ‘stuffy’ (Brown 1997).

Implications

Overseas research has demonstrated that poor indoor air quality results in very high costs to a nation, largely on the basis of health costs and lost productivity of workers. Estimates for Australia can be made based on the ratios of GDP here relative to those in countries where costs of poor indoor air quality have been estimated. Based on US figures, poor indoor air quality in Australia could incur a potential cost of several billion dollars per year (Brown 1997), but a detailed study of the incidence of health, well-being and sick building syndrome effects is needed for a more accurate estimate.

Environment Australia's Air Toxics Program has recently identified indoor air quality as a priority area. A State of Knowledge Report has been prepared, and Environment Australia is commissioning new research projects to improve air quality management in Australia (Environment Australia 2000).

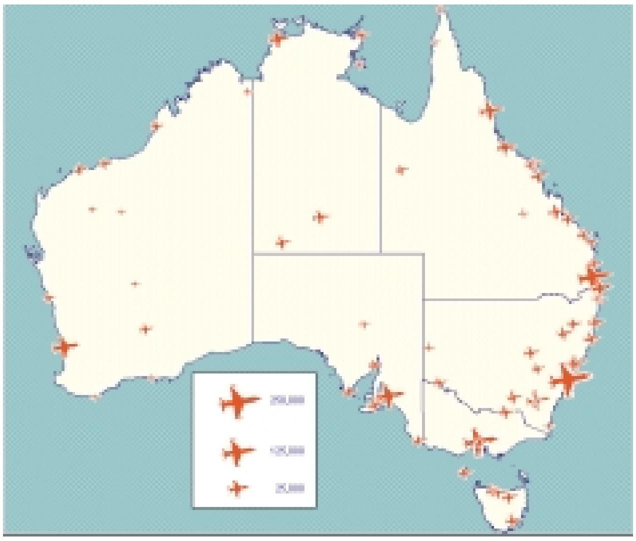

Figure 70: Annual aircraft movements from Australian airports, 1997–98. [HS Indicator 9.7]

Source: DTRS (1999).

Noise

Quality of life is affected by occupational noise at work, and by environmental noise outside and at times infiltrating the home. While nobody dies as a result of noise and very few people are seriously injured by it, the cumulative impacts of noise pollution are being increasingly acknowledged.

Environmental noise

Noise due to transport, industry and the community is perceived to be increasing in cities. Transport noise, predominantly due to road and air traffic, is of particular concern.

Aircraft noise—as airports grow and develop in line with the overall growth of aviation, noise generation increases as a result of the additional flight activity. Total annual scheduled aircraft movements from Australian airports grew by 40% to 1 266 335 between 1986–1987 and 1996–1997. Figure 70 shows annual aircraft movements by scheduled services in 1997–1998 (note the figure excludes private flights).

Aircraft overflight noise can, for example, make conversation difficult, disturb those watching television or listening to the radio, result in sleep disturbance, and reduced enjoyment of recreational areas (Sydney West Airport Taskforce 1999). Australian Noise Exposure Forecast (ANEF) contours indicate exposure to aircraft noise across cities based on the noise level of each aircraft passing overhead, the number of movements and the time of day or night. The degree of disturbance depends upon both the noise from aircraft and the number of overflights. The need to combine these factors has led to the development of noise unit measures. The ANEF system combines noise and frequency of flights and adds a weighting according to time of day. Every flight between 7 pm and 7 am is counted as equivalent to four daytime flights.

Mapped ANEF contours are used for planning for suitable land uses around all Australian airports. For example, new private dwellings should not be built within 25 ANEF contours. They have also been used to determine the need for impact amelioration by acquiring or insulating dwellings.

Growth in air traffic and noise, Sydney airport.

Source: CSIRO.

In contrast to the ANEF, which shows areas affected by aircraft noise, the Person–Events Index (PEI) allows comparison of how people are affected by noise between airports and cities. The total noise load generated by an airport is computed by summing, over the exposed population, the total number of instances where an individual is exposed to an aircraft noise event above a specified noise level over a given time period. For example, if 20 000 persons were exposed to a single noise event greater than 70 dB(A), the PEI (70) would be 20 000. A second event would double that to 40 000. PEIs for some Australian cities are given in Table 55.

Table 55: PEIs to aircraft noise for some Australian cities. [HS Indicator 9.2]

Airport	No. of persons exposed to >10 events/day >70 dB(A)	PEI (70)[A] (millions)
Adelaide	27 000	1.1
Brisbane	9000	0.2
Coolangatta	13 000	0.4
Melbourne	NA	NA
Perth	31 000	0.8
Sydney	270 000	8.7
Major international airport[B]	190 000	27.0

[A] PEI (70) is the total number of instances on the average day where a person is exposed to a noise event greater than 70 dB(A), and is a measure of the total noise load generated by the airport.
[B] The 'major international airport' is an anonymous USA airport used for comparison.

Source: Southgate et al. (2000).

Sydney, with the largest number of aircraft movements and its airport close to the city, suffers particularly from aircraft noise (see photograph on p. 102). Population exposure to noise from just one B747-2000 taking off from Sydney Airport is equivalent to the entire day's aircraft noise exposure in Brisbane (Southgate et al. 2000).

Traffic noise—cars and trucks are the major cause of noise in urban areas. It has been estimated that more than 70% of environmental noise is due to road traffic. Increasing levels of traffic and increasing goods movements leads to increasing exceedances of transport noise level guidelines. These are set, in most Australian states at between 63 and 68 dB(A) L_{10} (18 hour), the sound level which should not be exceeded more than 10% of the time during the 18-hour period. In New South Wales, L_{eq} measures an equivalent steady-state sound level containing the same acoustic energy as the time-varying level over the period, and is set at 65 dB(A) over 24 hours or 55 dB(A) at night. Brown (1994) estimated that nearly one in 10 dwelling units or 19% of the population in Australian urban areas with populations of greater than 100 000 is exposed to L_{10} (18 hour) noise levels of 68 dB(A) or greater. Traffic noise 'black spots', usually located close to major road routes, are the main sources of the problem.

Despite less stringent guidelines, OECD targets are L_{eq} 55 dB(A) for 6 am to 10 pm and L_{eq} 45 dB(A) for 10 pm to 6 am. Australia compared well with other OECD countries in terms of cumulative population exposure to traffic noise above 65 dB(A) (Figure 71).

Noise penetration—while fences, walls or hedges may play some part in limiting noise penetration into dwellings, the acoustic performance of the dwelling itself is more important (see photograph on p. 104). For a typical detached dwelling with open windows, the overall noise reduction from the building itself may be as low as 10 dB(A). Dwellings subject to aircraft noise or traffic noise levels from a busy street of up to 80 dB(A) need to give better protection from noise intrusion. Choice of building materials or addition of insulating materials for greater sound transmission loss can have a significant impact. For example, timber, prevalent in the construction of Queensland houses, allows more transmission than brick. An Australian sound transmission class (STC) rating system

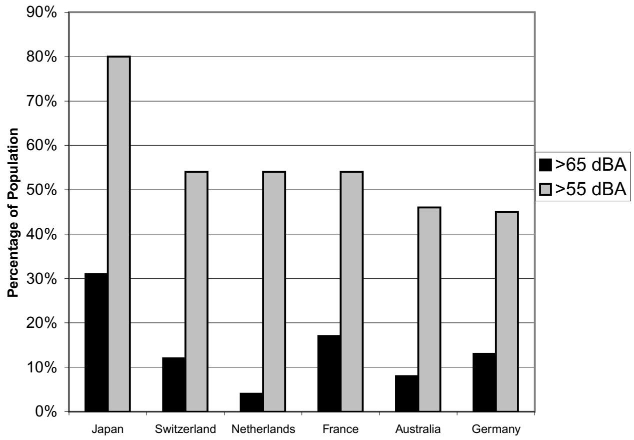

Figure 71: Percentage of population exposed to excessive traffic noise in some OECD countries. [HS Indicator 9.1]

Source: OECD (1991).

Noise barriers on major arterials and freeways.

Source: CSIRO.

allows architects and builders to compare building component performance. However, it is the entire structure which determines overall noise effectiveness. Windows and doors are generally the weakest links. A double-glazed and sealed window can reduce noise by up to 40 dB(A) compared to a single-glazed window with no seals at 20 dB(A) closed or 10 dB(A) open (SPCC 1991). However, designers need to ensure sufficient ventilation so that noise pollution is not replaced with indoor air pollution.

Containing sounds within buildings can be equally important to reduction of external noise. Noise from air-conditioners, swimming pool filters, domestic appliances and plumbing can be a problem. Noise from a toilet system flushing and refilling can exceed 70 dB(A) (Narang 1992). Residents also may be disturbed by loud conversation, parties or music. The impact of the latter is increasing. As technology for amplifying music becomes less expensive, a small device bought relatively cheaply can now output music louder than a brass band. The Building Code of Australia has requirements for minimum sound insulation, in the form of mandatory minimum STC, for components to protect adjacent occupants in multi-unit dwellings, but there are no standards for detached dwellings sited close to neighbours, or indeed internal partitions within dwellings. As tolerance to noise varies considerably, it is desirable to aim for higher acoustic performance. Good design can do much to improve the acoustic performance of dwellings. This can range from choice of construction materials, through the siting of plumbing, to small details such as automatic door closers to limit slamming.

Impact on residents—environmental noise is unpleasant when experienced outdoors, but most severely impacts health and well-being when it penetrates into and throughout buildings. This is due both to the higher percentage of time spent indoors—over 90% of time for the populations in larger cities—and to less tolerance to indoor noise. Typical indoor activities such as working, studying, reading, listening to music, watching television and, in particular, sleeping or trying to sleep require a quiet environment. Noise is often defined as unwanted sound; thus noise is context-dependent.

Many complaints about excessive environmental noise relate to concerns about disturbed sleep. Satisfactory background noise levels, as given in the Australian Standard AS 2107–1987 in private dwellings, are set at 35 dB(A) for work areas. The standard is set lower for bedrooms, varying from 30 dB(A) for inner suburban dwellings to 25 dB(A) in the outer suburbs or rural areas. Findings from studies of sleep disturbance, measured by awakening, changes in sleep state or after-effects, reflect the considerable variation in people's response to noise. Suggested peak permitted noise levels vary from 45 to 68 dB(A), depending on ambient noise (Griefahn 1991), and disturbance is related to both the number and maximum level of noise events (Bullen et al. 1996).

While physiological symptoms such as headaches are reported, the most palpable human impact is general annoyance. Contrary to popular belief, studies also show that people do not become accustomed to excessive noise. They do become less likely to be startled by expected noise events. This is perhaps why people are more tolerant by a factor of 5 dB(A) to noise from trains, which run regular services, than to noise from trucks (Narang 1992).

Implications

In all Australian cities, the overall amount of environmental noise is increasing and larger proportions of the population are suffering from exposure to noise. This is due to both growth in city activities and changes in urban form. As housing density increases, people increasingly hear noise from their neighbours, and this can be exacerbated in multi-unit dwellings with shared walls. There is thus a growing impact on community health and well-being.

Noise amelioration measures are of three types: limiting or eliminating noise at the source; providing barriers between the source and residences; and insulating the residences against noise. None are sufficient in themselves. Packages of measures will be needed to adapt to different situations, especially since a number of measures being introduced to reduce other environmental hazards have perverse effects with respect to noise pollution. For example, traffic calming devices and changes in urban form to reduce traffic may increase environmental noise.

Noise problems also extend over more of the day as big cities become 24-hour cities. Levels of noise that are tolerable by day may not be tolerable at night, engendering increased stress among the population. It cannot be assumed that people will develop immunity to noise. It has been shown that, while they may become resigned to the impost, they will still suffer impairment. Constant exposure to unacceptable noise can have cumulative effects on health. These can range from the impacts of disturbed sleep to industrial deafness caused by cumulative noise load on workers. While improved health and safety regulation, together with a decline in numbers of workers engaged in heavy manufacturing industries, have combined to reduce the incidence of industrial deafness, education is needed to ensure that exposure to very loud music for recreation, when added to workplace noise is not a new cause of deafness. Improved housing and urban design and utilisation of insulative materials is also overdue.

Water quality

Providing water supply and wastewater services

At a national scale, 93% of the population has access to reticulated water supply (ABS 2000f) and nearly 90% are connected to reticulated sewerage (AWWA 2000a). The 21 major water authorities (businesses that have 50 000 or more water service connections) supply 68% of the population with water and collect 65% of the population’s wastewater (WSAA 1999). Another 55 non-major water authorities (businesses that have between 10 000 and 50 000 water service connections) supply water to 16% of the population and collect wastewater from 14% of the population nationally (AWWA 2000c).

During the period of rapid urban growth after World War II, all cities lost the battle to match the rate of water supply provision with mains sewerage services (Smith 1998). However, by the 1960s and 1970s the sewerage backlog was addressed in all capital cities, with the exception of Perth. As recently as 1997, only 60% of urban, commercial and industrial developments in Perth and the south-west region of Western Australia had treatment and disposal services (Thomas et al. 1997). Most unsewered areas use septic tanks that come under the control of the Western Australian Health Department. Currently these areas are undergoing a large sewerage connection program.

The proportion of properties in a non-major water authority region that do not have a sewerage connection varies from 0% through to 53% in Geraldton and 78% in outer Adelaide (AWWA 2000c). Some utilities have customers awaiting reticulated sewerage services, but other authorities have employed on-site alternatives to relieve the need for a connection (AWWA 2000c). In unsewered areas of Australia there is a trend towards small-scale, single-household sewage treatment plants (Thomas et al. 1997).

Figure 72 illustrates the level of wastewater treatment provided by each state and territory in 1994. Throughout Australia, 17.8% of all wastewater was treated to tertiary standard, 54.6% to secondary standard, 27.2% to primary standard, and 0.5% received no treatment. The level of treatment received in each state and territory varies significantly: the ACT treats all wastewater to tertiary level, while in Western Australia two-thirds is treated to secondary level and the remainder receives primary treatment only.

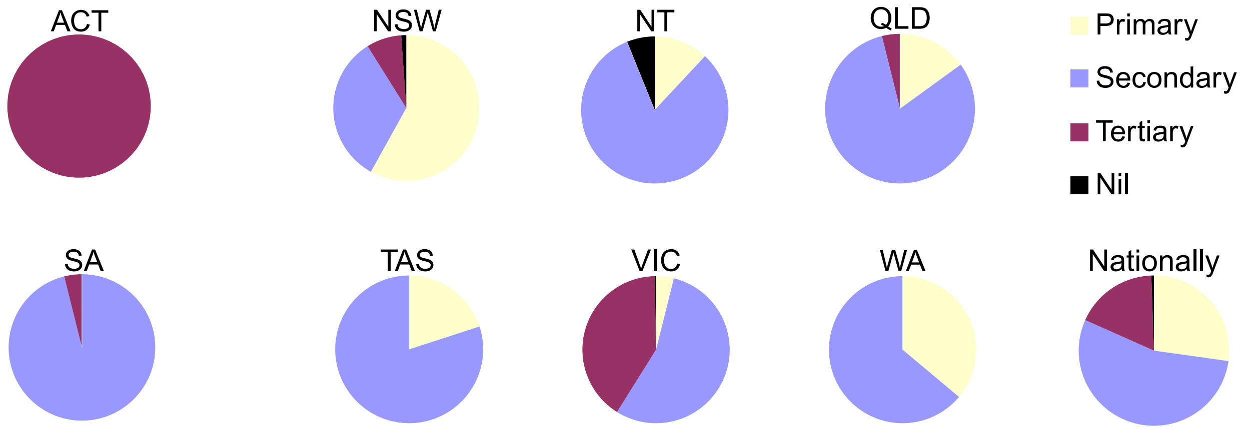

Figure 72: Proportion of wastewater treated to different levels, 1994.[A] [HS Indicator 2.6]

[A] Primary treatment involves separation of suspended solids from wastewater by screening and sedimentation; secondary treatment involves additional treatment, usually by biological processes, to remove organic matter and residual suspended material followed by disinfection; tertiary treatment produces higher quality effluent through the further removal of contaminants such as nitrogen, phosphorus, heavy metals, residual suspended and dissolved solids, and synthetic organic chemicals. Tertiary treatment can involve processes such as carbon adsorption, reverse osmosis, microfiltration, and biological nitrogen and phosphorus removal.

Source: Thomas et al. (1997).

Figure 73 presents data on the level of wastewater treatment provided by WSAA members in 1995–1996 and 1998–2000 respectively. It can be seen that treatment practices vary between major urban water authorities. ACTEW and Yarra Valley Water are two authorities that treat all wastewater to tertiary standard, with both discharging effluent to inland waterways.

Comparison of the level of wastewater treatment provided by the major urban water authorities in 1995–96 and 1999–2000 exhibits a general trend towards higher levels of treatment. Barwon Water dramatically increased the level of treatment its wastewater received,

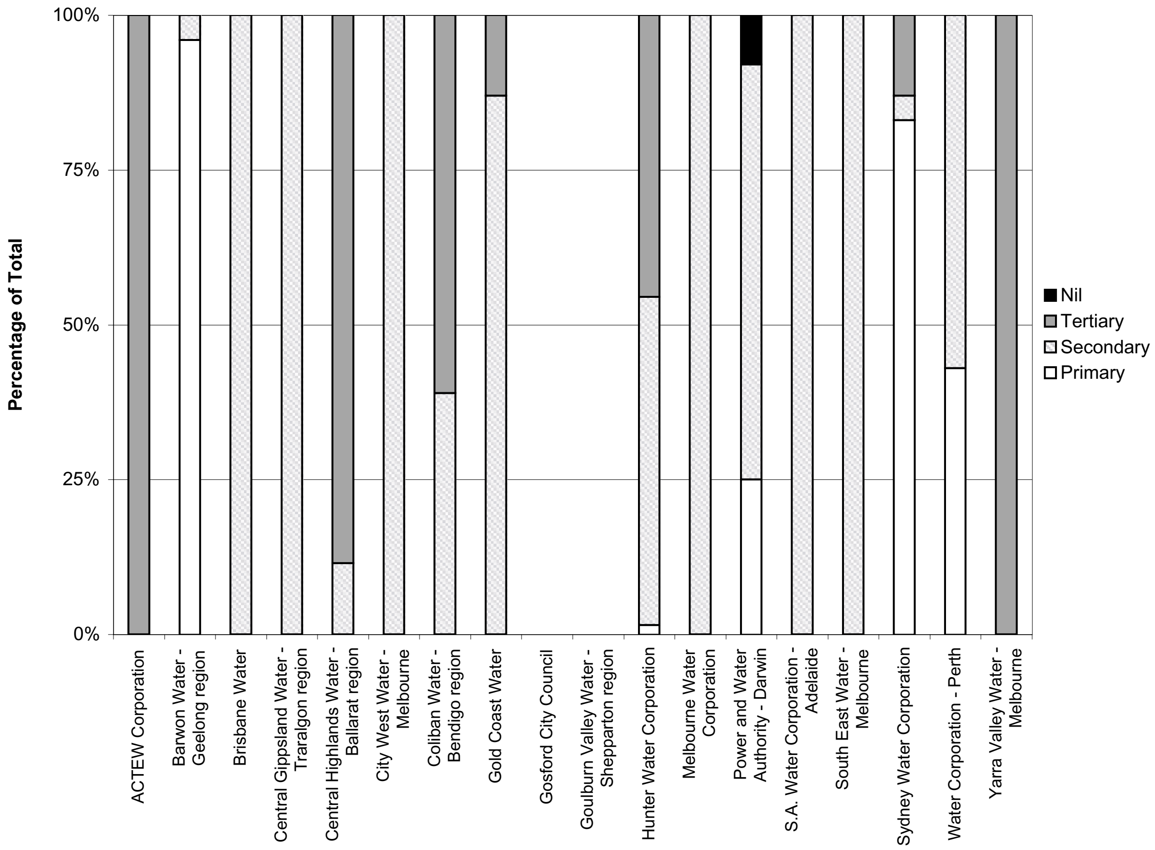

Figure 73: Levels of wastewater treatment for major urban water authorities, 1995–96 and 1999–2000.

Note: WSAA membership is drawn from businesses that have 50 000 or more water service connections.

Sources: WSAA (1997, 2000).

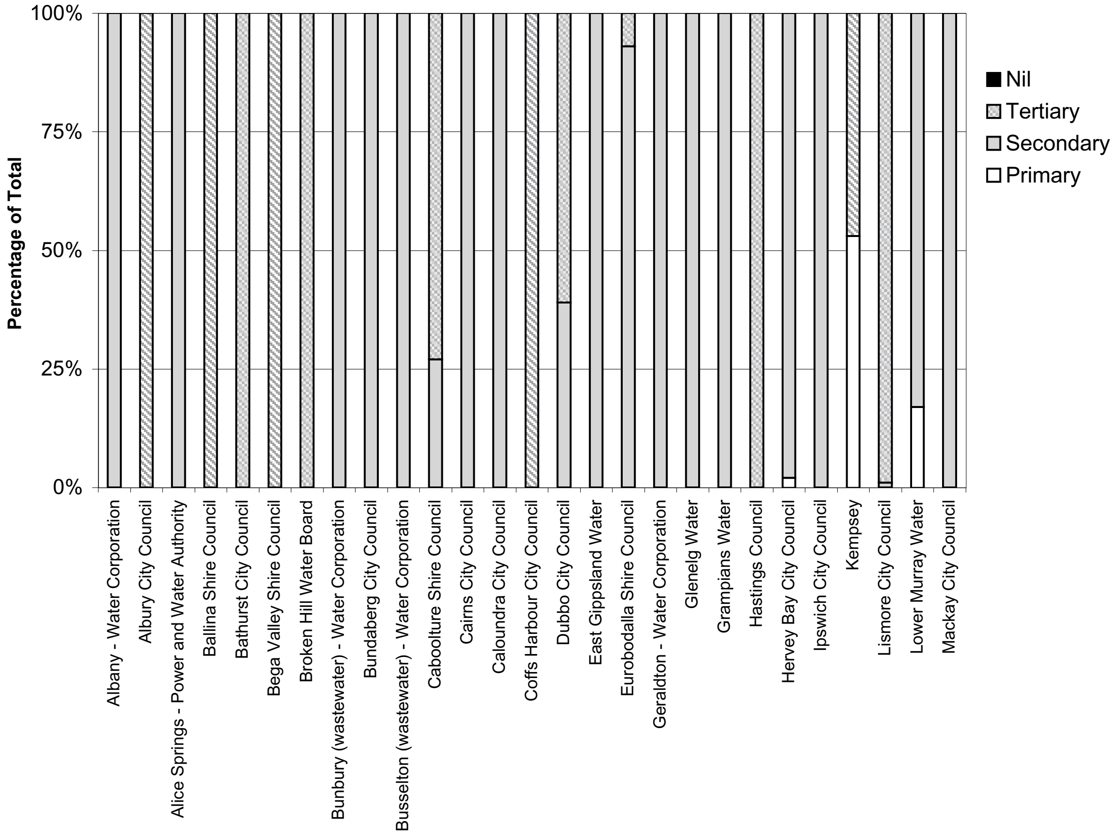

Figure 74: Level of wastewater treatment for non-major urban water authorities in 1998–99. [HS Indicator 2.6]

Note: Non-major urban water authority membership is drawn from businesses that have between 10 000 and 50 000 water service connections.

Source: AWWA (2000c).

with 100% receiving secondary treatment in 1999–2000 compared to 96% receiving primary level treatment in 1995–96. The Power and Water Authority of Northern Territory treated all wastewater from Darwin in 1999–2000, whereas 8% of wastewater received no treatment in 1995–1996. As a result, all wastewater in Australia received by the major urban water authorities was treated in 1999–2000.

Only three major urban water authorities employed primary treatment for a component of the wastewater in 1999–2000, being Power and Water Authority, Sydney Water Corporation and Water Corporation (WA), a reduction from four authorities in 1995–96. All three major urban water authorities employing primary treatment in 1999–2000 are located on the coast and discharge a large portion of the effluent via ocean outfall.

Figure 74 presents data on the level of wastewater treatment provided by non-major urban water authorities in 1998–99. These authorities collected 307 GL of wastewater in comparison to 1451 GL that the major authorities collected. It can be seen that treatment practices vary between non-major urban water authorities. The majority treat all wastewater to either secondary or tertiary standard, with only five treating a portion to primary standard only. Eleven of the 53 non-major authorities treat all wastewater to tertiary standard in comparison to only two major authorities.

Supplying water to remote communities

Many of the small communities in Australia are in arid and semi-arid areas with limited local water resources (AWRC 1989). Those who live in small rural communities are far less likely than residents of capital cities to have reliable, reticulated supply that fully meets capacity and water quality standards (Smith 1998). Data compiled in 1989 shows that 153 600 people lived in communities of between 30 and 1000 that did not have reticulated water supply, while another 284 600 people were supplied by a scheme serving less than 1000 people (AWRC 1989). This represented some 0.9% and 1.7% of the total population at that time.

The diseconomies of scale, particularly for headworks and treatment facilities, put the cost of conventional systems, and the standards and designs employed, beyond the reach of small communities. Providing fully treated and reliable supplies to match those of capital cities was estimated to cost close to $1 billion (in 1989 dollars) in capital works alone (Smith 1998). To reduce this cost, the alternative approach of providing less storage capacity per capita at a reduced reliability of supply, without compromising health standards for drinking water, was put forward by the Australian Water Resources Council (AWRC 1989). But even this low-cost approach would require $0.5 billion (in 1989 dollars) in capital works alone to implement.

Water supply for isolated dwellings—those below the small settlement threshold—is often via a combination of groundwater and roof runoff (Smith 1998). In the small towns of Ongerup and Newdigate in Western Australia, the most cost-effective way to overcome water supply shortages was found to be the fitting of dual-flush toilets throughout the communities (Crabb 1997). This approach can save between 4% and 12% of total residential water use in any region.

Meeting the needs of remote Aboriginal and Torres Strait Islander communities

For 61% of the 1291 discrete Aboriginal and Torres Strait Islander communities enumerated in the Housing and Infrastructure in Aboriginal and Torres Strait Islander Communities Report (ABS 2000l), the main source of drinking water was groundwater bores. Town water supply was the main drinking water source for 14% of communities, while rainwater tanks were the main drinking water source for another 9% of communities. Sixteen of the communities, all having a population of less than 50, had no organised drinking water supply. Just over half (55%) of communities with a population of 50 or more reported that their drinking water was treated (ABS 2000l).

Some 35% of discrete Aboriginal and Torres Strait Islander communities with a population of 50 or more experienced water restrictions in the 12 months prior to the survey, effecting 33 850 people. Equipment breakdown was the main contributing factor for water restrictions, reported by nearly 50% of these communities.

Of the 1291 communities, 71 reported that they had no sewerage system, all having a population of less that 100 people, accounting for 1% of the population and 2% of dwellings in these communities (ABS 2000l). Septic systems with a leach drain were the most common type of sewage disposal system, being the main system for 44% of discrete communities, although, as community population rose, community-maintained waterborne systems became more prevalent. Sixty per cent of communities with a population of 50 or more reported overflows or leakage of their sewerage system in the 12 months prior to the survey, with 10% having chronic sewerage problems. Commonly reported reasons for the overflows or leakage were blocked drains (55%), equipment failure (39%) and insufficient capacity (26%). The Federal Race Discrimination Commissioner (1994) found that ignorance of the linkages between technologies that assist in the delivery of water supply and sewerage services, and the values required to maintain and sustain the performance of these technologies, is a recurring factor in poor service provision. The Commissioner considered that application of appropriate technology that has community ownership is more likely to provide long-term service. This may address the prevalent of equipment failure being reported as a reason for water supply and sewerage system service failure.

Contamination of urban water

Waterborne disease is an illness caused by drinking contaminated water. The contamination can be bacteria (*Salmonella, Campylobacter, Shigella, Myobacterium, Vibrio, Leptospira, Escherichia coli*), viruses, or small parasites (*Cryptosporidium, Giardia, Toxoplasma*). Most outbreaks of waterborne disease are caused by faecal contamination of water by infected animals or people. Drinking water systems and public swimming pools have both been associated with waterborne disease outbreaks. People who have suppressed immune systems are at greater risk from waterborne disease.

For many years it has been widely accepted that contaminated water is the major vehicle for transmission of diarrhoeal diseases, and this has led to a predominant emphasis on the microbiological quality of drinking water. However, recent work by the World Health Organization and others has shown that food-borne transmission is more important and probably accounts for 70% of diarrhoeal episodes (Cooperative Research Centre for Water Quality and Treatment 1996). Outbreaks of waterborne disease in Australia are thought to be rare, although it is often difficult to determine the source of such diseases. They may be foodborne, faecal–oral, or person to person, as well as waterborne.

Campylobacteriosis, cholera, cryptosporidiosis, leptospirosis, salmonellosis, shigellosis, tuberculosis, typhoid and yersiniosis are nationally notifiable diseases in Australia that may be waterborne; giardia may be waterborne but is not nationally notifiable. The National Notifiable Disease Surveillance System annual reports provide little information on the source of the disease associated with the notification. Therefore, it is not possible to provide an indication of the relative importance of waterborne disease compared to foodborne, faecal–oral, or person to person transmission. In addition, water is often considered a food and so disease caused by contaminated water is reported as 'foodborne'.

Outbreaks of waterborne disease

Several incidents of confirmed waterborne disease have been reported in recent years. For example, 23 staff on a resort island in north Queensland had confirmed probable cases of campylobacteriosis in May and June 1997. The cause was determined to be due to contamination of a rainwater tank by faeces of wild animals (ADHAC 1999a).

Cryptosporidium constitutes a substantial public health hazard in swimming pools (ADHAC 1998). There were recent outbreaks of cryptosporidiosis in most states of Australia, traced to contaminated public swimming pools (ADHAC 1998; Swinton 1999).

In the Sydney event of July and August 1998, despite the erratic counts (of *C. parvum*) in the water supply, there was no disease attributed to the water (ADHAC 1999b, Swinton 1999). A number of questions remain unanswered in relation to the Sydney incident: Was the strain of *C. parvum* that was counted a non-infective strain? Were the wildly erratic analytical results correct? Or was the population sufficiently auto-immunised?

It is extremely difficult to monitor outbreaks of *Cryptosporidium*, since the incubation period after exposure is 6–7 days, followed by diarrhoea containing thousands of oocysts. Testing of the stools of severely affected patients does not usually occur for another 4–10 days, with further delay in reporting of 3–4 days (Swinton 1999). At present there are considerable variations in testing practices and reporting procedures between different states and territories, which makes it difficult to establish a comprehensive picture (ADHAC 1999b). As detection methods for *C. parvum* improve, the frequency of detection increases. However, we have no previous data to say whether there is an increasing trend, particularly as the background of gastroenteritis from food will mask all but a major waterborne outbreak (Swinton 1999).

The CRC for Water Quality and Treatment has recently completed a three-year study on the relationship between human health and water quality (AWWA 2000c). The study concluded that it is unlikely that Melbourne would derive a health benefit from filtering drinking water from its highly protected catchments. As found in Sydney during 1998, the health implications of applying ever-more sophisticated testing methods cannot always be determined. The study director, Professor Kit Fairley, considers the study a valuable tool in deciding whether contributing significant amounts of money to increase the degree of water treatment is justified, when there would not be any measurable benefits to human health (AWWA 2000c). The results of the study reinforce the Productivity Commission report on setting water quality standards in Australia, which stated that health benefits are rarely weighed up against the cost to the consumer when developing standards (AWWA 2000c).

Salinity of drinking water

If biological contamination of Australia's drinking water is rare, salinity is a much more pervasive problem, especially for cities and towns that draw water from inland rivers and groundwater aquifers (e.g. Dubbo in New South Wales, Katanning in Western Australia). For Adelaide in particular salinity represents a real challenge. Figure 75 summarises current Adelaide water use. On average the SA Water Corporation supplies 176 GL per annum to the Adelaide metropolitan area. The split between supply from the River Murray and the Adelaide Hills is 40:60 in an average year and 90:10 in dry years.

The recent salinity audit for the River Murray System (Murray–Darling Basin Ministerial Council (MDBMC) 1999) reports that, by 2020, water supplied to Adelaide will exceed the World Health Organisation threshold (upper limit 800 EC) for drinking water 20% of the time, and by 2050, 50% of the time. Table 56 shows estimated average salinity in the River Murray in South Australia. The current impact cost of salinity on irrigation areas and urban areas is estimated to be $46 million per annum (MDBMC 1999).

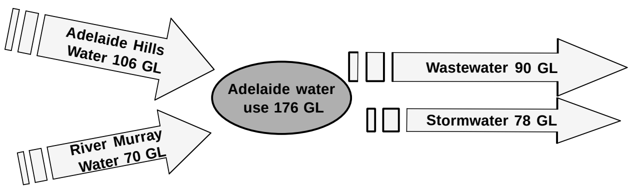

Figure 75: Average water use in the Adelaide metropolitan area.

Source: CSIRO.

Table 56: Estimated salinity in the River Murray, South Australia, 1998–2100.

Site	Average river salinity (EC)[A]			
	1998	2020	2050	2100
Murray Bridge	590	730	870	980
Morgan[B]	570	670	790	900
Berri	430	520	610	690
Renmark	400	480	550	620

[A] EC is electrical conductivity (measured as microsiemens per centimetre or µS/cm), a measure of dissolved salts in water. To convert 1 EC unit to mg/L of total dissolved salts, a multiplication factor of 0.6 generally applies.
[B] Morgan is used by the MDBMC as the key indicator site for monitoring and predicting salinity trends; it is upstream of the major off-takes of water to Adelaide.

Source: MDBMC (1999).

An economically and technically efficient solution to this problem in Adelaide has been advanced by CSIRO, the aim of which is to eliminate the need for Adelaide to source water from the River Murray (CSIRO 2000). Figure 76 summarises the extent of savings that might flow from the introduction of demand management, installing low-volume water appliances, replacing sewerage infrastructure with smaller scale plants, stormwater capture and use, aquifer recharge, using smaller pipes and levelling the peak loads on the supply system, and managing externalities sensitively.

One challenge in achieving this vision is the need to manage increasing levels of salinity detected in some Adelaide Hills catchments. Salt concentrations in several of these catchments already periodically exceed Australian drinking water guidelines (Jolly et al. 2000).

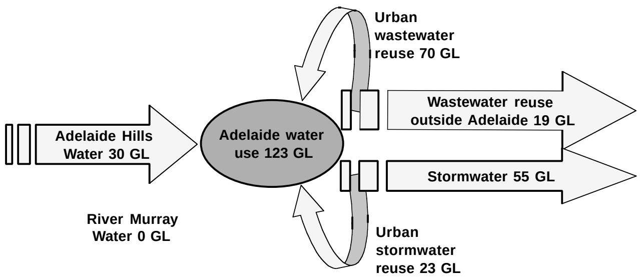

Figure 76: An optimistic model for water use in the Adelaide metropolitan area for an average year assuming a 30% reduction in aggregate water use from 176 GL per year to 123 GL.

Source: CSIRO.

Fluoridation of drinking water

Fluoride is a naturally occurring element found in soil, water and plants. Sodium fluoride is routinely added to drinking water supplies in the capital cities in Australia, with the exception of Brisbane, usually as one per million parts for its proven ability to reduce tooth decay and gum disease by up to 70% (NHMRC 1999). In addition to Brisbane, there are several other regional centres (e.g. Geelong, Ballarat, Sale, Latrobe Valley, Gosford) without fluoridation. Debate continues in epidemiological circles in relation to the pros and cons from a health perspective—although the weight of evidence seems to favour benefits. From a social equity perspective, fluoridation is seen as being of particular benefit to socially disadvantaged groups who have the highest rates of tooth decay and have less access to dental services.

Implications

Most of the Australian population has access to reticulated water supply and wastewater services, although the standard of service received does vary for location to location, with remote communities typically receiving a lower standard of service. In locations receiving a lower level of service, there is a shift towards the use of small-scale (and in some cases on-site) infrastructure because of the potentially high costs of providing the traditional large-scale centralised infrastructure. There is increasing interest in alternative methods of providing water services.

The Sydney ‘boil water’ alerts in 1998 and the failure of the Adelaide wastewater system in 1997 have highlighted the fragile nature of urban water infrastructure in Australia and the scale of the impact that a system failure can have on an urban area. Adelaide, amongst other urban centres, also faces the challenge of rising salinity levels in drinking water sources. So most, but not all, Australians receive a high level of water supply and wastewater service, although maintaining this current level of service in the face of ageing infrastructure is placing a financial burden on the water industry.

Food quality

Nutritional adequacy of the food supply

The Australian food supply provides a wide range of foods in fresh, processed, mixed or prepared forms. Overall the food supply is adequate to meet the nutritional needs of Australians (ABS 1998k). Although the vast majority of Australians do have access to a wide range of foods, this is not the case in rural and remote Australia.

A more complete discussion of food has been prepared for this SoE theme report and will appear in a technical paper.

A newly discovered issue is a resurgence of iodine deficiency in Australia. Australian soils are deficient in iodine, so our crops tend to be lacking in this nutrient. For three decades we have had sufficient iodine as a consequence of the use of iodine-containing sanitisers in the dairy industry and consumption of iodised salt. Cleaning methods and the pattern of salt consumption are changing. Now urinary iodine excretion levels are low enough to cause concern, especially for pregnant women and children (Gunton et al. 1999). Similar concerns are being expressed in the United States and New Zealand.

Food quality and safety

The most obvious impact of the environment relates to the contamination of produce with chemicals such as heavy metals in the soil, or persistent pesticides (such as organochlorines) which are now no longer in use but still remain available for uptake by crop and pasture plants. The current approach to surveillance and monitoring for these residues is summarised by Rowland et al. (1997) and is discussed in more detail in the Land Theme Report.

The National Registration Authority for Agricultural and Veterinary Chemicals results show that the quality of Australian produce is high with regard to residues. The UNEP/FAO/WHO Food Contamination Monitoring Program shows that Australian's dietary exposures are among the lowest in the world.

Attitudinal surveys indicate that consumers regard contamination by chemicals as much more important than contamination by microbes (Lester 1994). Hall (1999) regards this as perverse, as in general the actual chemical risks are smaller by orders of magnitude than those posed by microbial contamination.

There has been concern about the use of all antibiotics in animals if they are related to those used for therapy in humans. The concern centres on the induction of antibiotic resistance in the bacterial flora of the animals that may result in antibiotic-resistant infections in humans, the most important currently being vancomycin-resistant enterococci. Overall the problem in Australia appears to be small and efforts should be directed at keeping it that way. A report of an interdepartmental committee (the Joint Expert Technical Advisory Committee on Antibiotic Resistance) is currently under review. A resistance management plan is proposed that incorporates elements of regulation, surveillance, infection prevention, education (including prudent use principles), and research.

Geohazards

Australian settlements are not without risk in relation to a range of extreme events (geohazards) that include earthquakes, landslides, flooding, cyclonic wind and storm surges. Specific examples include the 1989 earthquake near Newcastle (5.6 on the Richter scale) that caused arguably Australia's most costly 20th century disaster; the Thredbo landslide in 1997; flash flooding common to most urban communities as well as more extensive flooding of entire drainage basins and their associated settlements; cyclones, of which there are several each year in northern Australia, the worst being Cyclone Tracey in 1974 which resulted in the destruction of Darwin.

A comprehensive natural risk assessment for Australia has recently been completed by the Natural Hazards Research Centre (NHQ 2000). Nine natural hazards have been considered in constructing a relative risk rating—tropical cyclones, floods, bushfires, wind gusts, hailstorms, earthquakes, tornadoes, landslides and tsunamis (Figure 77). The relative importance (contribution) of each natural hazard has been determined largely on cumulative data on 20th century damage to buildings. Tropical cyclones, floods and bushfires are the most important natural hazards, and tornado, landslide and tsunami the least important to date.

Table 57 shows a risk assessment for selected postcodes, comparing Darwin with several Sydney suburbs. The risk ratings indicate there is little differentiation on earthquake, but significant variation in risk across other geohazards. Darwin has a high risk of tropical cyclones and flooding, but a low risk of bushfire, wind gusts and landslides. Terry Hills and Hornsby, by way of contrast, have a relatively high risk of bushfire, as does Bondi Beach from tsunami.

Table 57: Risk rating of selected Australian postcodes.

Post-code	Reference	Bushfire	Earth-quake	Flood	Gust	Hail	Land-slide	Tornado	Tropical cyclone	Tsunami	Total
0800	Darwin	0.0	7.9	50.9	11.1	9.6	0.0	11.4	62.6	0.0	153.5
2026	Bondi Beach	0.0	7.7	0.0	10.4	20.3	0.0	11.7	0.0	0.7	50.9
2072	Gordon	0.0	7.3	9.4	10.4	17.4	1.0	9.8	0.0	0.0	55.5
2077	Hornsby	32.5	7.3	0.0	10.2	18.5	0.4	9.8	0.0	0.0	78.6
2084	Terry Hills	34.5	6.8	0.0	11.6	19.5	0.2	9.5	0.0	0.0	82.1
2135	Strathfield	0.0	7.3	33.1	9.8	18.0	0.0	10.1	0.0	0.0	78.3
2140	Homebush	0.0	7.8	7.1	7.6	18.5	0.0	11.2	0.0	0.0	52.1
2150	Parramatta	0.0	7.3	42.7	10.3	22.1	0.0	12.3	0.0	0.0	94.7
	Minimum	0	1.7	0	1.4	4.8	0	0	0	0	16.1
	Maximum	52	15.6	53	19.6	34.2	65	17.1	100	1.5	162.7

Source: NHQ (2000).

The objective of such studies is to raise awareness and preparedness in local communities in order to minimise the potential loss of life and economic impact. In the longer term, planning strategies will need to be implemented to relocate critical facilities that are at risk, to flood-proof buildings and infrastructure to the maximum extent possible, and to ensure new development is appropriately sited.

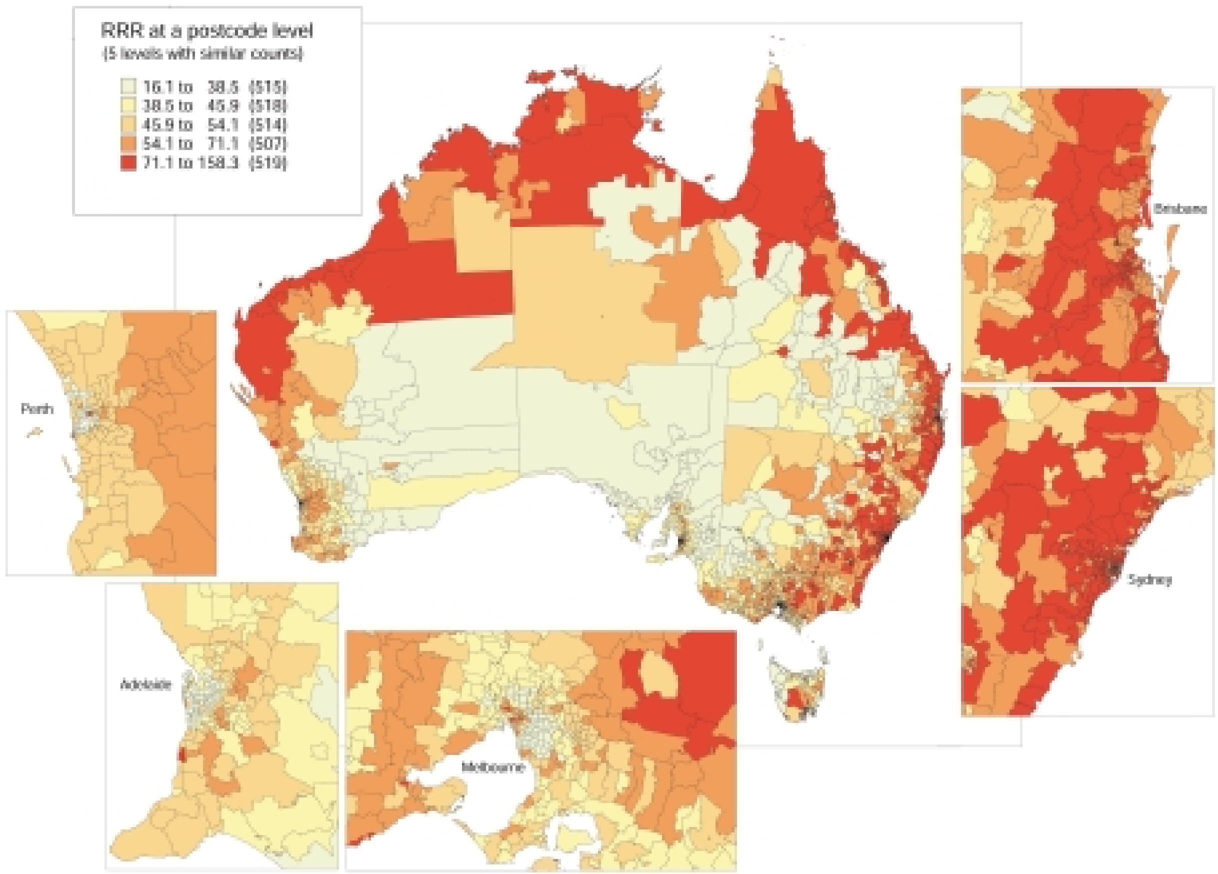

Figure 77: Relative risk rating (RRR) for Australian postcode regions.

Source: NHQ (2000).