Chapter 5

Effluent

Introduction

5.1 Although water is vital to our biological survival, human societies have also become reliant on water as the principle vehicle for transporting and removing waste products. Water that passes through urban centres becomes contaminated with a wide range of undesirable pollutants, which for many people, is a problem only until it vanishes down the sink, toilet or drain. However, for the waterways that are on the receiving end of these waste flows, the consequences can be severe.

5.2 This chapter examines this final part of the urban water cycle – the water that has been used by towns and factories and has become contaminated. The chapter begins with an overview of sewage treatment systems with particular examination of some of the innovative treatment processes that the Committee saw during the inquiry. The types of pollution and their effects on the receiving environment are then considered.

Treatment systems

5.3 Fortunately, emerging technology is providing many of the answers to the problems posed by these contaminants.

5.4 The processes used to treat wastewater varies, but can be generally divided into four stages, outlined below. The latter three – primary, secondary and tertiary – are also used to describe the standard of the treated water.[1] However, it should be noted that the meaning of these descriptors can vary from place to place. A useful 'star rating' guide that explains levels of treatment and water quality has been developed by the Australian Water Association.[2]

5.5 As wastewater goes through successive levels of treatment, increasingly types and quantities of pollutants and pathogens are removed, since no one system of treatment, disinfection or filtration can remove everything. Thus, for example, protozoa and helminth cysts are both resistant to chlorine disinfection, but can be killed by exposure to UV or ozone, or filtered out by membranes.

5.6 These levels of treatment are described below.

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1 The following description of the phases is largely taken from Simpson and Oliver, *Water Quality: From wastewater to drinking water to even better* and *The Dilemma of Watter Quandary*, 1996, pp 17-26.

2 Australian Water Association, *We all use water … A users' guide to water and wastewater management*, p 128.

Screening/pre-treatment

5.7 When sewage arrives at a plant, it is first put through a preliminary screening which removes larger solids and rubbish and protects pumps and other plant equipment. Common items that people put down the sink and into drains, like cigarette butts, cotton wool buds and the small brand stickers on apples, cause particular problems for treatment plants, jamming filters and causing blockages.[3]

Primary treatment

5.8 In the primary treatment stage, effluent is put into a settling tank, where solids settle to the bottom, allowing the cleaner water to flow over into the next stage. In a process called flocculation, chemicals such as alum (aluminium sulphate) and ferrous chloride are added which act as a coagulant to make suspended matter aggregate into larger, heavier particles that settle into the sludge at the bottom of settlement tanks. This process also captures much of the phosphorous and heavy metals.

5.9 Often water also has to be treated to remove iron and manganese which are common in Australian water (Perth groundwater, for example, is naturally very high in iron which causes discolouration[4]). Lime, sulphuric acid or sodium bicarbonate may also be added to alter the pH (acidity or alkalinity of the water). Effluent treated in this process therefore has some reduction in the amount of pollutants and pathogens, but a great deal remains.[5]

Secondary treatment

5.10 At the secondary stage of treatment, effluent receives biological treatment. In the biological reaction tanks, bacteria in the sludge is recycled continuously through the treatment plant. Different bacteria can then be used to consume organic matter, nitrogen and phosphorous. This is done in separate aerobic, anaerobic, and anoxic phases, which successively reduce levels of organic matter, nitrogen and phosphorous in the effluent.[6]

Tertiary treatment

5.11 The final 'polishing' level of water treatment will often involve running the water through filters consisting of coal, sand, fine gravel, anthracite (finely divided high carbon coal) or zeolite (a fine clay) to remove any remaining suspended solids. The water may then be disinfected by means of chlorine dosing or UV exposure, while shallow lagoons (know as maturation ponds, and allowing exposure to natural

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3 Sydney Morning Herald, *Sink sins make it fruitless being green*, 17 June 2002, p 3.

4 Dr Humphries, *Proof Committee Hansard*, 2002, Perth 29 April, p 417.

5 Water treated to this level can be referred to as Grade 1 wastewater.

6 Water treated to these levels can be respectively referred to as Grades 2, 3 & 4 wastewater.

UV in sunlight) or artificial wetlands may also be used for this effluent polishing role.[7]

Advanced treatments

5.12 Several other advanced techniques are available to treat wastewater.[8] In **membrane filtration**, water is forced through membranes made of polymers or ceramics with very fine pores, which vary in size depending on the type of membrane used.[9] There are four basic categories of membrane, which in decreasing size are: microfiltration, ultrafiltration, nanofiltration and reverse osmosis. The particulate matter and contaminants collected by the membrane are removed in a periodic backwash process. These improved membrane treatment technologies are particularly valuable for their ability to remove viruses from water, but they are expensive in terms of both capital and energy to run.[10]

5.13 Dosing with **ozone** or advanced **oxidising** agents can be used to disinfect and break down organic compounds. **Activated carbon** filters are made with a highly porous form of carbon, and are used to remove cyanobacterial toxins and chemicals such as herbicides, pesticides and pharmaceuticals.

5.14 In the **Dissolved Air Flotation** process, air saturated water is introduced into wastewater and forms millions of micro air-bubbles which attach to grease or tiny solids present in the effluent. This then floats to the surface forming a scum, which is skimmed off.[11]

By-products

5.15 When wastewater is treated, what is often forgotten is the problem of managing the waste products filtered from the water, which emerge as a sludge, high in pollutants. The quantities of sludge are quite substantial, and the most common solution is to dispose of it into landfill. However, other solutions are possible, such as incineration, and associated processing of ashes into fertiliser (see the example of Canberra, below), while there is also the possibility of turning dewatered biosolids into heating fuel[12] or oil for use in generators.[13]

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7 For example, Sydney's Cronulla Sewage Treatment Plant received a $90m upgrade to tertiary and UV treatments. Melbourne Water, *The Peninsula Project – Working towards a sustainable marine environment*, July 2001, section 5.

8 The following description is a summary based on Australian Water Association, *We all use water … A users' guide to water and wastewater management*, pp 173-179.

9 Used at the water treatment plant at the Sydney Olympic Park site at Homebush Bay, Sydney. See also Sydney Olympic Park Authority, *Submission 48*.

10 Mr Ringham, *Proof Committee Hansard*, Adelaide, 30 April 2002, p 472.

11 This technique is used at the Bolivar waste water treatment plant in South Australia. Committee briefing, SA Water, 1 May 2002.

12 Sunday Mail, *Sewage solution*, 14 April 2002, p 20.

Sewage treatment plants

5.16 In the course of the inquiry, the Committee visited a number of Sewage Treatment Plants (STPs) around Australia, each reflecting slightly different approaches to the same problem. Site visits included:

- Lower Molonglo Water Quality Control Centre (ACT)
- Bolivar Waste Water Treatment Plant (SA)
- Moa Point Waste Water Treatment Plant in Wellington, New Zealand
- Gibson Island Waste Water Treatment Plant (Qld)
- Western Treatment Plant in Werribee (Vic)
- Bendigo Waste Water Treatment Plant (Vic)
- Water Treatment Plant at the Sydney Olympic Park site at Homebush Bay (NSW)

5.17 Several of these are discussed in greater detail below.

Lower Molonglo Water Quality Control Centre, ACT

5.18 The LMWQCC,[14] as the treatment facility for Canberra has a number of particular characteristics. As Australia's largest inland city, wastewater is discharged into the Molonglo River and from there, into the Murrumbidgee River and the Burrinjuck Reservoir. With the importance of the rivers to downstream urban and rural use, it has been necessary to ensure the highest levels of treatment before discharge of water. One aspect of this requirement is that discharges must not have any significant levels of phosphorous, due to the danger of algal blooms.

5.19 These requirements have been recognised in the ACT where a high standard of tertiary treatment was adopted for the LMWQCC, which has also gained certification under the ISO 9002 and 14001 standards,[15] and conducts ongoing surveys up and downstream of the plant. In addition, the ACT Legislative Assembly resolved on 5 June 2002 that as far as possible, the water leaving the ACT via the Murrumbidgee River should be of no less a quality than the water flowing into the ACT.[16]

5.20 Interestingly, the LMWQCC also produces about 4 tonnes per day of incinerated ash from the sludge by-product which is high in phosphorous and

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13 A prototype of this system was constructed in West Australia, but has not yet been successful. West Australian, *Sewage has $30m stink*, 14 May 2002, p 3.

14 ACTEW, Lower Molonglo Water Quality Control Centre, fact sheet.

15 For more detail on the ISO standards, see Chapter 9.

16 ACT Government, *Submission* 75A, p 2.

nitrogen. This is then sold as a product called *Agri-Ash*, which is used as a soil conditioner in the region.[17]

Western Treatment Plant in Werribee, Victoria

5.21 The Werribee plant, run by Melbourne Water, is one of the largest STPs in the world, and offers an excellent example of best practice and sound environmental management.[18]

5.22 The plant covers 10,850 hectares and processes more than 500 megalitres of sewage per day, amounting to about 54 per cent of Melbourne's sewage including the major proportion of the city's industrial waste. The plant then discharges into the enclosed Port Phillip Bay, via four outlets. Werribee, which has been in operation more than 100 years, treats sewage with a mixture of lagoon treatment, land filtration (irrigation) and grass filtration (overland flow).

5.23 Port Phillip Bay is of vital economic, recreational and environmental importance to Victoria, and there were concerns over the effects of the high nutrient discharges for long term health of the Bay. Consequently, Melbourne Water commissioned the CSIRO to undertake the $12m Port Phillip Bay Environment Study, leading to nutrient reduction targets of 800 tonnes per year. The other major environmental driver for Werribee was the 1983 inclusion of the entire site as a Wetland of International Importance under the Ramsar Convention.

5.24 In 1998, Melbourne Water developed the Environment Improvement Project, which involved upgrading of the lagoon based treatment systems with an activated sludge plant and membrane covers over all the anaerobic processes to contain odour and capture the methane gas. This gas is then used for power generation, which will allow the plant to become almost energy self sustaining. Up to 50 per cent of the plant's effluent flow will be able to be sold as recycled water.

Potential for fish farming

5.25 A further possible method for dealing with sewage is fish farming in ponds filled with wastewater treated to secondary standard or better. Trials conducted at the Bolivar plant in Adelaide, in association with the South Australian Research and Development Institute, have suggested that carp bred in these ponds enjoy high growth rates and low mortality, while at the same time are effective at 'polishing' final effluent by removing nutrients. The resulting fish harvest can then be sold as fish meal used in animal feeds.[19]

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17 Committee briefing, ACTEW, Canberra, 10 August 2001.

18 Much of the information on the Werribee STP is drawn from *Melbourne's Western Treatment Plant – Innovation and cooperation the keys to upgrade*, B McLean and P Scott, Water, March 2002, p 78. See also Western Treatment Plant – A vision for the future, Melbourne Water.

19 Correspondence to the Committee from Ernest Manley, 26 April 2002.

Small scale treatments – Michael Mobbs' Sustainable house

5.26 At the other end of the spectrum is the house level of wastewater treatment. There are a range of systems available for individual houses that safely and effectively treat grey and black water. Some of these systems also produce high quality water available for reuse.

5.27 The Committee visited one such example in Chippendale in Sydney, created by Michael Mobbs. The renovation of this inner-city terrace house aimed to create a sustainable house, designed according to three criteria:

- no rainwater or sewage would leave the site;
- all water needs would be met from rainwater falling onto the roof; and
- over 12 months, the house would be a net exporter of clean, solar electricity to the main electricity grid.[20]

5.28 Of particular interest to this inquiry is the system used to treat water from showers, toilets, washing etc as well as vegetable and compost waste from the household. The wastewater tank contains a wet compost system[21] capable of handling 1200 litres of waste water per day. The system uses a 'biolytic filter' which operates through a series of filter beds housed within the tank, consisting of sandy and peaty material filled with worms, bugs and various micro-organisms which treat the water in an aerobic process. Particulate matter is filtered out by the compost beds and the cleaned water then passes through an ultraviolet lamp, designed to kill pathogens, and into a holding tank. From this tank, water is either used for toilet flushing or clothes washing, or discharged into reed beds and a miniature wetland detention basin.[22]

5.29 The solution used in the Sustainable House is one of a number of on-site disposal systems for wastewater that are available, including dry composting, chemical, combustion, hybrid, biofilter, or sandfilter methods that can be used in association with constructed wetlands that can give a final 'polish' to the processed water.[23]

Sources of water pollution from urban areas

5.30 Urban areas produce large quantities of wastewater, comprising domestic waste from toilets, showers, washing machines and drains, and industrial, or trade waste. The sewage treatment plants are the most important point source of nutrient

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20 *Sustainable House,* Michael Mobbs, CHOICE Books, 1998, p 12.

21 *Sustainable House,* Michael Mobbs, CHOICE Books, 1998, pp 106 – 111.

22 *Sustainable House,* Michael Mobbs, CHOICE Books, 1998, p 123.

23 *Mission Beach Sewerage Report,* prepared for the Cardwell Shire Council (Qld) by Sinclair Knight Merz, 1999. Manufacturers include Clivus Multrum, Wheelie-Batch, Poo-Lution Buster Dunny, Nature-loo, Separett, Envirolet, and Rota-Loo.

pollution from metropolitan areas, constituting around 99 per cent of phosphorous and nitrogen, with stormwater runoff constituting the major non-point source.[24]

5.31 Trade waste can be divided into organic compounds which include pesticides and solvents, and inorganic compounds which come from industries that use metals such as copper and lead. Examples of such industrial sources include copper from the electronics industry; chromium from electroplating works; lead and nickel from the battery shop; silver from jewellers; and mercury from the dentist.[25] Wastewaters from urban areas may also include organochlorines and dioxins.[26]

5.32 The Committee saw several examples of this first hand. In Townsville, accumulated pollution of soils from the railway maintenance facilities, such as oils, paints and solvents, poses a significant threat to downstream waterways, as they leach into the stormwater systems,[27] while the old railway yards in Brisbane are the major source of pollution into Breakfast Creek, which is a tributary of the Brisbane River.[28] Also in Brisbane, old landfill disposal sites, constructed prior to modern requirements to line and cap landfills, are leaching a cocktail of contaminants as their contents decompose.[29]

5.33 Similar problems were encountered by Sydney Olympic Park Authority in preparing the Homebush site for the Sydney Olympics. Various parts of the site had been contaminated with a 'bewildering range and types of pollutants'[30] by previous users, including an abattoir, a brickworks and an armaments depots, as well as in extensive landfill of surrounding former wetlands.[31]

5.34 A further significant source of sewage pollution affecting waterways is the release of often raw sewage from vessels. This has been identified as a particular problem in Queensland's Moreton Bay,[32] and Sydney's Hawkesbury River,[33] where thousands of leisure craft, houseboats, yachts, and recreational fishing boats operate. A recent Queensland Transport survey found that more than forty per cent of the

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24 Department of Agriculture, Fisheries, Forestry–Australia and Environment Australia, *Submission 54*, pp 7-8.

25 Australian Water Association, *We all use water … A users' guide to water and wastewater management*, p 121.

26 Great Barrier Reef Marine Park Authority, *Submission 60*, pp 8-9.

27 Committee Briefing, Townsville City Council, Townsville, 3 April 2002.

28 Committee Briefing, Healthy Waterways, Brisbane, 5 April 2002.

29 Committee Briefing, Brisbane City Council, Brisbane, 4 April 2002. Chandler Recycling and Waste Transfer Station.

30 Sydney Olympic Park Authority, *Submission* 48, p 3.

31 Homebush Bay Development Guidelines, Vol 1 Environment Strategy, p 2.

32 Courier Mail, *Councils call for cleaner bay*, 16 May 2002, p 5.

33 Sun Herald, *Up the creek without an excuse*, 19 May 2002, p 42.

state's boaties regularly discharge untreated waste into the water, with twenty five percent admitting to also discharging bilge water.[34]

5.35 But even where wastewater is fully treated to potable standards, prior to discharge, large influxes of freshwater into the marine environment of coastal waters may itself cause environmental problems. According to the Great Barrier Reef Marine Park Authority:

> Reef corals exist in seawater salinities ranging from 25 to 42% […]. Many examples exist of lethal and sublethal effects of lowered salinities following storm and flood events[…]. Symptoms of coral stress caused by lowered salinities include excessive mucous release and loss of zooxanthellae (bleaching).[35]

5.36 Bad land management practices are also a major source of contaminant, with destruction of the vegetation along rivers and streams (riparian vegetation) and poorly planned urban developments causing erosion of soils into the waterways, raising sediment loads.[36] This problem is complicated in many of the coastal regions of Eastern Australia which have acid sulphate soils. Land clearing and developments in these regions can trigger leaching of acids into the waterways.[37]

Pollution from septic tanks

5.37 Although sewage systems can certainly create problems for the environment, perhaps a worse problem is areas of higher density population which have remained unsewered. The septic tank systems on individual blocks can become a major problem, particularly if the tanks are leaky or not properly maintained.

5.38 A recent study in South Australia conducted by SA Water, the Environment Protection Authority and local councils, of septic tanks in the Adelaide Hills, Mt Barker and Onkaparinga councils found that of the 1,449 tanks examined, 44 per cent did not work correctly. Leaking effluent is pooling on the surface and leaching into the stormwater systems, creeks and rivers.[38] Failure rates are highest from older tanks, as would be expected, however 24 per cent of newer aerobic systems are also

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34 Sunday Mail, *Boaties pumping sewage into sea*, 11 Aug 2002, p 20.

35 Great Barrier Reef Marine Park Authority, *Submission 60*, p 8.

36 Department of Agriculture, Fisheries, Forestry–Australia and Environment Australia, *Submission 54*, p 8. The submission gives the example of urban expansion along Perth's south east and north-east corridors increasing 'nutrient loads to the already highly eutrophic Swan-Canning system.'

37 Department of Agriculture, Fisheries, Forestry–Australia and Environment Australia, *Submission 54*, pp 6 and 11.

38 Advertiser, *Septic tanks leaking into the waterways*, 7 June 2001, p 29.

failing, while even systems installed after the introduction of the SA Health Commission Standards in 1988 are failing at a rate of almost 22 per cent.[39]

5.39 Given that there are 12,000 septic tanks in the region, the magnitude of the problem is evident.

5.40 These factors have seen programs to extend areas covered by main sewage systems taking priority for water authorities. In 1994, for example, the Water Corporation in Western Australia commenced the Infill Sewerage Program, worth $800 million over ten years, to replace most domestic septic systems in the Perth area and in many country urban areas with reticulated sewerage. Prior to that, twenty-five per cent of the Perth area was unsewered.[40]

Pharmaceutical products and endocrine disruptors

5.41 Perhaps the most alarming of the evidence received by the Committee is that relating to the presence in the water of active pharmaceutical products and endocrine disruptors. These chemicals enter the water systems through effluent, and derive from natural hormones in the body, as well as medicated drugs and plastics.[41] According to Dr Fisher:

> up to 90 per cent of oral medications actually pass straight through the body and come out in urine or excrement. Even those parts of the medication which are used by the body have a tendency to recombine and form the original substance once they are outside the body.[42]

5.42 These chemicals include thyroid growth regulators, the contraceptive pill, baldness treatments, blood pressure and heart drugs, anti-depressants, and antibiotics. A less obvious source are soft plastics like Gladwrap and Tupperware, which produce a substance called phthalate, a very strong female hormone mimicker. Dr Fisher argues that Australian sewage treatment plants are generally ineffective at removing these chemicals from the wastewater stream:

> When we get to sewage treatment plants, early British research shows something like 38 to 83 per cent of pharmaceutically active chemicals, or PACHs, are actually removed by sewage treatment plants. In the case of Sydney, there is virtually zilch removal.[43]

5.43 The presence of these chemicals is compounded by two factors. First, these drugs may survive in the waterways for several years. Second is the problem of synergism, in which the chemical compounds interact with other chemicals in the

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39 Advertiser, *Hills septic tank pollution alert*, 14 November 2001, p 27.

40 Water Corporation of Western Australia, *Submission 49*, p 13.

41 Ms Ridge, *Proof Committee Hansard*, Sydney 18 April, 2002, p 246.

42 Dr Fisher, *Proof Committee Hansard*, Melbourne 23 April, 2002, p 365.

43 Dr Fisher, *Proof Committee Hansard*, Melbourne 23 April, 2002, p 365.

receiving environment, in the process creating wholly new compounds, with effects that are not tested for because the number of possible interactions are too complicated:

> Most of the toxicology tests are done in labs on single chemicals. When they are out in the wild, there are all sorts of possible interactions—even with herbicides and pesticides.[44]

5.44 The consequences of these chemicals in the environment can be frightening, including bisexual or altered gender fish, spawning boosts in shellfish, and potentially, the emergence of antibiotic resistant strains of bacteria.[45]

5.45 These concerns are described by the Nature Conservation Council of NSW, which argues that endocrine disruptors:

> have a very insidious chemical impact on the environment because they attack ecosystem function—the very basic processes of life, the ability of species to reproduce and the ability of species to effectively give birth.[46]

5.46 The Nature Conservation Council of NSW also comments that endocrine disruptors cause these effects at very low levels:

> It is almost at below detection limits where you start to see problems emerging in relation to endocrine disrupting effects on species such as fish and reptiles. Put simply, it is much safer to keep them out of natural ecosystems because to go around and try and clean them up once they have been discharged to those environments is very expensive.[47]

5.47 The extent to which pharmaceutically active chemicals constitute a problem in Australia is difficult to ascertain. The CSIRO acknowledges that they are potentially a very significant issue and one that has been largely overlooked due to lack of knowledge.[48] According to the Nature Conservation Council of NSW though, what little research that has been done in Australia does little to allay fears:

> There have been some isolated investigations carried out by Dr Lim in South Creek catchment, which receives effluent from the St Mary's sewage treatment plant.
>
> He found that the male *Gambusia*, which is a feral fish, also called the mosquito fish, … . All of the *Gambusia* that were being sampled had secondary sexual characteristics. The length of the male gonads had shrunk.

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44 Dr Fisher, *Proof Committee Hansard*, Melbourne, 23 April 2002, p 367.

45 Dr Fisher, *Proof Committee Hansard*, Melbourne 23 April, 2002, p 367; *and* Ms Ridge, *Proof Committee Hansard*, Sydney 18 April, 2002, p 245.

46 Ms Ridge, *Proof Committee Hansard*, Sydney 18 April, 2002, p 245.

47 Ms Ridge, *Proof Committee Hansard*, Sydney 18 April, 2002, p 246.

48 CSIRO, *Submission 47*, p 10.

> He carried out an experiment which linked that back to the level of oestrogen coming out of the St Mary's sewage treatment plant.[49]

5.48 In contrast, Mr Ringham of the South Australian Water Corporation told the Committee that:

> There has not been a lot of long-term studies on endocrine disruptors. There has been some work done in South Australia by the Department of Human Services – before I arrived here – which gives a fairly good indication that it is not a significant issue at this point in time.[50]

5.49 This view is cautiously supported by Professor Bursill:

> Most of us feel that the risks to public water supplies will be close to zero, but we have no evidence at the moment to prove that.[51]

5.50 Several things are evident from the evidence presented to the inquiry. Although there is limited evidence available in Australia of the effects of pharmaceutically active chemicals, overseas research does give a clear indication that the problem is a serious one. It is likely that Australia, by reason of its lower population density, will be slower to feel the effects of these problems than Europe or North America, however the Committee believes that this should not induce any complacency. Accordingly, the Committee strongly endorses the recent creation of the Global Water Research Coalition, and its planned research into the issue, which will include the participation of the Water Services Association of Australia and the CRC for Catchment Hydrology.[52]

Effects of pollution – receiving waters

5.51 This section examines the effects of pollutants on the receiving waters: the rivers, creeks, estuaries, bays and other coastal waters into which they flow. Each type of pollutant causes a particular range of effects on the ecology. These are examined together with more detailed consideration of pollution effects on the health of waterways such as the Great Barrier Reef, Moreton Bay and Port Phillip Bay.

5.52 Sediments in water reduce the penetration of light, restricting the growth of seagrasses and corals. Seagrass requires light penetration of 1.7 metres, and the Committee found that in parts of the Brisbane river, turbidity from sedimentation has reduced penetration to 0.6m.[53] The implications of this can be far reaching, as

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49 Ms Ridge, *Proof Committee Hansard*, Sydney 18 April, 2002, p 246. *See also*: Daily Telegraph, *Fish sex life up the creek*, 9 June 2001, p 7.

50 Mr Ringham, *Proof Committee Hansard,* Adelaide 30 April, 2002, p 472.

51 Prof Bursill, *Proof Committee Hansard,* Adelaide, 30 April, 2002, p 536.

52 Prof Bursill, *Proof Committee Hansard,* Adelaide, 30 April, 2002, p 535.

53 Committee Briefing, Healthy Waterways, Brisbane, 5 April 2002.

damage to the seagrass ecosystems may also affect the breeding of a range of fish species, excessive algal growth and plagues of starfish and sea urchins.

5.53 Excess nutrient levels in water cause a process called eutrophication, which is an unnatural proliferation of growth of macrophytes (large water plants), algae, diatoms and cyanobacteria (blue-green algae). This process can lead to the death of fish and bottom dwelling (benthic) organisms, and reduced biodiversity, through bloom collapse and rapid deoxygenation.[54] The Committee was shown an example of this in the Ross Creek catchment, Townsville, where over 10,000 fish of more than nineteen species died in an urban lake after rain washed a high in nutrients through the drainage system.[55]

5.54 Faecal contamination from sewage outfalls, or leaking septic tanks may also have serious effects on fisheries. As Professor Troy told the Committee:

> the sewage effluent finds its way into the rivers, lakes, estuaries and small coastal bays to the detriment of the natural systems, the oyster farms and fish breeding grounds … The recent disaster in the Forster-Tuncurry region on the mid-North Coast of New South Wales is an illustration of the process and the consequential dramatic economic costs of that process.[56]

5.55 Pollution from sewage has had similar damaging effects on oyster beds in the Sydney region. Professor White gave the example of the Sydney rock oyster which is an estuarine feeder, living on particulate and dissolved matters in brackish waters, and which has been declining steadily in numbers since the early 1970s.[57] This has had a catastrophic effect on the industry reliant on the oysters:

> I want to emphasise how significant this is. The Georges River was once a major oyster production area in Sydney. It drains southern and western Sydney. The Georges River, in 2001, ceased all production of Sydney rock oysters. The last farmer there was a fifth generation oyster farmer.[58]

5.56 Equally, heavy metals, pesticides, herbicides and hydrocarbons (oil) leaking into the waterways from industry and stormwater can destroy marine organisms. In Brisbane, for example, new termite treatments used in urban areas have been implicated in the loss of benthic (bottom dwelling) organisms in the intertidal and estuary area of the Brisbane River, leading into the sensitive waters of Moreton Bay.[59]

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54 Australian Water Association, *We all use water … A users' guide to water and wastewater management*, p 55: *and* Department of Agriculture, Fisheries, Forestry–Australia and Environment Australia, *Submission 54*, p 7.

55 Mr Bruce, *Proof Committee Hansard*, Canberra 22 March, 2002, p 80.

56 Prof Troy, *Proof Committee Hansard*, 2002, Canberra 22 March, p 23.

57 *Safeguarding Environmental Conditions for Oyster Cultivation in New South Wales*, Report for the NSW Healthy Rivers Commission by Professor Ian White, Jack Beale Professor of Water Resources, CRES, ANU, August 2001, p 5. [Tabled document, 22 March 2002]

58 Prof White, *Proof Committee Hansard*, 2002, Canberra 22 March, p 25.

59 Committee briefing, Healthy Waterways, Brisbane, 5 April 2002.

Chemicals such as organochlorines and dioxins are implicated in reproductive and immunological abnormalities in various species.[60]

Algal blooms

5.57 As noted above, algal blooms are a significant problem in both inland and ocean waters resulting from high levels of nutrients and associated eutrophication. One such organism is *Lyngbya majuscula*, a toxic marine cyanobacteria found in estuarine and marine environments which grows as strands attached to seagrass, rocks, and coral. In the right conditions, it grows rapidly to form large mats which can have destructive ecological impacts. These include smothering seagrass beds, and when floating mats are deposited on beaches, smothering mangrove seedlings resulting in mangrove dieback. *Lyngbya* blooms have also been associated with dugong death and infertility in turtles.[61]

5.58 Another toxic algae called Pfiesteria produces a toxin which can kill fish and cause brain damage and organ failure in humans if inhaled or absorbed through the skin. Pfiesteria has been found in three locations in the Brisbane River, although not in dangerous concentrations,[62]

5.59 It is often after algal blooms dissipate or die, that further problems arise, as the dying algae can release virulent toxins, which may linger in the waterways and requiring ongoing treatment:

> We also have a problem with our urban communities, and that is why we are carting tonnes of activated carbon to take the toxins out, because even if you can get rid of the algae you still have a lingering toxin problem which you have to manage by activated carbon.[63]

Land based discharges to the Great Barrier Reef

5.60 The problem of land based discharges to the Great Barrier Reef is typical of the types of problems affecting many of Australia's waterways. By reason of its enormous significance and sensitivity, it has been subject to detailed research,[64] and so gives a clearer picture of the impacts of human activities.

5.61 The Great Barrier Reef catchment covers 22 per cent of Queensland's land area, and contains 23 per cent of its population, including over 100 urban centres, many of which, like Cairns, have high growth rates. This amounts to almost one

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60 Great Barrier Reef Marine Park Authority, *Submission 60*, p 9.

61 Healthy Waterways - healthy Catchments, Synthesis of scientific results of the South East Queensland Study, p 8. [Tabled document, 4 April 2002]

62 Courier Mail, *River breeds 'cell from hell' killer algae*, 28 May 2002, p 1.

63 Dr Blackmore, *Proof Committee Hansard*, Canberra, 23 May, 2002, p 564.

64 The Great Barrier Reef has, for example, a dedicated Cooperative Research Centre, the CRC for Reef Research.

million people living within the catchment, nearly half of whom live in six coastal cities.[65] In addition, the catchment area includes thirteen heavy industry operations including: alumina, zinc, copper and nickel refineries; aluminium and zinc smelters; a power generation station; and a trade waste facility.[66] Water supplies for these urban and industrial areas include 123 dams and weirs.[67]

5.62 In overall terms, urban centres account for only a small proportion of wastewater discharges relative to agricultural uses, however these effects are still significant, and create localised problems up to five kilometres around the discharge area.[68]

5.63 Whilst these pollutants cause the general problems outlined above, an issue of particular significance to the reef is the phenomenon of 'marine snow':

> When you combine sediment and nutrient, it causes 'marine snow', which is a sticky polysaccharide exudate. It is a sticky substance that forms big globules. That comes down and it will settle on barnacles and coral polyps, … They cannot clean themselves, they cannot move it away, and they tend to die.[69]

5.64 Despite the amount of research done on the reef, officers of the Great Barrier Reef Marine Park Authority (GBRMPA) warned that a great deal is still unknown, and the overall state of the reef is difficult to assess, in large part due to the relatively recent nature of most research (ie the last twenty years) and the corresponding difficulty of knowing what the reef was like before human impacts. In this context, there are also problems in trying to identify what damage can be attributed to urban run-off as distinct from other impacts such as agriculture, or coral bleaching, or the cumulative effects of low impact stresses.[70]

5.65 Officers of the GBRMPA warned that:

> There is a tendency to want to break everything up: 'Is this urban run-off?' 'Is this run-off from a cane farm?' and so on. The reality is that these reefs see all of it. They see hot water, they see run-off coming off land, they see high sediment loads, they see high nutrient loads, they see pesticides – and they are seeing it all at once. The synergism of those factors is what causes

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65 Brochure, *Land Use and the Great Barrier Reef World Heritage, Current state of knowledge,* November 2001.

66 Great Barrier Reef Marine Park Authority, *Submission 60*, pp 2-3.

67 Great Barrier Reef Marine Park Authority, *Submission 60*, p 8.

68 Mrs Morris, *Proof Committee Hansard*, Townsville, 3 April 2002, pp 66, 67 and 69. *See also* Great Barrier Reef Marine Park Authority, *Submission 60*, p 6.

69 Mrs Morris, *Proof Committee Hansard*, Townsville, 3 April, 2002, p 70.

70 Brochure, *Land Use and the Great Barrier Reef World Heritage, Current state of knowledge,* November 2001.

> the impacts and that is why there is considerable concern at this point in time.[71]

5.66 What is certain is that land based discharges do cause damage to corals and seagrasses.[72] GBRMPA estimates that 750 reefs lie within ten kilometres of the coast in the area strongly affected by land runoff, and are thus at risk. Of particular concern are reefs between Port Douglas and Gladstone.[73]

Damaged waterways in Moreton Bay

5.67 Moreton Bay, a listed Ramsar site that lies off the coast of Brisbane, offers another example of the damage associated with urban runoff. Although still in good condition overall:

> Moreton Bay was continuing to degrade, with 38% of catchments and rivers showing a continued decline, 38% unchanged and only 24% improving. Of the catchments, 37.5% are in decline and 38% of our rivers are likewise. Only 1 catchment had improved (Waterloo Bay). Of those rivers and catchments showing no change in their scorecard result in 2000 to 2001, 62.5% of these are still rating a fail.[74]

5.68 The causes of these problems are a range of discharges from industrial and urban uses. Three quarters of the total discharge load into Moreton Bay comes from the Brisbane River, including the discharges from the Luggage Point and Oxley Creek Sewage Treatment Plants.[75]

5.69 Moreton Bay is also illustrative of the way in which geographical factors influence a particular waterbody's capacity to cope with pollutants. Moreton Bay has a high catchment to bay ratio – the area of the catchment is about fourteen times as large as the area of the bay, and has only three major entrances through which water is exchanged with the ocean. This results in a 'residence time' for water in the bay of about 120 days.[76] The implication of this is that a large area of land is draining into a small and largely confined body of water, and pollutants will not be able to dissipate into the open ocean.[77]

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71 Mrs Morris, *Proof Committee Hansard*, Townsville 3 April, 2002, p 70.

72 Mrs Morris, *Proof Committee Hansard*, Townsville, 3 April 2002, p 67.

73 Brochure, *Land Use and the Great Barrier Reef World Heritage, Current state of knowledge,* November 2001.

74 Wildlife Preservation Society of Queensland, *Submission 7a*, p 5.

75 Moreton Bay Study, Healthy Waterways, p 46.

76 Dr Abal, *Proof Committee Hansard*, Brisbane 4 April, 2002, p 90.

77 The Great Barrier Reef has similar characteristics but on a larger scale. Mrs Morris, *Proof Committee Hansard*, Townsville 3 April, 2002, p 66.

Ocean outfalls and Gunnamatta

5.70 For Australia's coastal cities, the most common solution to effluent disposal is to discharge it to the sea. According to the Clean Ocean Foundation, there are a total of 142 ocean outfalls around Australia which collectively discharge 1,325 gigalitres of water.

5.71 Of particular concern to the Clean Ocean Foundation is South East Outfall at Boags Rocks, Gunnamatta, which is 83 kilometres south of Melbourne and inside a national park. The outfall discharges at the shore, 135 gigalitres per year of Class C effluent from the Eastern Treatment Plant,[78] from the approximately 1.4 million people of Melbourne's South Eastern suburbs and the Mornington Peninsula, amounting to around 42 per cent of Melbourne's sewage. Prior to discharge, the water receives secondary treatment, and disinfection.[79]

5.72 The Clean Ocean Foundation claims that this discharge is responsible for damage to marine ecosystems,[80] adverse health effects for swimmers and surfers including sore throats, infected abrasions and earaches, as well as degrading the use of the region for activities such as walking, surfing and swimming.[81] On this basis, it is further claimed that the outfall puts Melbourne Water in breach of the Victorian State Environment Protection Policy (Waters of Victoria).[82]

5.73 The Clean Ocean Foundation points out that water reforms have led to groundwater being available for $1.40 per megalitre which means that reuse is not currently viable for effluent treated to Class A standard at a cost of $300 per megalitre. The Foundation argues that the effluent should be treated to potable standard which would open up more markets for the reclaimed water.

5.74 In responding to these concerns, Melbourne Water commissioned a $1.5m CSIRO research project which has led to an environmental improvement program that aims to reduce flows to the plant through water conservation; reduce ammonia discharge water by more than 75 per cent; and introduce tertiary filtration and enhanced disinfection.[83] Melbourne Water has also increased monitoring of waters and has proposed to pipe the outfall 1.5km offshore and into deeper water.[84]

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78 Mr Morehead, *Proof Committee Hansard*, Melbourne, 23 April 2002, p 380.

79 Melbourne Water, *The Peninsula Project – Working towards a sustainable marine environment*, p 4.

80 Mr Graham Quail, quoted in: Herald Sun, *Surfers cry foul over outfalls*, 30 March 2002, p 22.

81 Clean Ocean Foundation, *Submission* 76, pp 9-10.

82 Clean Ocean Foundation, *Submission* 76, p 3. *See also* Mr Morehead, *Proof Committee Hansard*, Melbourne, 23 April 2002, pp 379 and following.

83 Sustainable Resource Management at the Eastern Treatment Plant, Boags Point, Power-point presentation slides, Melbourne Water.

84 Melbourne Water, *The Peninsula Project – Working towards a sustainable marine environment*, pp 6-8.

5.75 Ocean outfall is also the principal form of effluent disposal for Sydney, with ninety per cent of Sydney's wastewater being discharged from ocean outfalls at Bondi, North Head and Malabar, after undergoing primary treatment. The use of these deep ocean outfalls has substantially improved the quality of water around Sydney's beaches and harbour, however, as Sydney Water comments:

> floatable grease from the treatment plants can still be detected at some nearby beaches, particularly the northern ones.[85]

5.76 The deep ocean outfalls also stand in contrast to the combination of low level treatment and shoreline discharges, such as at Cronulla, Port Kembla and Bellambi:

> This can regularly affect bathing water quality and have an impact on the biodiversity of marine species close to the discharge points. In addition, local weather and current conditions play a role in bringing wastewater releases from the Cronulla plant back to the beaches.[86]

5.77 The extent of the damage caused by outfalls is unclear. In general terms, outfalls certainly cause some degree of degradation to the marine environment. From the human perspective, deep ocean outfalls are also much preferable to onshore outfalls, and result in higher water quality and less damage to shore based ecosystems. According to the Australian Water Association:

> Ocean outfalls can work efficiently and may be a satisfactory solution to effluent management. Under the right conditions, properly treated effluent discharged into deep ocean water with strong currents will have little or no environmental impacts.[87]

5.78 Sydney Water also claims that continued monitoring of its outfalls has not revealed any significant environmental impacts,[88] with the AFFA/EA submission noting that sediment monitoring at twelve sites off the NSW coast has shown few effects from the deep ocean outfalls.[89] Similarly, the Water Corporation of WA submissions states that:

> Treated water in Perth is discharged through ocean outfalls at distances between 1 and 4 kms offshore. World class studies continue to show no adverse impacts of this method of disposal. This is a sustainable solution to

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85 Sydney Water, Waterplan 21 site, at: www.sydneywater.com.au

86 Sydney Water, Waterplan 21site, at: www.sydneywater.com.au

87 Australian Water Association, *We all use water … A users' guide to water and wastewater management*, p 211.

88 Ms Howe, *Proof Committee Hansard*, Sydney, 18 April 2002, p 174.

89 Department of Agriculture, Fisheries, Forestry–Australia and Environment Australia, *Submission 54*, p 11.

> the challenge of managing increasing loads associated with population growth … .[90]

5.79 Other scientists are less optimistic about the sustainability of deep ocean outfalls. The two key limitations with assessments that find 'no significant impacts' is that, first, little is known about the ecology of deeper marine environments so there is inadequate baseline data to monitor effects. Second, deep ocean outfalls are (almost by definition) relatively inaccessible making effective monitoring of the sites difficult.[91] The concern is therefore that we have not yet **noticed** any impacts, rather than there **are** no impacts.

Options for improved effluent management

5.80 The problem of waste disposal is, as always, best dealt with at source, by reducing the quantity of effluent through more efficient practices and greater recycling. Second, as is discussed below, society has the technology to treat wastewater to a very high level, so this technology should be used wherever possible to ensure that water discharged to the ocean does not contain harmful pollutants.[92] Third, where ocean discharge is inevitable, deep ocean outfalls are preferable to shore discharges, and can be sustainable where they are carefully planned and managed, taking into account water depth, distance from shore, currents, exchange rates and residence time in the receiving waters.[93]

Optimum scale for treatment

5.81 An emerging question that stems from the range of available techniques for wastewater treatment, is whether treatment needs to be done by large centralised facilities such as those at Werribee or Bolivar.

5.82 Some evidence to the inquiry has argued that the optimal point for treating wastewater is on-site at the individual block level, and this is certainly borne out by the success of Michael Mobb's house described above. The submission from the Centre for Resource and Environmental Study states that:

> Domestic sewage is relatively benign. That is, it is relatively simple to process. The development of small scale biological treatment plants that

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90 Water Corporation of Western Australia, *Submission 49*, p 14

91 Private briefing, National Science Week, Canberra, May 2001.

92 Australian Water Association, *We all use water … A users' guide to water and wastewater management*, p 212.

93 Dr Abal, *Proof Committee Hansard*, Brisbane, 4 April, 2002, p 90. One such example is the outfall from Moa Point in Wellington New Zealand. The outfall, using diffusers, discharges into the Cook Strait and is rapidly dispersed and diluted by the very strong currents flowing through the strait. This is in contrast to the confined waters of Moreton Bay.

> can be installed in single houses or small groups of houses now makes it feasible to introduce recycling systems for small scale subdivisions.[94]

5.83 This view is supported by the Nature Conservation Council of NSW:

> We believe that innovation in urban water cycle management is very much needed and that decentralised solutions, stage treatment and resource recovery, demand management and distributed storage in Sydney need to be raised from the boutique status they have within current water management planning and given a place at the table along with traditional water supply and sewerage solutions.[95]

5.84 Household or suburb level treatments have four further, and very significant advantages. First, they allow a dramatic reduction in the capital costs of the piping systems to convey wastewater, as well as the energy required to pump it. The scale of savings becomes apparent when it is considered that these systems represent about 80 per cent of the overall cost of a sewerage system, with only 20 per cent spent on the treatment plant itself.[96] These savings are ongoing as well, since the water infrastructure only has a life of around 100 years, and consequently requires constant investment in repairs and renovations.

5.85 Second, numerous smaller wastewater treatment plants dispersed over an entire urban area provides multiple sources of water available for various local reuse projects. This would do much to mitigate one of the current barriers to widescale reuse, which is the cost of transporting recycled water to where it can be reused (see Chapter 3).

5.86 Third, the sewage systems themselves are large users of water required for 'self-cleansing flows for systems'.[97] Although some systems make extensive use of recycled water for this purpose, these flows represent a further possible water saving from localised systems. [98]

5.87 Finally, reducing the need to transport wastes also reduces the extent of leakage from the system with the pollution that it causes to groundwater and streams, as well as the resources needed to track down and rectify these leaks. (See the discussion in Chapter 3).

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94 Centre for Resource and Environmental Studies, *Submission 50*, p 4.

95 Ms Ridge, *Proof Committee Hansard*, Sydney 18 April, 2002, p 245.

96 The following description of the phases is largely taken from Simpson and Oliver, *Water Quality: From wastewater to drinking water to even better* and *The Dilemma of Watter Quandary*, 1996, p 17.

97 Mr Ringham, *Proof Committee Hansard*, Adelaide 30 April, 2002, p 484.

98 Mr Woolley, *Proof Committee Hansard*, Brisbane, 4 April, 2002, p 605.

5.88 Other evidence suggests that these systems are not yet mature enough to replace the large scale treatment systems currently in use. As the Water Corporation of Western Australia argues:

> it is about $7½ thousand to $10,000 for a household system, which then becomes the responsibility of the householder. The energy used per house is much higher than the energy used per capita from a reticulated system. Where you have big waste water plants like we do, there are major economies of scale in the treatment, and of course the professionalism, of their running rather than a bulkanised, dispersed system. So all of the pros and cons need to be objectively looked at.[99]

5.89 There are also doubts over the capacity and inclination of individual householders to maintain on-site systems, especially given that individual failures in urban areas can result in severe health threats to surrounding houses and waterways.

5.90 According to evidence, currently the optimum cost effective number of connections to a sewage treatment plant is between 1000 and 10,000 connections.[100] Nevertheless, it is clear that the optimum scale for sewage treatment is falling, and it is likely that in the next decades, treatments will increasingly be viable at the suburb or individual development level.[101]

5.91 Given the advantages of smaller scale treatments, the CSIRO identifies research in this area as a priority, especially in relation to systems to remove nitrogen and phosphorous.[102]

Conclusions

5.92 As this chapter shows, our actions in cities have direct consequences on the health of our environment. Our culture tends to believe in the unspoken myth that when we make a mess, we can wash it away. Water managers though, understand what the rest of society needs to learn. Every pollutant that leaves our cities goes somewhere, and most often, where it ends up is in rivers and then on into bays and coastal waters. While natural ecosystems can absorb a certain amount of these pollutants, the sprawling and high density metropolitan centres produce waste streams that are too concentrated to be assimilated. The results of this are becoming increasingly apparent: algal blooms, fish kills, closed beaches and shrinking fisheries, all of which have direct effects on the health, prosperity and lifestyles of our society.

5.93 However, as this chapter also shows, we already have the knowledge and skills to fix many of these problems – the most important ingredient lacking is the

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99 Dr Humphries, *Proof Committee Hansard*, Perth 29 April, 2002, p 430.

100 Mr Woolley, *Proof Committee Hansard*, Brisbane, 4 April, 2002, p 598; *and* CSIRO, *Submission 47*, p 5.

101 CSIRO, *Submission 47*, p 5.

102 CSIRO, *Submission 47*, p11.

commitment across society as a whole to take responsibility for our waste. In practical terms this means minimising the amount of waste flows and dealing with wastes as close to source as possible, as well as a readiness to make the investments needed to upgrade all sewage treatment plants to the highest tertiary standards, so that discharge water is at least as clean as the receiving waters.

5.94 At a more strategic level, it also means making the investment in research and science to make sure that our planning decisions are informed by a detailed understanding of the surrounding environment and its particular characteristics, to ensure that our actions cause the minimal possible harm.